POLITECNICO
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Design for Autism

Research on Autism and Built Environment, Develop an Evaluation Tool of Hospital Space for ASD users

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A Report for the requirement of Master of Science
in Architecture and Urban Design

Thesis submitted to the
School of Architecture Urban Planning Construction Engineering

Politecnico di Milano
MI, Italy

2020

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Thesis period: 09/2019 - 04/2020
Thesis presentation: 28/04/2020

Abstract

Autism is a lifelong developmental disability affects every aspect of people's lives. The main challenges that people with autism face are related to everyday social communication, interaction with others, and repetitive behaviours. Apart from these core deficits, the problems in sensory processing make them easily experience sensory overload, and it may result in anxieties or collapses in a building environment where various sensory elements are contained. Their unstable emotions, poor motor skills and the unaware of risks that are likely to put them in danger and make them have an urgent need of a more important safe space.

Series of difficulties prevents them from using building space and related services like ordinary people, especially when it comes to health-related buildings. This paper attempts to study how to build an autism-friendly medical space and develop an evaluation tool of hospitals built environment for ASD users. The forces research area in hospitals is reception halls, circulation spaces, and ambulatory spaces. The paper consists of 3 phase:

(1) The knowledge is collected through a literature review and case study, which is about characteristics of the space needed by ASD users, design guidelines of the autism-friendly space, and how to apply guidelines and concepts to architectural design.
(2) Developing a prototype of an autism-friendly tool. It including 6 characteristics of the built environment and 12 criteria that can have positive or negative impacts on the built environment.
(3) Apply the prototype to the medical environment, and research how to improve the performance of 12 criteria in the hospital to create an autism-friendly hospital environment. Eventually, the prototype can be transformed into a tool specially designed for an autism-friendly hospital environment will be obtained. It provides design guidelines and can be used as an evaluation tool.

The research results of this article will be presented with a series of design considerations and strategies for each of the 12 criteria. Based on the resultant, an evaluation tool can be developed to assess the accessibility of ASD users in 3 hospital areas, aiming at providing non-barriers medical space for ASD users and helping them use medical services successfully.

Keywords: autism, built environment, design guidelines, autism-friendly, hospital, reception halls, circulation spaces, ambulatory spaces, evaluation tool

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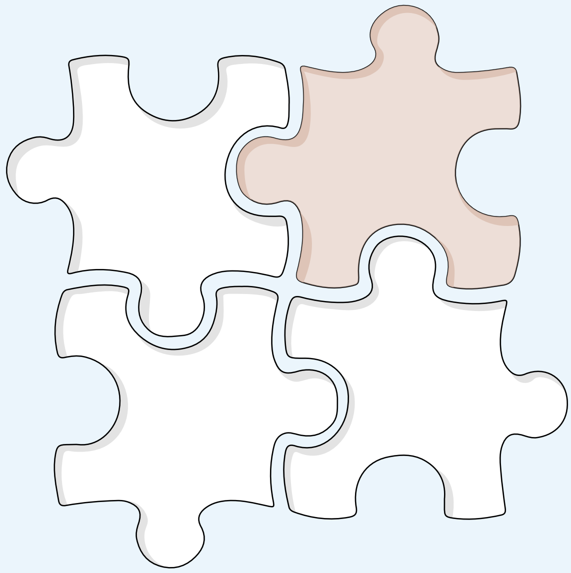


1. Introduction :

Autism Spectrum Disorder (ASD)

Index

1.1 Background

Autism is a lifelong developmental disability that affects how people perceive the world and interact with others. It is a spectrum condition that all people with autism share certain difficulties, but the degree of autism varies in accordance with different individuals. Some common behaviours associated with this disability include proce, language delays, difficulties with communication and narrow interests.

1 in 54

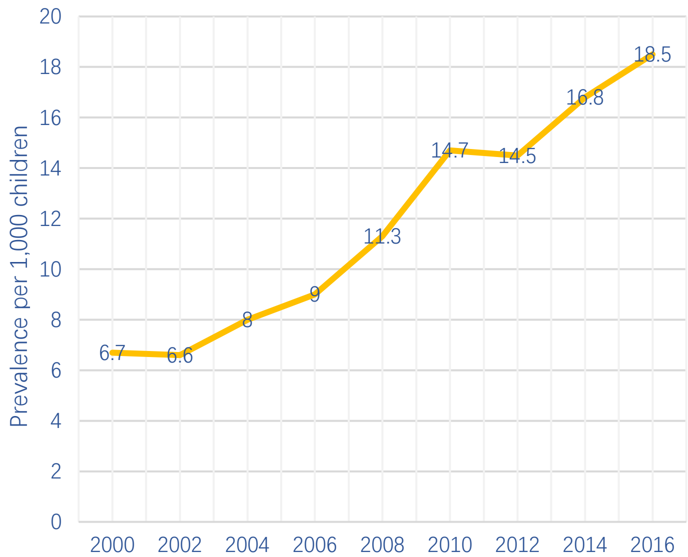
population were identified with ASD by ADDM in 2016

Data & Statistics on Autism Spectrum Disorder

Autism is much more common than many people think. In the UK, there are around 700,000 people on the autism spectrum, which means more than 1 in 100 persons suffer it. If their families are included in statistics, autism is a part of daily life for 2.8 million people (Source from The NHS Information Centre website).

A number of medical studies have found an increasing trend in the prevalence of ASD. The Centre for Disease Control and Prevention 's (CDC) Autism and Development Disabilities Monitoring (ADDM) Network's latest report finds that autism prevalence has increased from 1 in 150 children to 1 in 54 from 2002 to 2016 in the USA. The following table shows the increasing population in the recent 20 years. (Source from ADDM official website).

Table 1.1 Prevalence of People with Autism Spectrum Disorder in USA (ADDM 2000-2016)



Surveillance Year	ASD prevalence
2000	1 in 150
2002	1 in 150
2004	1 in 125
2006	1 in 110
2008	1 in 88
2010	1 in 68
2012	1 in 69
2014	1 in 59
2016	1 in 54

World Population Review (WPR) tracked the rates of autism around the world in 2020, although there is a bit of a challenge. The reason is that there are also no specific, uniform criteria for assessing autism and some nations do not track or report their autism rates, as the institution reported on its official website.

At the top of the list is Hong Kong, where 372 children out of every 10,000 have been diagnosed with autism, which means 1 out of every 27 children in Hong Kong has been diagnosed with this developmental disability. South Korea has the next highest rates of autism. In this country, 263 out of every 10,000, or 1 in 38 children have received a diagnosis of autism. The tracked rates of autism in different countries are showed in the following table (Source from WPR official website).

Table 1.2 Prevalence of People with Autism Spectrum Disorder in world (WPR, 2020)

Country	Prevalence of Autism per 10,000 children	ASD prevalence	Population 2020
Hong Kong	372	1 in 27	7496.981
South Korea	263	1 in 38	51269.19
United States	222	1 in 45	331002.7
Japan	181	1 in 55	126476.5
Ireland	153	1 in 65	4937.786
Switzerland	145	1 in 69	8654.622
Canada	106	1 in 94	37742.15
Denmark	69	1 in 145	5792.202
Singapore	67	1 in 149	5850.342
Belgium	60	1 in 167	11589.62
Estonia	60	1 in 167	1326.535
Finland	54	1 in 185	5540.72
Norway	51	1 in 196	5421.241
Netherlands	48	1 in 208	17134.87
Germany	38	1 in 263	83783.94
China	23	1 in 435	1439324
Taiwan	5	1 in 2000	23816.78
Poland	3	1 in 3333	37846.61

1.2 Characteristics of people with autism

As autism is a “spectrum” condition, it affects different people in different ways, therefore it is very difficult to generalise about how an autistic person will develop over time. Some people with autism have accompanying learning disabilities while others may have a high level of intellectual ability. But there are some common difficulties exhibited by most people with autism, the disorders can be characterized by three core deficits: impaired social interaction, impaired communication and restricted, repetitive and stereotyped behaviours and interests. Besides due to the impairment of the sensory system, most of them have difficulty in making sense of the world. The presence of symptoms and impairments is variable in range and severity depending on individual differences and often changes with the acquisition of other developmental skills, affecting how people perceive the world and interact with others

(1) Social interaction

People with autism are likely to exhibit less social understanding, and less responds to emotions and communicate nonverbally. The difficulty with social interaction makes them hard to understand social rules and live in the community environment, eventually suffer more frequent loneliness and tension compared to non-autistic people. In addition, some studies reported aggression and violence often occurs in individuals with ASD, and limited data indicate that among children with intellectual disabilities.

(2) Communication

People with autism can be difficult to understand communications, even non-verbal communication such as understanding the meaning of common gestures, facial expressions or tone of voice. In some cases, people might have limited or no ability to talk with others. Generally considered that individuals with autism do not develop enough natural speech to meet their daily communication needs.

(3) Repetitive behaviours

Repetitive behaviours mean that actions that are repeated over and over, it may involve parts of the body or the entire body, or even objects or toys, for example, repetitive movements with objects such as keep turning the lights on and off or spin the wheels of a toy car, repeated body movements such as rocking, flapping their arms or swinging left and right and suffers trend to spend a lot of time on staring objects. Sometimes their repetitive body movements may result in self-injurious and anxiety.

(4) Other Symptoms

Preference for routine

The report of Signs and Symptoms of Autism Spectrum Disorders, published by CDC, stated that people with autism usually prefer routine. A tiny change in normal patterns of a day or from one activity to the next may causing problems. For example, an unusually stop on the way home from school can make them upset. They may lose control or melt down, especially in strange places.

Easy irritability

Autism often has a high degree of anxiety, Changes, including the one mentioned above, as well as changes in daily activities, in circumstances or in characters (classmates, family, colleagues, etc.) will make them nervous. As soon as they become nervous, some self-injurious behaviours such as biting hands will follow, and others of them may react unusual routine by negative emotional behaviours loss of temper and anxieties.

Sensory system

People with autism display a series of other symptoms, of which the closest one to the built environment is their impaired sensory system. Most of them might have unusual responses to sounds, sights, touch, smell, taste and feel, they can be over- or under-react to the sensory inputs. For example, hearing and touch of ASD suffers are more sensitive than the neurotypical people, they may be over-reacting to loud noise or uncomfortable touch contact. They might have abnormal eating habits. For instance, some people with ASD limit their diet to only a few foods, others might eat non-food items like dirt or rocks.

Dealing with different senses at the same time is also a challenge, such as processing visual and auditory information at once seems difficult for some of them. An individual who struggles on dealing with everyday sensory information can easily experience sensory overload and result in withdrawal, disruptive behaviours or meltdown. The sensory elements may include in conveyed messages such as the leaflet or advertisement, the overnumbered and complex information is not friendly to them because they can't find out the required message easily under the existence of sensory information.

Autism is a lifelong developmental disability, currently, no treatment has been shown is available for the cure of ASD, but some treatment and education approaches have been developed and proven that can address some of the challenges associated with it. These interventions can lessen disruptive behaviours, improve social communication and cognitive skills and daily living skills, and help them to learn self-care and self-help skills for greater independence, and maximize children's function and ability to participate in the community.

Table 1.3 The common symptoms exhibited by people with autism

Social interaction

- Lacks of interest to participate in social activities and like to be alone.
- Lacks of physical or even non-verbal communication skills, such as eye contact, have flat or inappropriate facial expressions
- Has troubles in detect, understand and respond to the feelings and needs of others, feels hard to talking about own feelings as well.
- Does not understand personal space boundaries.

Communication

- The language development is slow, lacks of understanding of expression.
- The communication skill is weak, only understand the word or the literal meaning of the expression, but not the meaning behind it.
- The expression is stereotyped, repetitive and direct.
- Does not respond to others' words or behaviours.
- Tends to talk in a flat, robot-like, or sing-song voice.

Repetitive behaviour

- Tends to have repetitive movement, such as flaps hands, rocks body or roll head, or spins self in circles.
- Obsessed with unusual objects (rubber bands, keys, light switches).
- Tends to self-injury such as eye-poking, skin-picking and hand-biting.
- Tends to stare at certain items or typical objects for a long time.

Other Symptoms

- Very well-organized.
- Easily gets upset by minor changes in routine or environment. (e.g. lines up toys, follows a rigid schedule)
- Unusual reactions to the sensory input like sound, smell, taste, sight or feel.
- Has unusual emotional reactions, tends to fall in aggression, temper tantrums easily.
- Has short attention span.
- Has unusual eating and sleeping habits.
- Lack of fear or more fear than expected.
- Hyperactivity (very active).
- Impulsivity (acting without thinking).

Characteristic of autism and its related symptoms

Lack of language and communication skills make it difficult for them to interact with others and integrate into the social environment. They often respond to social disorders and sensory stimuli with disruptive behaviours such as emotional collapse, aggression, self-injury or eating disorders. The presence of these reactions is likely to cause physical harm.

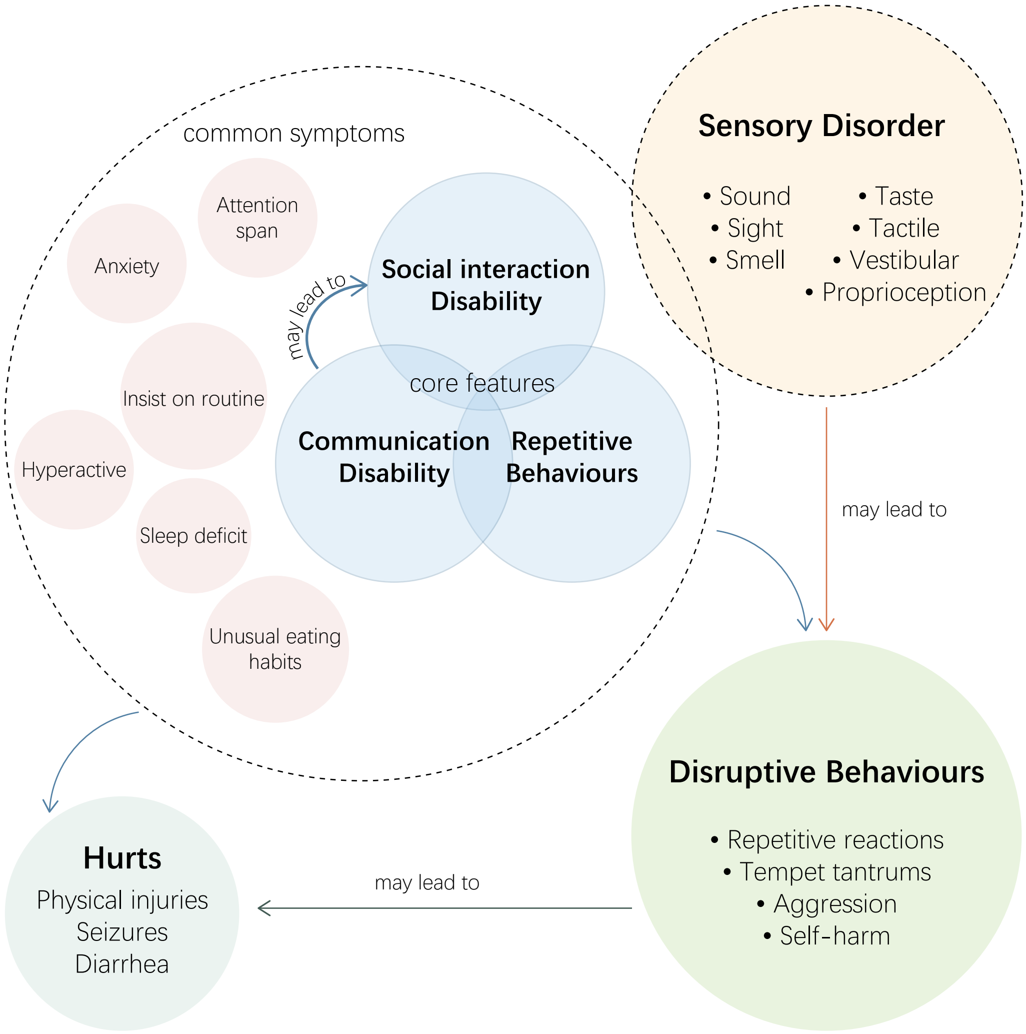


Figure 1.1 Characteristic of autism and its related symptoms

1.3 Hyper- and Hypo-sensitivity

People with sensory processing issues have trouble organizing information received from the senses. In general, they can be over-(hyper) or under (hypo)-react to sensory information about auditory, visual, smell, tactile and taste.

Hyper-sensitive means their sensory is too acute and they are unable to use all of the senses at one time. Suffers can easily fall in sensory overload when too much information gets into the brain. The sensory elements are generally involved in the building environment, sometimes the interior space can be terrifying for them and may lead to physically painful or disruptive behaviours. For example, they can notice the tiniest pieces of fluff on the carpet, can see a 60-cycle flickering under fluorescent lights and may be frightened by sharp flashes of light, loud or sudden noise.

Hypo-sensitive, on the contrary, as if certain sensory information goes unnoticed or certain senses are impaired. They are unable to feel their own body or clearly see, hear or feel the world around them. The internal feelings like pain, body awareness and hunger may be under notice until it becomes overwhelming. Hypo-sensitive people are often qualified as "sensory-seeking," meaning they often or generate their own sensory experiences either for pleasure or to block out other unpleasant stimuli. To stimulate their senses, they might wave their hands around or rock forth and back or make strange noises.

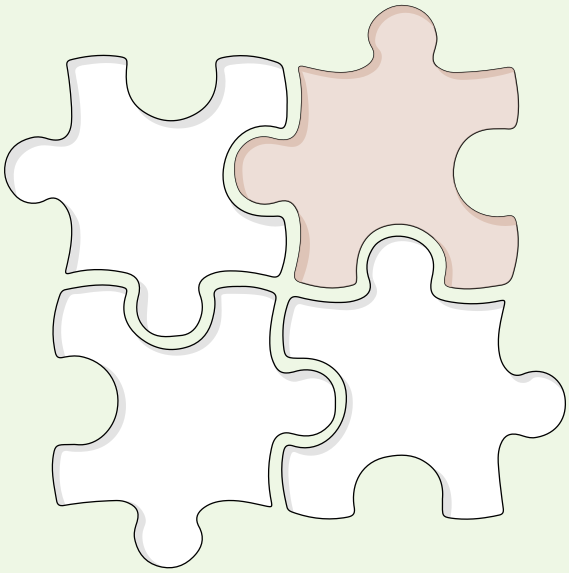
The senses usually mean the five traditional ones we mentioned above. But there are actually two other senses. The sixth sense is vestibular which helps control balance, eye movement, and spatial orientation. It helps keep people stable and upright. Individuals with vestibular issues may not know where their body is in space which can make them feel off balance and out of control.

The seventh sense, proprioceptive helps the control of body awareness. The receptors in our muscles can tell us where our body parts are. For example, when people raise hand up people can know that the arm is overhead without the need of thinking about it or looking in a mirror. But people with poor proprioception may think their arm is over their head when it's actually straight out in front of them.

Following table lists examples of symptoms that individuals with autism may face related to sensory processing and the symptoms classified as hypo-sensitive or hyper-sensitive.

Table 1.4 Hyper- and hypo-sensitive symptoms of ASD

Hyper-sensitive	**Hypo-sensitive**
Hearing	
• Easily distracted by background sounds; • Over reacts to loud noises; • Has unpredictable reactions to sounds (e.g., scream or cry to sound).	• Does not respond to the call of name; • Tends to ignore the sounds from surrounding; • Enjoys strange noises and making loud noises, tend to create sounds to stimulate themselves.
Visual	
• Has distorted vision, objects, movements and bright lights can appear to jump around; • Images may fragment; • Often stares at certain people or objects; • Easier and more pleasurable to focus on a detail rather than the whole object.	• Unaware of other people; • Loses sight of moving people or objects; • Objects appear quite dark, or can only see outlines of objects; • Likes bright colours and sunlight; • Has poor depth perception (e.g., has problems with throwing and catching; clumsiness).
Smell	
• The smell sense are intense and overpowering; • Refuses go to areas with strong odours; • Dislikes products with scents (e.g., distinctive perfumes, shampoos).	• Seeks out strong smell to stimulate themselves; • Has no or weak sense of smell and fail to notice extreme odours; • May licks things to get a better sense of what they are.
Tactile	
• Dislikes being touched and reacts negatively; • Dislikes having anything on hands or feet; • Only likes certain types of clothing or textures; • Dislikes being wet or going barefoot; • Has difficulties in brushing and washing hair.	• Touches people and objects unnecessarily; • Has high pain threshold and doesn't respond to hurts, even may tend to self-harm; • Holds things tightly and enjoys heavy objects (e.g., weighted blankets) on top of them.
Taste	
• Picky eater, has restrictive diet due to flavours or texture of food.	• Frequently puts things into mouth; • "Feel" object with mouth; • Eating non-food substances (e.g., soil, grass); • Likes very spicy foods.
Vestibular sense (balance)	
• Has poor balance ability; • Becomes distressed when feet leave the ground; • Has difficulties with activities like sport, which control movements are needed.	• Seems to need constant movement, such as rock, swing or spin to get some sensory input; • Moves around unnecessarily.
Proprioceptive sense (body awareness)	
• Uncomfortable in most positions; • Has difficulties with fine motor skills: manipulating small objects like buttons or shoelaces; • Moves whole body to look at something.	• Unaware of body position in space; • Hard to navigate rooms and avoid obstructions; • Often leans against people or objects; • May bump into people.



2. State of the art:

Autism and Built Environment

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2.1 Methodology of literature review

In order to achieve and collect most of the information about the presented topic, a systematic literature review has been conducted. The purpose of this search is to find an evaluation tools in the existing knowledge system that can assess the accessibility of space to autistic individuals and provide guideline for designing an autism friendly environment.

This process has been conducted through different and sub-sequential steps, giving back a rigorous selection as output, coherent with literature projects that focus on spaces for autistic people in all the possible forms, from micro- to macro-scale.

(1) Definition of search terms

In order to select the literature related to specific topic, a three parallel level keywords assembly structure has been defined.
Space: It cover the area of architecture, urban, engineering and design.
Autism: There are various fields interested into the topic comprising medicine, sociology and psychology.
Evaluation tools: A vocabulary selection from architecture and design areas is needed, but also from psychology is related to ASD user therapy.

Table 1.5 Three parallel level keywords

Space	Autism	Evaluation tools
• architecture • environment • “built environment” • “living environment” • hospital • therapy • school • classroom • “health care” • housing	• autism • “autism spectrum disorder” • asd • autistic	• “design evaluation” • “design guide” • “design guideline”

The selection was divided in three parallel levels:
The search keywords reset the singular because it could enclose both singular and plural when searching in the database.

In the semantic group **Space** include general space and some specific place which are closely related to people’s life. There are many articles that involve neurology but are not relevant to this article. In the semantic group **Autism** including all autistic patients, there is no age division.

(2) Combination of selected terms and research string

In order to ensure the research string contain at least one word from each semantic group, boolean operators as OR and AND were used to combine the words. Use AND between semantic groups to in order to each semantic group must appear while use OR between words within semantic group for one word must appear. Double quotation used to search special characters:" autism spectrum disorder".

Search string is as following:
TITLE-ABS-KEY (architecture OR environment OR "built environment" OR "living environment" OR hospital OR therapy OR school OR classroom OR "health care" OR housing AND "Autism Spectrum Disorder" OR asd OR autism OR autistic AND "design evaluation" OR "design guide" OR "design guideline")

(3) Selected databases

First database we chose Scopus, search field set as Title, Abstract and Keywords. By searching 28 documents result were obtained in search phase, published year ranged from 2004 to 2019. A variety subject area it covers from documents result, arranging from high to low, namely social science (12), computer science (9), engineering (7), medicine (5), psychology (3), etc.

From Scopus 28 published documents were selected.
From Avery Index to Architectural Periodicals 2 published documents were selected.
From PubMed 0 published documents were selected.

(4) Selection of results and additional documents

Through the search of the above database, 30 effective documents were obtained. By reading the title and abstract, 7 irrelevant articles were excluded because ASD is also an abbreviation for other professional terms. 2 conference reviews were not related with evaluation of autism related space and were not available. 9 articles were screened because the design guides and evaluation mentioned in these articles were about technology tools, including application, computer programs, virtual environment robots etc. that designed for supporting individuals with autism.

By reading the abstract we selected 8 documents related to space, autism and evaluation tools were selected, but 2 of these could not find full text, eventually 6 documents were available. We also referred to the publications mentioned in these selected documents. so we searched through the title in different database to find the full text of them, eventually 18 new documents related to themes were added. In summary, 24 documents were selected and will be analysed and researched in deep.

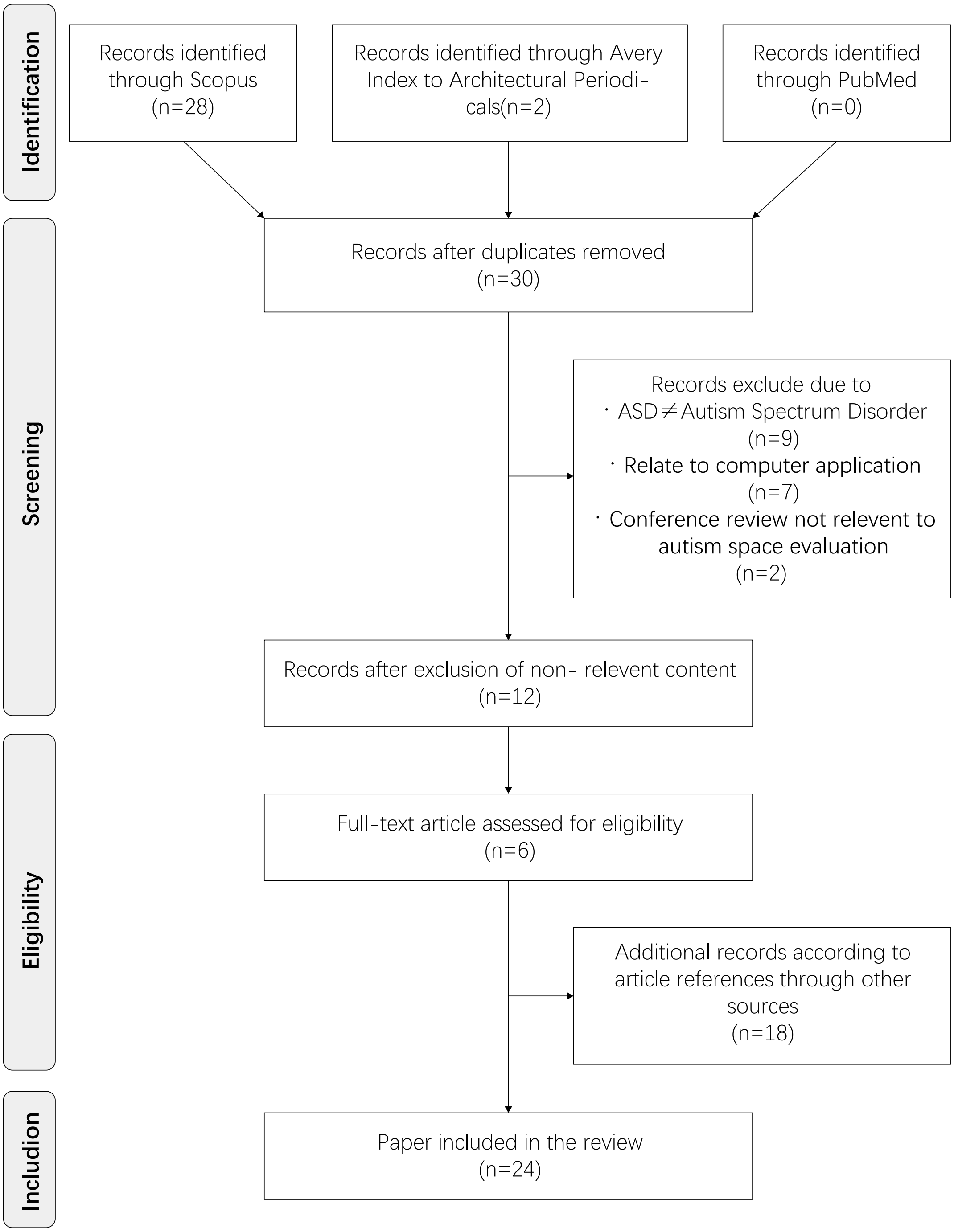


Figure 2.1 The process of selection of results and additional documents

(5) List of reviewed publications

By literature search and selection, we got the following 24 papers related to the autism-friendly and built environments. Through reading the full text, we extracted the core theories of these papers and learned their research methods and processes. These pieces of knowledge accumulated as the foundation for our subsequent research.

Table 1.6 List of selected documents

	Year
Official design guideline	
Building Bulletin 77	1992
Building Bulletin 102	2009
Designing for Special Needs	2002
John Richer & Nicoll Stephen	1971
Christopher Beaver	2006
Teresa Whitehurst	2006
Magda Mostafa	2008; 2010; 2014a; 2014b 2015; 2018
Rachna Khare & Abir Mullick	2008a; 2008b; 2009a; 2009b 2014
Simon Humphreys	2008
Claire Vogel	2008
Sherry Ahrentzen & Kimberly Steele	2009
Iain Scott	2009
Sánchez et al.	2010
Mcallister Keith & Barry Maguire	2012a; 2012b

2.2 State of the art: autism and built environment

2.2.1 Classification of articles

Published documents about autism-friendly can be divided into three groups. The first group is based on literature review and experiment. Authors first conducted extensive literature research, through existing theory, interviews with autistic individuals, parents, carers, medical staffs, then proposes new hypotheses, which will be finally validated by intervention experiments. Such studies are based on experiments can obtain more reliable results (Mostafa 2008, Khare & Mullick 2008, Mcallister & Maguire 2012).

The second group of research is based on design projects (Whitehurst 2006, Beaver from GA architects 2006, Humphreys 2008, Vogel 2008). According to years of practice and research, the architects have summarized some aspects that needed to be consider when designing a built environment for children and adults with autism. They applied the design guide to the project, then collected user feedback, evaluated the building after occupancy, and updated the original design guide. Design indicators were gradually revised as each project progressed.

The third group of studies is to summarize the existing knowledge system of autism friendly architectural design. Researchers and architects have their own special views on autism non barrier buildings, related design guidelines are gradually increasing. Scott (2009) and Sánchez et al. (2010) have critically compiled them, proposed some key indicators, and explained their meanings in depth in their articles, then explored the use of these indicators in actual projects.

2.2.2 Timeline of masterpiece

We list representative autism-related research and introduce their achievements in chronological order as below:

2002-2018, based on the results of questionnaire of caregivers of autistic children and design intervention experiment, **Mostafa** obtained the Sensory Design Matrix, which can be used as an architectural design guideline for autism. On this basis, the Autism ASPECTSS™ Index was proposed in 2014, it is a set of criteria developed specifically for the design of built environments. ASPECTSS™ contains seven design criteria, verified by Mostafa, such method can be applied in living environment (Mostafa 2014), learning environment (Mostafa 2014) and assessment tools (Mostafa 2015;2018).

2006, Beaver proposed a practice-based approach to developing autistic and friendly building environments by communicating with customers and collecting feedback from users. It is an iterative process, research on the autistic building environment will improve with the project progresses.

2006, Whitehurst analysis the project of residential accommodation of GA Architects design at Sunfield School. She improves the autism environment design strategy by comparing students' experiences in old and new built environments in order to enhance the existing situation.

2008-2014, Khare & Mullick published several publications on the autism- friendly educational environment. Firstly, 18 autism-related design parameters were confirmed, then they were verification by designed assessment tool. The design guidelines were proposed based on this in order to develop an effective educational space for children with autism.

2008, the same practice-based research followed by **Humphreys**' publication, he proposed eight indicators that need to be considered when designing a built environment for autistic people.

2008, Vogel developed a design strategy through a series of interviews with relevant individuals, including parents, teachers, and therapists of autistic people. His research is for general architectural environment but more particularly for the design of learning space for children with autism.

2009, with the development of research, the design guides for autism friendly building environment has increased significantly, and architects have their own special opinions on the space with special needs. **Scott** (2009) and **Sanchez et al.** (2010) provide a critical review of existing code and design guidelines, detailing some of the indicators in the guide and extending them according to their own research and projects. Rather than summarizing the design criteria in the existing literature, Scott also analysed four autism related buildings, interviewed architects and users to get feedback after building occupancy. These four cases will be analyses in the case study chapter.

2009, although most of the research is about the learning environment for children with autism, residential design has always been a frontier fields of research topic because of its importance. Mostafa applied the Sensory Design Index to the home and proposed design criteria for a reconstruction project of home for autistic people. In the same year, **Ahrentzen & Steele** extended the study to provide a more comprehensive housing design consideration for autistic patients.

2012, as most architects did not have knowledge of the autism-friendly building environment, **Mcallister & Maguire** created a “Classroom Design Kit” to guide the design of autism-friendly classrooms based on the work of Humphreys (2008) and Vogel (2008), this tool is used as a bridge between architects and autism related teachers. Through this tool, relevant experts and teachers can clearly and effectively transfer their knowledge and architectural requirements to architects, in order to provide students a more relaxed learning environment.

2.2.3 Review of publications research on autism and built environment

01. Official design guideline

Building Bulletin 77

Building Bulletin 77, Designing for People with Special Educational Needs and Disabilities in Schools, (updated 2005), published by the Department for Education and Employment.

It contains the following points in relation to designing educational spaces for children with autism:

(1) The building should have a simple layout which reflects order, calm, clarity and has good signage and wayfinding.

(2) Pupils may show different sensitivities to spaces: some will be frightened by large, open spaces and wish to withdraw to smaller spaces, whilst others will not like enclosed spaces. Providing a mix of larger spaces with smaller ones to withdraw to when anxious can help.

(3) Designing low sensory-stimulus environments reduces sensory overload, stress and anxiety.

(4) The provision of pleasant, well-proportioned space, with plain, bare walls decorated in muted soft colours will allow teachers to introduce stimulus, (such as wall displays of work or information), gradually to suit pupils needs.

(5) Classrooms can be arranged so that teachers may employ different teaching methods, with spaces for individual work or screened personal workspaces.

(6) Use of indirect lighting and the avoidance of noise or other distractions, (blind cords, exposed pipes or dominant views out), need to be considered.

(7) Containment in the class base for reasons of supervision, safety or security by the use of two door handles, at high and low-level, must neither compromise escape procedures, nor violate human rights, (in that children must not be locked up unless they are secured or detained legally in secure provision).

(8) Robust materials should be used where there are pupils with severe disabilities and safety precautions for doors, windows, glass, plaster and piped or wired services will be required.

(9) There is a need to balance security and independence and to find the right mix between tough materials and special equipment on the one hand and ordinary, everyday items on the other, in order to avoid an institutional appearance, whilst at the same time eliminating risks.

(10) Simple or reduced detailing and changes of plane may reduce the opportunity for obsessiveness.

Building Bulletin 102

Similarly, the recently 2009 published UK government Building Bulletin 102, it can be used to guide the design for disabled children and children with special educational needs, the proposed the design issues for children with ASD as:

Simple layout: calm, ordered, low stimulus spaces, no confusing large spaces; indirect lighting, no glare, subdued colours; good acoustics, avoiding sudden / background noise; robust materials, tamper-proof elements and concealed services; possibly risk assessments; safe indoor and outdoor places for withdrawal and to calm down. (DfEE, 2009, p.199)

Designing for Special Needs

Designing for Special Needs (Maurice Harker & Nigel King, 2002), published by RIBA Enterprises, which contains a section on 'Autism and Design', which focused largely on service provision. The design criteria can be summarised as:

(1) The requirement to provide an ordered and comprehensible, spatial structure.
(2) The requirement to provide a mix of large and small spaces.
(3) The requirement to provide increased control of the environmental conditions to the user.
(4) The requirement to provide for different, autism specific teaching methods.
(5) The need to balance security and independence.
(6) The need to provide simple and reduced detailing.
(7) The requirement for the end user to be actively involved in the brief-building and design process.
(8) Appropriate use of technology to aid the learning experience.
(9) Appropriate technical specification.

02. John Richer & Stephen Nicoll (1971)

One of the first publications on autism was that of Richer and Nicoll in 1971. They attempted to achieve two main goals through a design playroom space. The authors aimed to achieve two main goals: reduce the frustration and reduce the flight behaviours.

- Reduce frustration

· Subdividing space in smaller areas allowed overstimulation and an excessive number of social interactions are avoided. A retreat box was also provided in which the child could escape from the stimulus.
· Space for activities such as climbing, rolling, sliding, etc. was provided.
· Stereotypes were not stopped, toys which could easily be played with in repetitive movements were included in the playroom.

- Reduce flight behaviours

· Structures and fixtures were robust and firmly anchored, so that there was no need to interrupt the children's games with safety warnings or instructions from the caretakers. Areas were provided in which the children could demand two types of social interaction: a close tactile contact, and a rough and tumble play.

The experiment also involved several instructions given to the caretakers. The main instruction that was given was to avoid approaching the children as much as possible. The experiment resulted in seeing an increase in the number of social interactions between children.

The design criteria employed by Richer and Nicoll can be summarized into:
(1) Subdivision of spaces
(2) A controlled sensory experience in subdivided spaces
(3) Use of light dimmers to allow staff to control lighting within the room
(4) Inclusion of a retreat space
(5) Minimizing the intrusion of teachers or assistants as much as possible to leave the children to play as they will
(6) Safety and sturdiness of furniture and of fixtures
(7) Elements and materials that are durable

03. Christopher Beaver (2006)

Teresa Whitehurst (2006)

Christopher Beaver is an architect and senior partner in GA architects, specializing in special needs buildings and more particularly in the design of environments for children and adults with ASD or other learning difficulties. He explained his strategies when designing a Sunfield Residential Unit for 12 children with residence and education functions. Whitehurst, who is the researcher and developer at the Sunfield Research Institute, reported a research paper based on this project. Their design consideration and strategies can be summary as following:

(1) Circulation space
Corridor would be banished and turn into circulation space, which is a multi-functional space including storage, rest, and social activities.

(2) Colour
There are neutral colours, clamming colours, disturbing and stimulating colours, carefully choices must be made in common and private space. Provide opportunities for residential to choose the colour in a range.

(3) Curvilinear design
Curved walls help children to move through the building rather than sudden corners because they like to follow the curve.

(4) Noise reduction
Carpet on the floor will reduce the impact of foot traffic and will absorb sound. Rough wall will break up reflected sound waves and so reducing noise levels. It is recommended the usage of ceiling with sound-absorbent backings.

(5) Underground heating
The biggest advantage of under floor heating is that it does not need the radiator. A radiator would occupy the space also dangerous for children to climb.

(6) Ventilation
It is vital for residents to live in a building that has a freshness about it, windows on only one face never works well. High level windows which can only be opened and closed by staff are suggested. Additionally, Beaver mentioned the mechanical ventilation in bathrooms to avoid dripping after shower.

(7) Lighting
Flickering fluorescent lighting should be avoided as it could be disturbing to autism. Flexibility is important for lighting design and a dimmer or scene-setter would be achieve.

(8) Outdoor space

A secured outdoor playing area would be beneficial for children to generate a sense of independence. They can enjoy playing freely without interference of observation.

(9) Sensory suit

Sensory suit, opposite to multi-sensory room, is a flexible room to meet the need of students' performances and needs. All the room is white so it could transform from exciting environment to relaxing environment by sensory equipment.

(10) Communication

Carpet tiles were mounted on the frame outside the bedroom to put their names, photos on. In the dining room, symbols were put in a drawer for children to select the meal.

04. Magda Mostafa (2008; 2010; 2014a; 2014b; 2015; 2018)

In 2002, when the project "Advance Special Education Centre" was first started, a guideline for the autism non barrier building environment was needed to guide the architectural design, but at that time, no accessibility code that incorporates requirements were available. In response to this academic gap, Mostafa began to research on developing a preliminary framework of architectural design guidelines for autism. We divided her research into six phases through the publications of Mostafa:

① Information collection and intervention experiments

First, her research team determine the most influential building elements for children with autism through a questionnaire of first-hand caregivers of autistic children. Based on the findings, they design the intervention experiment to test the conclusive highest ranking architectural elements on autistic children in their school environment. The experiment was divided into a control and study group, the specific behavioural indicators were used to compare the performance of two group children, which determine whether the architectural elements influenced them.

② Sensory Design Matrix and ASPECTSS™ Design Index

By summarizing the results of the survey and experiment. Mostafa proposed a "Sensory Design Matrix" which matches architectural elements with autistic sensory issues and is used to generate suggested design guidelines, it was first published in 2008. Based on this study, the Mostafa developed the Autism ASPECTSS™ Design Index, which contains seven design principles for autism friendly building environments: Acoustics, Spatial sequencing, Escape, Compartmentalization, Transition spaces, Sensory zoning and Safety.

③ Application of ASPECTSS™ Design Index as a design guideline for home and school environments

Mostafa applied the ASPECTSS™ Design Index respectively in 2010 and 2014 to Charis Workhome for Autistic Adults in Rotterdam and Advance Centre for Special Needs in Cairo. According to the design principles, some detailed considerations were listed. The goal was to get an autistic and friendly living and learning environment.

④ Application of ASPECTSS™ Design Index as an evaluation tools for home and school environments

Mostafa applied the ASPECTSS™ Design Index into an evaluation tool to assess the level of autism friendly of the living environment and the learning environment. She did the following two evaluation tests:

2014， use ASPECTSS™ to evaluate 3 homes of Cairo families with autistic children.

2015， use ASPECTSS™ to evaluate 6 school which were purpose built for autism.

⑤ Post-Occupancy Evaluation

Based on the research experience of using ASPECTSS™ Design Index as an evaluation tool, the Post-Occupancy Evaluation was developed as a more comprehensive assessment method It includes the ASPECTSS™ scoring of the school through a survey of teachers and administrators; on-site behavioural and in-class observation; and interview with parents, teachers, staff and administrators. In 2018, Mostafa use POE tools to evaluate an existing pre-K-8th grade public school built for children with ASD. During assessment period, Mostafa's research team not only measured the level of autism friendly of the learning environment, but also proposed detail recommends based on the seven design principles, making the school environment more inclusive.

⑥ Future research

Mostafa's latest published article shows that the application of the Autism ASPECTSS™ Design Index as a design guideline for autism friendly building environment and as a basis for Post-Occupancy Evaluation is scalable and reproducible. The current research is only conducted to evaluate the lower grade teaching environment. In the future, it will be applied to the higher grade (9-12) teaching buildings, even gymnasium, cafeteria building, cultural arts pavilion, medical and research facility as well as an adult services building.

This shows that Mostafa's nearly 20-years-research has achieved irreplaceable results and greatly promoted the development of autism friendly building environments. Here we list the seven design principles in the ASPECTSS™ Design Index, which will be very helpful for our research:

(1) Acoustics

This criterion proposes that the acoustical environment be controlled to minimize background noise, echo and reverberation within spaces used by individuals with ASD. The level of such acoustical control should vary according to the level of focus required in the activity at hand within the space, as well as the skill level and the severity of the autism of its users. For example, a gym could handle a higher level of acoustics than a classroom.

(2) Spatial sequencing

This criterion is based on the idea of the affinity of individuals with autism to routine and predictability. The criteria require that spaces be organized in a logical order based on the typical schedule of such spaces. The organization of spaces should reflect the schedule of the students and how they move throughout the day. There should be minimal disruption between spaces.

(3) Escape spaces

Spaces need to be provided that offer respite for the autistic user from the overstimulation found in their environment. Such spaces may include a small partitioned area or crawl space in a quiet section of a room, or throughout a building in the form of quiet corners. These spaces should provide a neutral sensory environment with minimal stimulation that can be customized by the user to provide the necessary sensory input.

(4) Compartmentalization

There needs to be a limit to the sensory input within each space or environment. Each compartment should include a single and clearly defined function and consequent sensory quality. The sensory qualities of each space should be used to define its function and separate it from its neighbouring compartment.

(5) Transition zones

The presence of transition zones helps the user recalibrate their senses as they move from one level of stimulus to the next. Zones can take on a variety of forms from a distinct node that indicates a shift in circulation to a full sensory room that allows the user to re-calibrate.

(6) Sensory zoning

Spaces should be organized in accordance with their sensory quality rather than their programmatic function, which is typical in architectural design. Grouping spaces according to their allowable stimulus level, spaces are organized into zones of high-stimulus and low stimulus.

(7) Safety

Safety is more of a concern for children with autism than their neurotypical peers, since those with autism may have an altered sense of their environment and could easily injure themselves by running into walls to falling downstairs.

05. Rachna Khare & Abir Mullick (2008a&b; 2009a&b; 2014)

The research of Khare and Mullick is carried out based on the belief that 'Performance of pupils with autism is enhanced in appropriate physical environment'. The goal is to identify the enabling aspects of educational environments, measure their effects on educational performance and develop design guidelines that will lead to the development of effective educational spaces for autistic children.

① Literature review

The study began with literature review, interviews with experts and on-site surveys to understand the educational needs of children with autism. Finally, two authors sum up 18 designs criteria which have strong connections with autism. Three test tools were subsequently developed to evaluate these parameters, include Environmental Assessment (EA), Performance Measure for Pupil with Autism (PMPA) and Design Parameter Rating Scale (DPRS).

② Establishing relation between environment and children's needs

The Environmental Assessment is based on a study of 18 autism friendly environmental design parameters, and the presence of these parameters is expected to improve student performance. The results of EA and PMPA are used to verify the relationship between the environment and children's educational performance. The authors used these two tools to evaluate the educational environment in the United States and India, including elementary, middle, and high schools, and the results showed a strong correlation between the built environment and educational performance of students.

③ Collecting suggestion from experts

Design Parameter Rating Scale (DPRS) is used to gather information from experts and teachers about the autism friendly environment. Teachers were asked to review the eighteen environmental design parameters and rate them for their importance in education and development according to their past experiences and future expectations. The authors used the DPRS to collect suggestions from 18 autism experts and 14 regular education experts, both of whom highly recommended these design parameters, which verify that these design parameters are not only beneficial for children with autism, but also helpful for improving the performance of all students at school.

Until now, Khare and Mullick have verified the validity of design parameters through developed evaluation tools, and the next phase of their research is to develop guidelines for autism friendly building environment according to pervious study. Although the research results have not been published, but the research process and methodology are remarkable, we believe that these 18 validated design parameters will be great helpful to this article, we will list them here:

(1) Provide physical structure
Organize physical environment through clear physical and visual boundaries to establish context of activity associated with a physical space.

(2) Maximize visual structure
Organize visual environment through concrete visual cues and visual importance by incorporating colour coding, numbers, symbols, labelling, illuminated sign boards, highlighters etc.

(3) Provide visual instruction
Give sequence of steps to follow an activity (in the spaces where activities are to be performed) in the form of written instructions, pictures, visual schedules etc.

(4) Opportunities for community participation
Involve pupils in the community activities in every day works such as shopping or using public transport.

(5) Opportunities for parent participation
Involve parent in school activities to address pupil's individual educational needs.

(6) Opportunities for inclusion
Present an environment to the children with autism to interact with able bodied peers.

(7) Maximize future independence
Provide environment for learning life skills and vocational skills that makes them independent in future.

(8) Generous space standards
Help pupil with autism to deal with social demands as they are sensitive to loss of personal space and threatened by crowding.

(9) Provide withdrawal spaces
Quiet areas that allow pupils with autism to withdraw to avoid unnecessary stress and anxiety in socially demanding spaces.

(10) Maximize safety
Minimize threats to pupil due to their own condition, unawareness or any disaster.

(11) Maximize comprehension
Clear layout, direct routes, clear zoning, simple forms, and no visual clutter assist pupil with autism to perceive the school environment easily.

(12) Maximizing accessibility

Poor coordination and balance, epilepsy, poor attention span in autism may require building to be made physically accessible.

(13) Provide assistance

Space needed to help pupil doing learning activities in classroom, toilet, dining areas and others

(14) Maximize durability and maintenance

Durability and maintenance of equipment, hardware, furnishing, fitting, furniture etc from damage and misuse by pupil.

(15) Minimize sensory distractions

Least distracting settings that are away from any visual, auditory, tactile distractions.

(16) Provide sensory integration

Include multisensory stimulations in the environment like opportunities for rolling, jumping, spinning, vibrations, music, different visual experiences etc.

(17) Provide flexibility

Relating to broad spectrum of functional skills and diverse teaching models.

(18) Provide monitoring for assessment and planning

Monitoring pupil with minimal distraction for assessment, safety, and activity planning.

06. Simon Humphreys (2008)

Humphreys creates a variety of design criteria which are to be considered in deigning building for autistic individuals. He suggests:

(1) Clam order and simplicity
The author suggests trying to maintain a stable, ordered secure environment for that the autistic child simply cannot function if there are too many daily changes, and rhythm, routine, sequence, ease of use should be taken into consideration.

(2) Minimal details
It is better to limit complexity of detail because of the fact they have difficulties filtering foreground and background information and they are often capable of perceiving details that are unnoticed by others.

(3) Proportions
The author suggests trying to confer harmonious proportions (gold proportion) on buildings and spaces designed for people with autism.

(4) Natural light
An extensive use of natural light is important, but dazzling sun, deep shadows or excessive contrast produce visual overstimulation. Skylights and clerestory windows can help in getting diffuse lighting.

(5) Proxemics
Proxemics is the measure of personal space surrounding the personal body. Autistic individuals they may need more space for social relationships

(6) Containment
It infers the places to escape from immediate demands which are safe within the enclosure.

(7) Observation
This will fulfil the need of supervision, try to create spaces both inside and outside that allow for the above, but also provide staff with the knowledge that it is safe and secure and allow discreet observation.

(8) Acoustics
People with ASD often have to make an enormous effort to differentiate sounds and are more sensitive than other people to noises.

We complement his design criteria according his other work in the following years. He also emphasized:

(9) Distinction

There is distinction between spaces for work and leisure and living. It is helpful that there is distinction between types of spaces for people with autism so that they understand expectations placed upon them.

(10) Materials:

Materials should have limit number and they are durable, of good sound qualities. Natural materials are also nice for them to touch and smell.

(11) Flexibility

Every individual is different. It is important that spaces are as flexible as possible within the need to maintain sameness.

07. Claire Vogel (2008)

In 2008, Claire Vogel summarized eight design standards according the distinct needs of individuals with ASD. The information is collected by people who most directly affected by autism --- parents, teachers, and therapists, as well as college students and adults with autism. These standards are primarily intended for educational facilities, but they can be applied to bedrooms, family rooms, play spaces and other places.

The following are eight design standards and solutions:

(1) Flexible and adaptable
Flexibility, which can also be thought of as adjustability or adaptability. As to the people with ASD, flexibility will not mean constant change, but rather being able to transform an environment on a moment's notice. Rolling shelving units and furniture pieces that are easy to move are suggested.

(2) Non-threatening
For a physical space to be non-threatening, it is vital that settings should provide restful, restorative places and offer a sense of security and the layout should be welcoming. For example, using elements that are soft and can provide sensory input, such as beanbag chairs, stuffed couches, carpeting, swings, clay, and water.

(3) Non-distracting
A non-distracting room will decrease sensory overload as much as possible---free of clutter, relatively odour-free, and visually and aurally restorative.

(4) Predictable
Predictability is key, particularly for children with ASD who need consistency and visual cuing. Designers can offer multiple sensory cues because individuals with autism often have trouble multi-tasking.

(5) Controllable
When a child can understand his or her environment, emotional security can rise and the child feels an increased sense of control. From the point of space, the individuals feel more comfortable and in control when they have a transition zone between private and public spaces.

(6) Sensory motor attuned
Children tend to have puzzling sensory integration needs and challenges, often ignoring their visual environment. They may need help in directing their attention to sensory information that will allow them to interact more effectively. Sensory-motor needs can fluctuate with age, from person to person, and from day to day in the same child, making it important to plan and fine-tune an environment that is most suitable.

(7) Safe

Designers and teachers need to pay attention to both physical hazards (wiring, open stairways, unscreened windows, loose flooring, toxic paints, etc.) and emotional safety and security.

(8) Non-institutional

Feeling truly at home in their surroundings will allow children to relax and retain more information. Classrooms designed with softer lighting and home furnishings are recommended.

08. Sherry Ahrentzen & Kimberly Steele (2009)

Sherry Ahrentzen is the professor of Housing Studies at the University of Florida. She has co-authored a book with Kim Steele on designing housing for adults with autism. In 2009, they formulated evidence-based design goals and guidelines to direst future housing design and development. The design guidelines based on case study research into current housing models for autism and other development disabilities as well as extensive research in therapeutic interventions for autism and sciences that address autism and environment.

(1) Neighbourhood
Select a site with convenient transport, well-established public facilities and consider the potential for residents to be integrated into community.

(2) Floor plan strategies
Smooth transitions should be needed between rooms and users. Separate high stimulus with low-input transition zones and every residence should include escape space for activity free and calming.

(3) Technology
Technology should be easy to use and maintain, protected and unobtrusive.

(4) Visual cues
Minimize visual distraction elements instead to employ visual signs to assist with the safe use of features.

(5) Ventilation
Good ventilation reduces the smell that have a negative impact in the room. There should be operable windows in the living area, especially in the bathroom and kitchen silent duct exhaust fans should be used.

(6) Lighting
Choose an anti-glare surface, a flicker-free bulb, and natural light controlled by blinds or other obstructions. Natural light would be available in every room.

(7) Material
Choose materials that create a warm family environment rather than creating an institutional atmosphere. A soft colour would be better than a bright, primary colour. Choose safe, durable materials and install nonslip flooring in the bathroom and kitchen.

(8) Acoustic
Increase the sound-proofing insulation in ceiling and walls, choose quiet system to minimize ambient noise.

(9) Appliances and fixtures
Durable, quiet, easy-to-use appliances and equipment are important for people with autism.

Published literature review of Autism-friendly built environments

09. Iain Scott (2009)

His paper examines the existing body of knowledge to ascertain what relevant criteria exist with respect to designing for autism. This includes published statutory guidance, books, research publications, journal articles, feasibility studies, web-based and anecdotal information, such as Building Bulletin 77, Building Bulletin 95, Designing for Special Needs(Harker and King, 2002), Whitehurst (2006), Humphreys (2008) and so on. In the end, Scott summed up nine design indicators related to the autism friendly building environment:

(1) To create an ordered and comprehensible spatial structure.
(2) To generate a mix of small and large spaces.
(3) To provide the user with more control over environmental conditions.
(4) To accommodate different teaching strategies for pupils with autism.
(5) To achieve a balance between safety and independence.
(6) To reduce and simplify detailing.
(7) To grant the user active participation in the brief building and design process.
(8) To appropriately use technology to aid the learning experience of pupils with autism.
(9) To provide adequate technical specification.

10. Pilar Arnaiz Sánchez et al. (2010)

The authors made a systematic literature review of publications and research on design criteria relative to individuals with ASD. The criteria focus on different spaces, including residential project, classroom, and other type of design projects. They extracted valid approaches and summarized the strategies purposed by scholars and researchers who listed as follows:

Richer & Nicoll (1971), Khare & Mullick (2008; 2009), Humphreys (2008), Beaver (2003;2006;2010), Mostafa (2008), Ahrentzen & Steele (2009), Scott (2009). The authors grouped these strategies according to different impairments for the purpose of systematizing their discourse

(1) Imagination
Resistance to changes and a limited ability to imagine are, two of the most common symptoms present on individuals with ASD. From the architectural design point of view, we need to provide the building with a clear structure, along with elements that endow it with certain order and unity, in such a way that it becomes easily readable, predictable, imaginable. Regarding transitions between spaces, anxiety may be reduced. It is recommended to create intermediate transitional threshold spaces where the necessary anticipation can be achieved.

(2) Communication
The individuals with ASD always have impairments in verbal and non-verbal communication, in conjunction with difficulties in information processing so that they need visual support to communication. The built environment should be able to accommodate these forms of communication, planning their right location and integration. the use of coding elements with colours is a good example. It is also of importance that the visual background be as neutral as possible. An effort must be put on decluttering the environment, removing superfluous elements, minimizing detailing, and employing reduced non-vivid chromatic ranges.

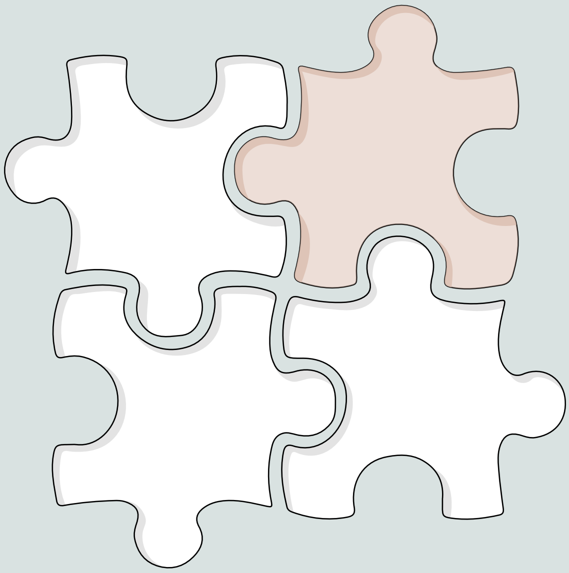
(3) Social interaction
Impairments in social interaction are present in individuals with ASD.it will be necessary to provide ample spaces to allow and even favour those interactions and a small space where to retire and escape

(4) Sensory difficulties

Difficulties in the reception or processing of sensory stimuli is also a frequent symptom of ASD. Consideration towards this issue will lead us to carefully select colours, textures, pattern, acoustic properties of the different materials and constructive elements, lighting(trying to achieve a diffuse, preferably natural, illumination, avoid flickering and buzzing) fixtures; heat, ventilation and air conditioning (reducing gradients of temperature and limiting noises and vibrations).

(5) Behaviour and safety

Behavioural problem is frequent in cases of ASD. We need consider bathroom equipment, lighting fixtures and mechanisms, hardware, banisters, wall and floor tiles, etc. They must be well anchored.



3. Design for Autism

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3.1 The challenges faced by autistic people

The main challenges that people with autism face are related to sensory processing disorders, everyday social communication, interaction with others, and repetitive behaviours. In general, they have unusually delicate sensory systems, sensory issues affect one or more of the senses and they can be either over-developed (hyper-sensitive) or under-developed (hypo-sensitive), both can have an impact on how people experience different environments, and their behaviour, reaction and eventually have a profound effect on a person's life. Some autistic people are highly sensitive to the surrounding environments, meaning that their senses (sight, hearing, touch, smell, and taste) can all be easily overloaded, of course, the degree of sensitivity varies according to the development of the individual's physical sensory system.

How space feels, sounds, looks, smells, and functions can be incredibly influential on how people with autism experience the world. Imagine yourself as one of this vulnerable group, when you are taking the test in the classroom and it is difficult for you to ignore various senses information around you. Not only the whistle of vehicles outside the window and the huge noise from the lawnmower can be heard clearly, but you can also even hear the humming sound of light bulb sounds like construction workers keep drilling cement. You cannot bear the smell of perfume on the proctor's teacher, the glare caused by the reflection of light on the shiny waxed floors. Under these sensory inputs, you start to become headaches, have blurred vision, your skin suddenly itches. These physical discomforts make your thoughts begin swimming around the head and prevent you from continuing to take the test in this environment. Sensory interference is magnified beyond normal comprehension by autistic people.

3.2 The gap between research and users need

Individuals with disabilities are one of the most disadvantaged groups in society, the legislation of government and institutions are keeping seeking strategies to protect the rights of persons with disabilities. As more people are identified as autistic, the needs of facilities to educate and treat them, their parents, and teachers, as well as therapists are increasing continuously. Apart from education, people with autism, like everyone, need to use the service available in all types of buildings. The current design of the built environment takes into consideration various accessible facilities for people with disabilities, such as ramps and handrails for wheelchair users, Braille and broadcasting systems for the visually impaired, and other services that can benefit disabled people. There is a lack of awareness of architects about how the built environment can affect people with autism and the project teams are often unaware of involving related specialists in the design process. And the design guideline and standards are limited, architects and engineers can hardly find codes of an inclusive environment that fits ASD users' needs to follow. However, contemporary society should be inclusive, autistic people have the same right to use functional spaces on an equal and barrier-free basis, just like non-ASD. How to achieve an autism-friendly built environment should be the goal pursued by architects and researchers now and in the coming future.

3.3 Research focus --- Hospitals

Architecture deals with the manipulation of the physical environment to provide comfortable space for daily activities, both fitting the needs of users and conveying messages to them. Sensory elements contained in the environment play an important role in autistic behaviours and their cognition and sensory integration. People with autism, as a group with sensory impairment, the inappropriate design of the built environment prevents them from using the services provided in the building successfully, they may even suffer physical harm because of it. When it comes to the hospital, the contradiction appears more severe.

As a healthcare-related building, it is necessary to provide an interior space that is accessible to all types of users. But autism-friendly design considerations are hardly included in existing architectural official design guidelines of hospital. Studies have been proved that people with ASD are likely to incur an injury and have medical treatment more frequent. Part of the reason is that disruptive behaviours, such as self-injury behaviours are common among people with ASD and easily cause physical harm to themselves, which make people with autism usually have a more urgent need of medical care service. However, the hospital visits are undoubtedly stressful for some individuals with ASD. The hospital experience for ASD patients, their caregivers, and healthcare provider is multifaceted and complex, with many high stimuli (Figure 3.1). The combination of the presenting complaints and the complex traits and medical disorders associated with ASD can bring problems during the hospital visit.

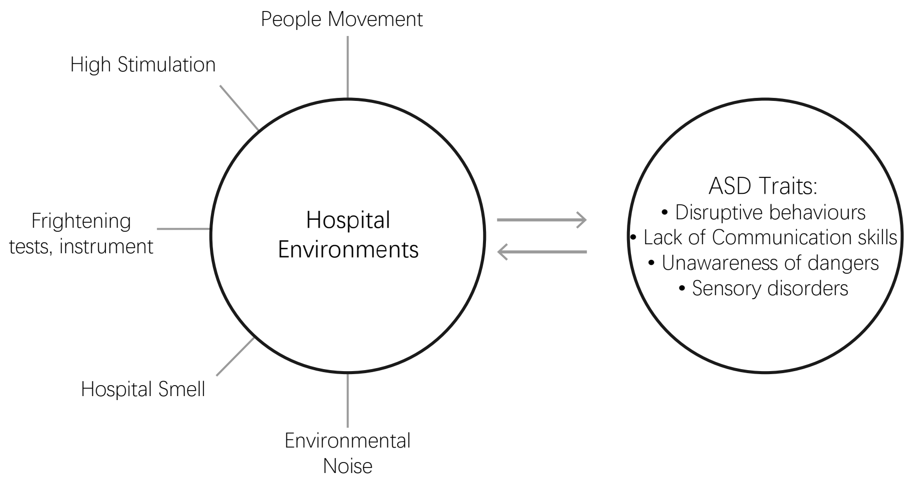


Figure 3.1 Hospital environment and features of autism

3.4 Research objectives

The first part of this paper research on the impact of built environment elements on the well-being and daily activities for people with autism. The results of it will be applied to the medical environment then a series of autism-friendly architectural design considerations and strategies for different spaces in the hospital can be proposed. The ultimate purpose of is to define a tool which can be used to guide the design of hospital by architects and interior designers, can be used to evaluate the degree of accessibility of hospital space to ASD users as well.

3.5 Methodology

Research on Autism

The study starts with the knowledge of autism, understands the impacts of their characteristics, common symptoms and individual differences in daily life and activities. The resultant from the study shows that contradictions appear in sensory elements that are generally involved in the built environment, but ASD suffers usually have problems with receiving and processing sensory information. The accumulation of knowledge paves the way for future research.

Relationship between autism and built environment

With the increasing attention of people with autism by society, more and more scholars have committed to the research the relationship between autism and the built environment, and related research and publications have been increasing, especially in the past 20 years. The scholars proposed architectural design guidelines for autistic users based on their experimental research or design experience.

A literature review is carried out to know the theory of autism and the built environment proposed by these authors while a case study is conducted in the meantime. From buildings designed for people with autism, we learned how to apply theory to the architectural environment. The case study involves educational buildings, residences, and medical centres. Because the child-friendly environment and warm atmosphere of the children's hospital can provide useful information for this research, we also collect some information about the design of children's hospitals. From these publications and cases, we learn about the architectural characteristics required by autistic users, the elements that influence the daily activities of autism and a range of design considerations.

The development of a prototype tool

Based on the accumulated knowledge of the research, we conclude the needs of ASD users and key points of the design considerations in different spaces. These principles can be summarized into a set of common requirements, which contribute to the autism-friendly environment. These requirements can include architectural and technological factors that have impact on ASD users. It is a prototype of the evaluation tool in the universal built environment. It can be used as a basis for the development of the tool in the hospital.

The application of prototype in hospital

Firstly, the requirements of the hospital environment are collected from a series of official documents that are widely used in Europe. Among the design guide, there may be some conflicts between the needs of ASD users and hospital requirements, which may cause sensory disturbances to people, will be discussed. These conflicting points will be resolved as much as possible in the following research. By applying the prototype tool in hospitals, we explore how to improve the performance of built environments for ASD users, aiming at proposing a range of autism-friendly design considerations and strategies. The research results can evolve to be the design guidelines of ASD-friendly hospitals. Meanwhile, it can be used as an evaluation tool to assess the degree of autism-friendliness of different hospitals.

Research on the requirements of ASD users

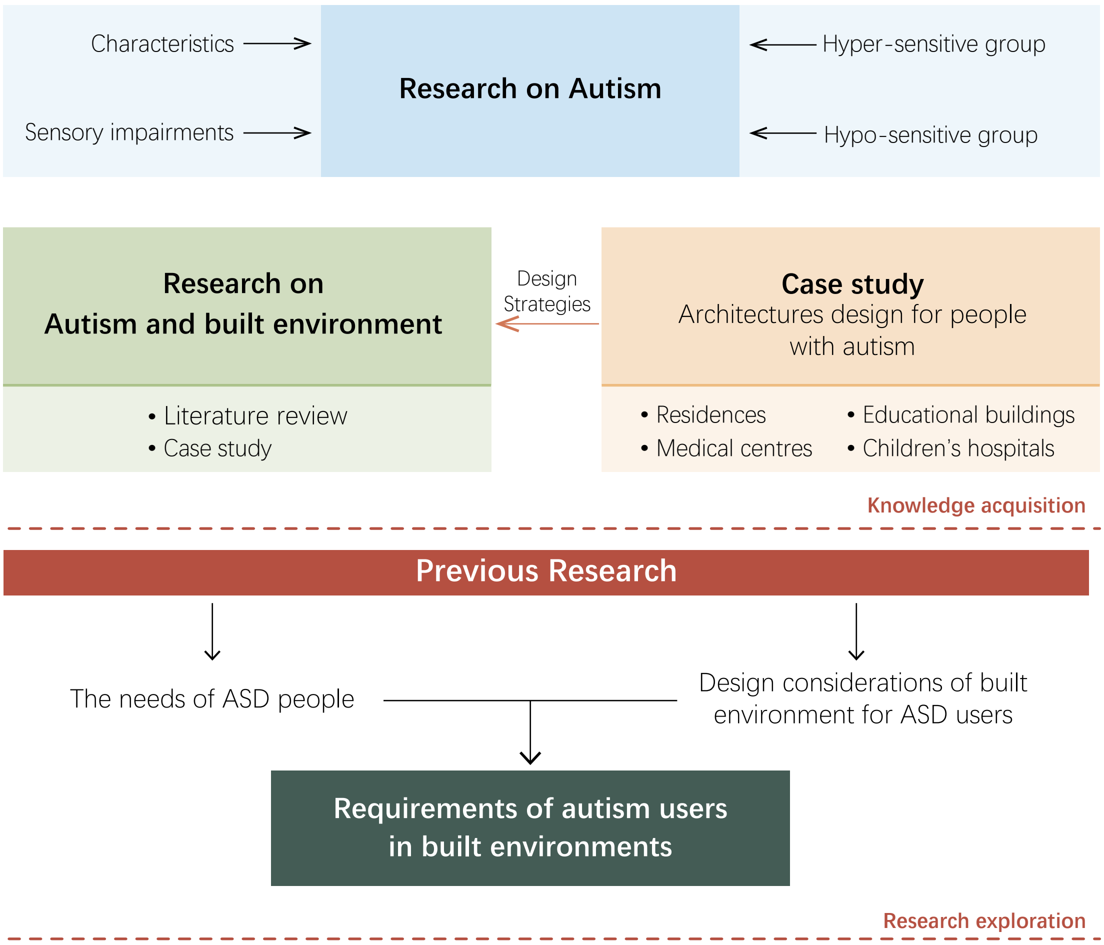


Figure 3.2 Research framework of the relationship between autism and built environment

The application of prototype in hospital environment

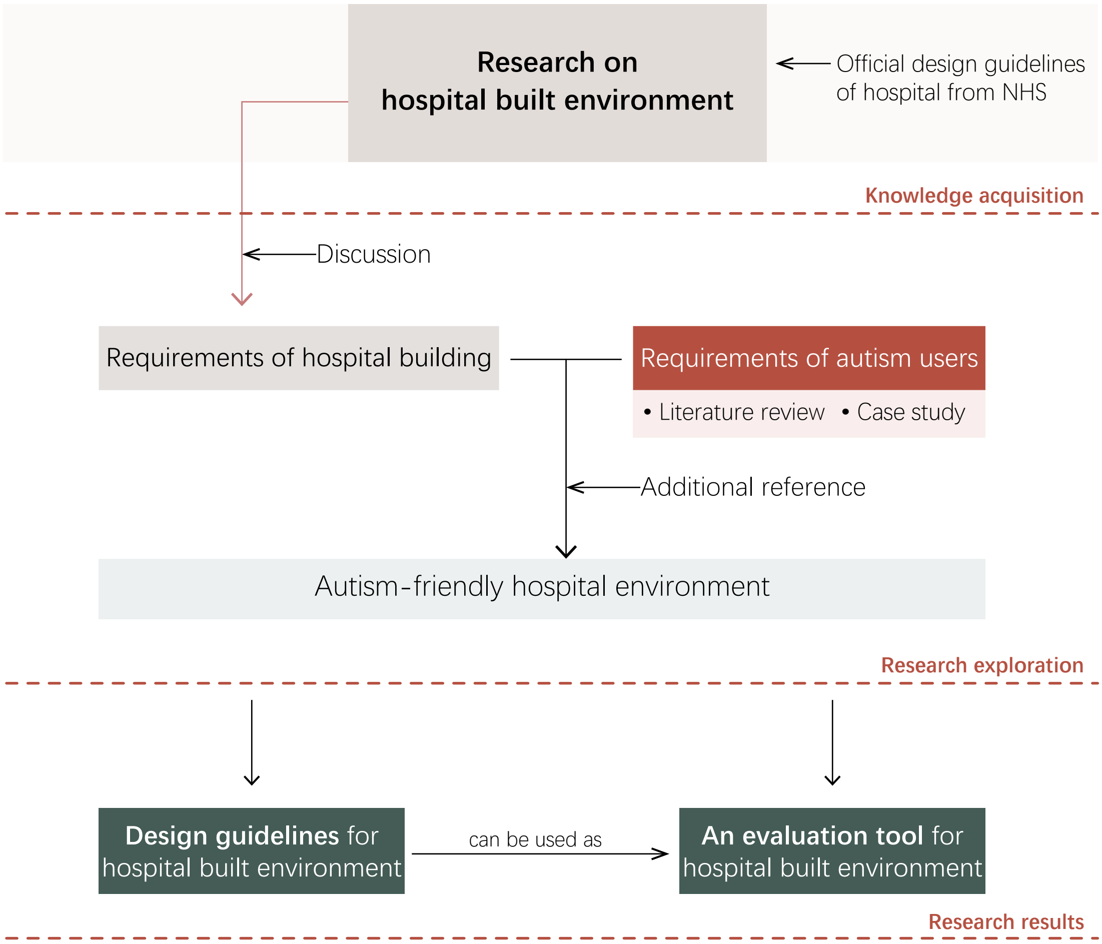
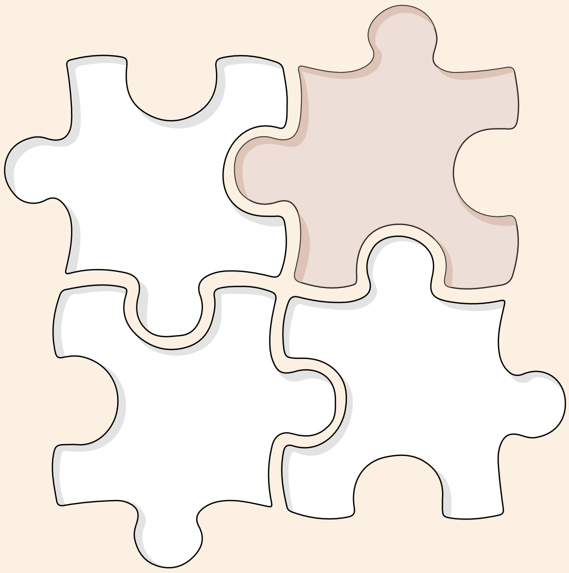


Figure 3.3 Research framework of focus area



4. Case Study:

Autism-friendly Architecture

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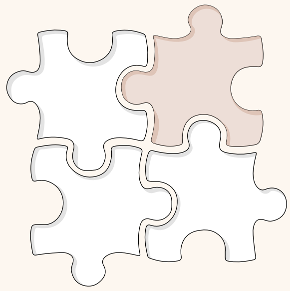


4.1 Architectures designed for people with autism

Introduction

This chapter presents in detail the cases about buildings for people with autism and other reference buildings, which may serve as useful advice for the hospital environment for the people with autism in the next chapter.

This chapter consists of two main sections, the architecture design for people with autism and the children's hospital. For the architecture designed specifically for children and adults with autism section, we classify the buildings as the educational environment, residential environment, and therapeutic environment. For the children's hospitals, some of them have an autism department or a therapy room specific for the patient with autism, which closes to the aim of this thesis. Other children's hospitals for neurotypical we chose because there are valuable aspects that enlighten the environment design such as wayfinding system and safety. Sometimes the overall hospital environment may be too stimulating for autistic patients like numerous bright colours.

For each case study, we have a brief introduction about the background information such as the architect, location, project year, user and a general description for the whole project. Following the valuable factors for creating an autism-friendly environment would be highlighted and explain them in detail with photographs and diagrams.

The full case study summaries are presented at the end. A large amount of information is contained in the summaries. In order to assist with comparing among the various studies, tabular summaries of relevant details are presented at the end of the summaries section.

4.1.1 Several autism-friendly buildings designed by 'Ga Architects'

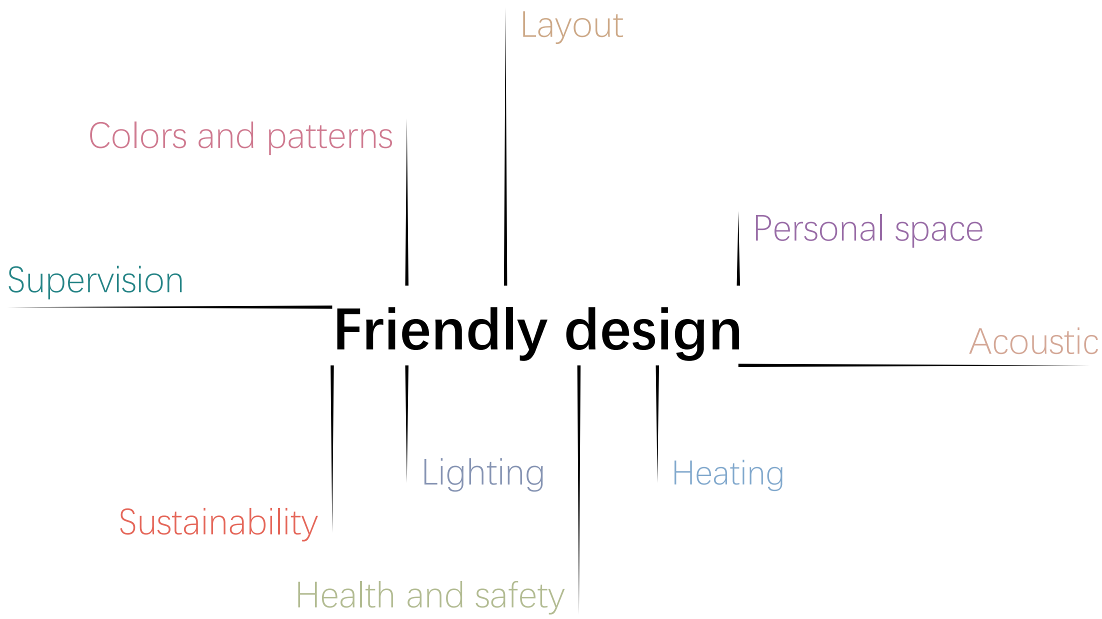


Figure 4.1 Friendly design guideline
(Source: www.autism-architects.com)

Autism-friendly design guidelines of 'Ga Architects'

(1). Layout

① No corridors.
② Create a circulation space with areas for seating, socializing or sitting alone.
③ Simple way-finding.
④ Curved walls add humanizing effect and eliminate harsh corners.

(2). Colours and patterns

① Choose low arousal interiors.
② No complicated or fussy patterns.
③ Avoid colours as red and orange.
④ No highly reflective surface.

(3). Acoustic

① A sense of calm is essential.

② Noise will result in anxiety.

(4). Health and safety

① Good natural light and ventilation.

② Reduce glare with integral blinds.

③ Reduce jumping and running opportunities.

④ Secure windows with restricted opening

(5). Lighting

① Avoid harsh and flickering fluorescent lighting.

② Choose lighting with an indirect source where possible.

③ Dimming controls will provide the opportunity to change the "mood" and offer choice of lighting intensity.

(6). Heating, choosing underfloor or ceiling heating

① Eliminate radiators.

② Reduce jumping and "posting" opportunities.

③ Provide an even and controllable heat zone by zone.

(7). Personal space

① Adequate personal space will reduce anxiety from being forces too close to others.

② Avoid crowded spaces with no choice to "escape".

(8). Supervision

① Individuals are more content when they are free to express themselves without being under constant supervision.

② Good planning can contribute to unobtrusive supervision.

(9). Sustainability

① Low Carbon refurbishment.

② Reduce energy demand.

③ Natural light.

④ Indoor air quality and ventilation.

⑤ Temperature and relative humidity.

⑥ Machinery and equipment.

Sunfield Residential Unit

Architect: Ga Architects
Location: Stourbridge West Midlands
Project year: 2012
User: Children with autism

Description: A new building for 12 children with profound ASD, comprising single bedrooms, bathrooms, living, dining and kitchen facilities, commercial laundry and sensory room. A creative design of the circulation space and living accommodation combined with a sense of home from home for residents provided the building as a model for good practice to visiting care providers.

Figure 4.2 Overview of Sunfield Residential Unit
(Source: Ga Architects)

Figure 4.3 Interior of single bedroom

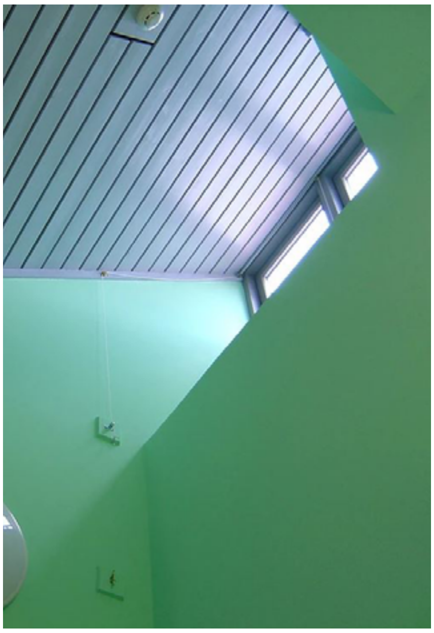


Figure 4.4 Above eye-level window

Acland Burghley School

Architect: Ga architects
Location: Burghley Road, London, UK
Project year: 2018
User: Children aged 3 to 5 with special needs

Description: This is a mainstream school in the London Borough of Camden that required to be refurbished for children with special needs including autism spectrum. This was a conversion within the existing hall to provide nursery, offices for social workers and new occupational therapy facilities as well as ancillary service. The building has been designed to provide an autism-friendly environment based on our specialist knowledge and experience in this field.

Highlights:

(1). Ceiling heating system with lighting

A dominant feature in the project is the radiant panel ceiling heating which has been incorporated into the lighting concept.

(2). Weakness

An existing and very run-down space was designated for the project which had to be mechanical ventilated due to the proximity of the site to the school playground that meant the windows could not be opened.

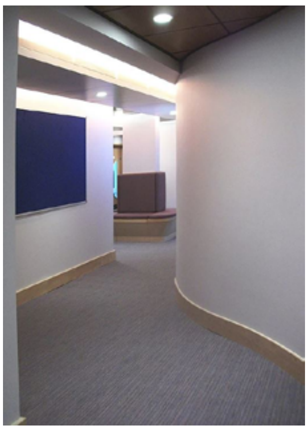


Figure 4.5 Curved wall and avoid long corridor.

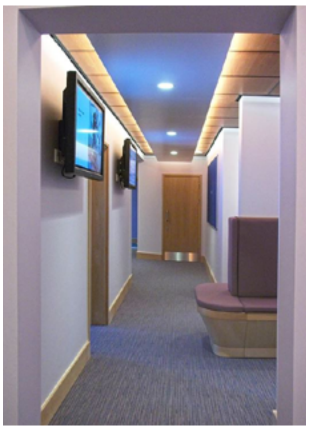


Figure 4.6 Corridor is broken up with seating area.

Figure 4.7 Visual connection between different area.

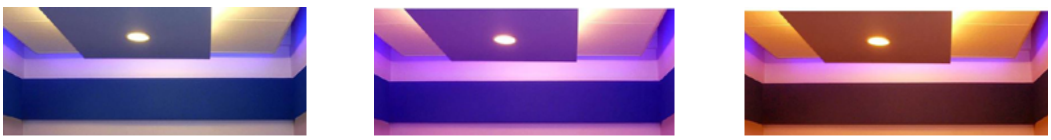


Figure 4.8 The changeable and indirect lighting

Phoenix SEN Primary and Secondary School

Architect: Ga Architects
Location: Tower Hamlets London
Project year: 2009

Description: Project include the refurbishment of parts of the school to make more autism friendly. This included a classroom to provide teaching kitchens and life skills facilities. Also refurbishment of the dining hall to provide arts laboratory for dancing and experimental theatre. There was also an assessment of classrooms to advise on work needed to achieve a good standard of teaching environment in regard to acoustics.

Figure 4.9 Refurbished kitchen

Figure 4.10 Arts laboratory

Autistic Children Residential Building

Architects: Ga architects
Location: Langley Mill Nottingham
Project year: 2010

Description: New building for six adults with ASD comprising single bedrooms with en-suite bathrooms, living, dining and kitchen facilities, commercial laundry and sensory room.

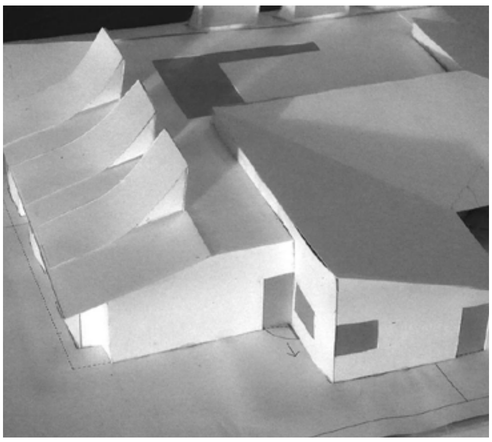


Figure 4.11 Physical model of project

Figure 4.12 Ground floor plan

4.1.2 Educational buildings

Advance School for Developing Skills of Special Needs Children

Architects: Magda Mostafa

Location: Qattameya, Cairo

Area: 4200 m^2

Project year: 2013

Description: The Advance School for Developing Skills of Special Needs Children in Qattameya, Cairo, is the first building worldwide to be designed using the Sensory Design Theory and its consequent Autism “ASPECTSS” Design Index.

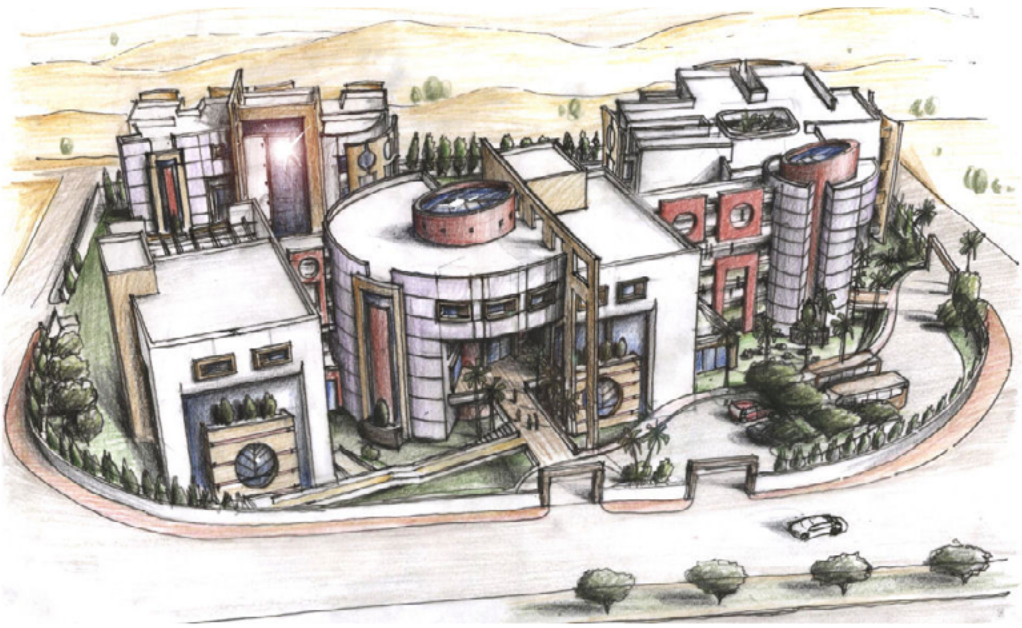


Figure 4.13 View of the overall organization of building (Source: Mostafa)

1. About autism ASPECTSS ™ design index

After interviewing people with autism, parents and teachers, and testing potential designs in a school environment, Mostafa created the Autism ASPECTSS ™ Design Index, which outlines seven architectural design criteria that allow individuals with autism to focus better and improve their skills. These groundbreaking guidelines have been applied to the design of schools like the Advance School for Developing Skills of Special Needs Children in Qattameya, Cairo. To create these guidelines, Mostafa had to truly understand the perspective of an individual with autism.

Mostafa said: “Imagine that every noise, every colour, ever texture, every smell, every detail is multiplied and amplified in your environment and how difficult it would be to focus on learning anything in that kind of environment……When you design a school or a building for someone with autism, the basic principle is to minimize and control the sensory environment as much as possible. You need to take away all that sensory overload and minimize everything that is unnecessary.”

2. Application of autism ASPECTSS ™ design index

2.1 Whole school issue

(1). Context and Community

① Facilities such as the commercial outlets proposed create an opportunity for student interaction with society. This helps develop social and vocational skills in the students as well as promote a positive productive image of autism to the community at large.

② As with all student areas throughout the centre, these outlets are kept visually simple to reduce student's over-stimulation.

③ Storage areas, display areas, workspaces and customer areas are kept visually and spatially separated and organized.

④ Natural lighting and natural ventilation is used as much as possible.

⑤ Noise exposure is kept to a minimum in "high focus" areas such as computer stations in the business centre or accounting stations in the other outlets.

⑥ The functions that are provided in the assembly hall can also be utilized to encourage inclusion. These functions may include, but are not necessarily exclusive to: awareness campaigns, parent home program training sessions, parent support groups, teacher training seminars, school organized shows and school assemblies.

(2). Zoning

① Designing for a group of students with the sensory challenges found predominantly in those with autism, the organization of functions with respect to one another is of great importance.

② Autistic user identifies with the architectural environment around him or her in accordance to sensory zoning rather than conventional functional zoning (Figures 2).

Sensory zoning and circulation schemes

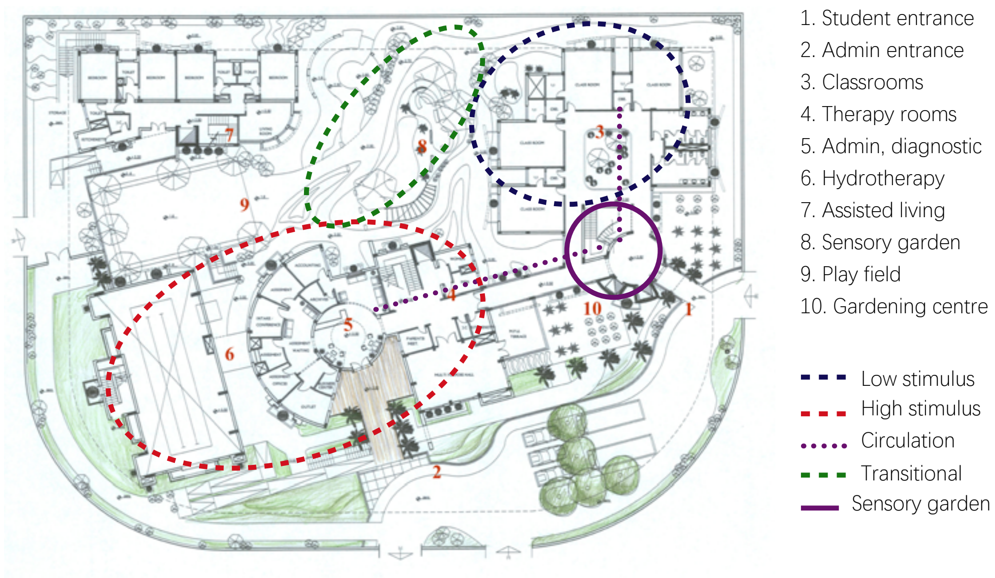


Figure 4.14 Entry level plan and sensory zoning (Source: Mostafa)

③ High-stimulus functions like music, art, crafts and psychomotor therapy, requiring a high level of alertness can be grouped together.
④ Low- stimulus functions or "high focus" areas like speech therapy, one to one instruction and general classrooms, requiring a high level of concentration, can be grouped together.
⑤ Services, which are usually high-stimulus, including bathrooms, kitchens, staff-rooms and administration, should be separated from the student areas.
⑥ Buffer areas such as gardens, free-play, sensory curriculum rooms and some other open spaces may act as transitional areas between the low-stimulus "focus" zones and the high-stimulus "alertness" zones.

(3). Way-finding, Navigation, Circulation and Spatial Sequencing

① A "one-way" circulation scheme that builds on the special needs user's affinity to routine is employed throughout this building.
② Creating a transition zone between the two sensory zones.
③ Visual aids such as colour and pattern are employed in circulation areas to assist way finding. This is done discreetly to avoid visual over-stimulation.
④ For guidepost, using pictures as well as written language. These types of signs can be included in all area where children can see and read.
⑤ Various colours and themed symbols are used to indicate different functions in the school.
⑥ Various textured materials are also used to indicate circulation areas, changes in levels and for the creation of interesting sensory experiences, particularly in outdoor learning environments.

2.2 Learning Space

(1). General Classroom Design

① Creating an internal, contained, open-air space that can fulfill various functions.
② The classrooms themselves are designed acoustically to reduce external noise permeation as well as internal echoes.
③ With a concept similar to that of sensory zoning, the classroom is designed in a compartmentalized fashion. Each function or activity is allocated to a "station" which can be physically and visually separated from the remainder of the classroom by low partitions, levels or different flooring materials and colours. These stations are organized throughout the classroom according to their sensory requirements with high focus functions like fine motor skills, matching, sorting and academics located in well-lit areas allowing alertness without distraction.
④ Natural lighting is introduced with above eye-level window to allow indirect sunlight in without visual distractions. Optimally these windows are north facing to avoid glare and direct light.
⑤ For each activity an optimum and distinct furniture and equipment layout is used consistently.
⑥ Open areas for floor play are also included as well as provisions for group work.

Resources are to be organized so that they are readily available without being highly visually accessible to avoid distractions to the child. Closed storage cupboards or open shelving with neutral boxes are ideal.

⑦"Escape space" is located in the lowest stimulus area of the classroom. It is a small partitioned area where a child may seek refuge whenever over-stimulated or overwhelmed. This space is intimate and partially enclosed to limit the sensory environment, like a small "Snoezelen" sensory curriculum room.

⑧ Joint observation rooms are made available directly adjacent to the classrooms. These are small rooms with one-way mirrored windows looking directly into the classes, with a/v equipment for taping sessions. These can be used as part of teacher training courses as well as parent awareness and home program training.

(2). Specialized Therapy Spaces

① The centre provides various specialized spaces for speech, occupational, psychomotor therapy etc..All these spaces, with the exception of speech therapy, are considered the high stimulus functions and should be grouped accordingly in that sensory zone.

② Each function is kept acoustically separated from the others using high quality wall systems.

③ Lighting is natural and indirect, from a source above eye-level to avoid visual distraction.

④ Fluorescent lighting, which emits a low hum and flickers, is avoided.

⑤ Shared resource and preparation areas, as well as observation rooms are also provided.

⑥ As an activity, each of these therapies has different characteristics and hence requires a different quality of space.

⑦ The enclosed swimming pool and hydrotherapy are located at the farthest possible location from the classrooms and the low-stimulus zone. Being a high-stimulus function, this essential activity needs to be housed in an enclosure that minimizes acoustical disturbances such as echoes, whilst being safe and hygienic.

⑧ The speech therapy rooms should be located as part of the low-stimulus zone. To avoid a "greenhouse" effect a group of rooms with various levels of soundproofing are provided.

(3). Outdoor Learning Spaces

① The small outdoor classroom courtyards may help create the opportunity for small-group social interactions between students. In a similar manner the larger playground area may allow for larger scale interactions.

② The architectural role of the outdoor learning space as a transitional zone. This zone is essential to the success of the sensory zoning concept in that it allows the sensory recalibration of the student. When moving, for example, from a high stimulus function such as music and movement therapy in the high stimulus zone, to a low-stimulus high focus activity such as communication therapy the student can pass through the outdoor area and be allowed a few minutes to perform a sensory readjustment to prepare for the upcoming task.

③ A sensory garden comprised of textured pathways, water-play, ball pools, sand pits and an aromatherapy herbal garden is the core of this space.

④ Water features may also be used to mask background noise.

⑤ Various shaded seating to protect student's from overheating.

⑥ To improve their sense of achievement and provide them with viable skill training, part of the students' vocational training will be the maintenance of the sensory garden.

2.3 Support Spaces: Diagnostic Centre

① Comprised of rooms for parents, assessment and diagnosis, specialists, intake and conferencing as well as training. The diagnostic centre is used for intake of new students, provision of outside assessment services and extra-curricular support for special needs individuals affiliated and enrolled elsewhere.

② The diagnostic room is arranged much like a small class, with various stations, and is visually accessible from an observation room.

③ The general atmosphere of this area of the centre is respectful, private and welcoming, to reassure both the parents and children.

2.4 Living spaces: Assisted Living Centre

① The objective of this assisted living service is to provide supervised on site accommodation for students. Such accommodation may act as a transition towards supervised living off-campus or independent living with the ultimate objective of integration into the community.

② Each of these apartments has 3-4 bedrooms with private bathrooms for each, a small kitchenette and workspace. Students may share a room with another student, a supervisor or live independently, depending on their skills and level of independence.

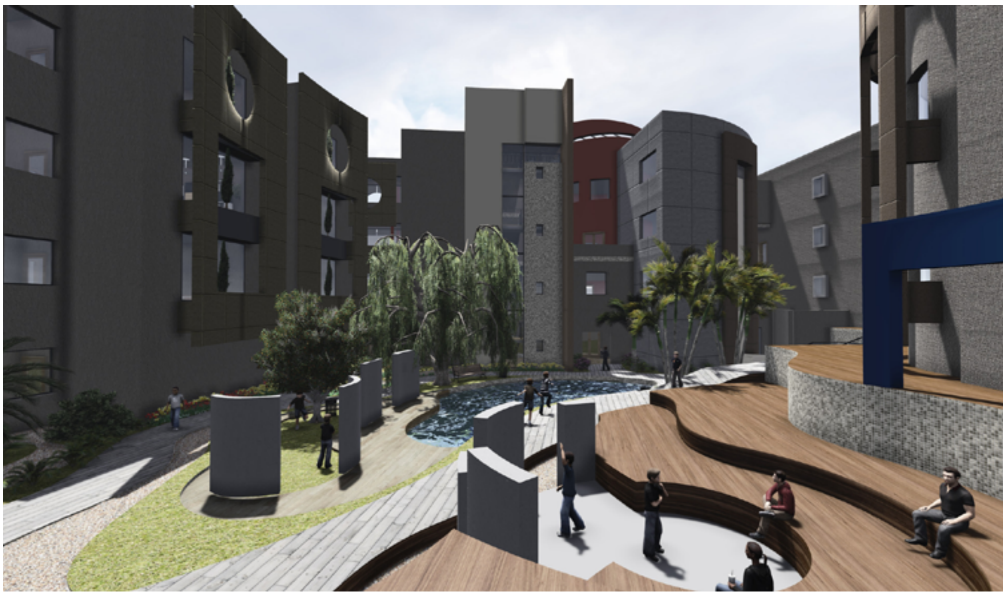


Figure 4.15 Courtyard, sensory garden (Source:Mostafa

New Struan School

Architects: Aitken Turnbull
Location: Alloa, Scotland, UK
Project year: 2005
User: Children with autism

Description: Opened in 2005, New Struan is the most advanced centre in the world for the education of children with autism. The school was designed by Aitken Turnbull architect Andrew Lester, whose daughter has autism, with the Scottish Autism Society. The building is purposed to enable children with ASD, having more complex and intensive support needs, to achieve their maximum potential. In addition, the building also includes a National Research Centre, Autism Advisory Centre, Training Centre and Administration Facilities.

Figure 4.16 The gate of New Struan School
(Source: Aitken Turnbull Architect)

Highlights:

(1). Spatial sequencing

The T-shape plan creates a clear distinction between public and private. The building includes seven classrooms, a multi-sensory room, splash area, library, early learning centre, staff room and an area for visiting therapists.

(2). Window and lighting

The 'gull wing' roof has been developed to encourage as much natural light as possible into the building. The pointed centre of the 'gull wing' forms a glazed patio that runs the length of the buildings and floods the space with brilliant sunlight. The patio is the 'social heart' of the school and is a powerful orientation device.

Figure 4.17 'Gull wing' roof for natural light

The classroom section incorporates clerestory windows, with a shading shelf, which diffuses direct sunlight, throwing it up onto the ceiling. The windows and doors below this have opaque blinds, which can be manually operated. The system of artificial lighting mimics the source of natural light by throwing light up onto the ceiling in the same way, from above the clerestory window.

(3). Classroom design

Seven classrooms are located on both sides of the patio, each incorporating floor-to-ceiling windows with a shading shelf to diffuse direct sunlight. The classrooms are smaller than the typical one, accommodating a maximum of up to six children. They also incorporate a 'one-to-one' space for individual or small group tuition. These are visually connected to the classroom through glazed panels. In this way a child can receive individual tuition without feeling removed from the social structure of the group.

The classrooms also have a window wall that provides an unobstructed view of the external play areas on either side. These play areas are completely secure and can be accessed directly from the classroom.

(4). Transition space

The classrooms are integrated with the patio space by threshold spaces or 'lay-bys', which are personalized and allow the children to adapt in advance the environmental and spatial change from the patio space to the classroom.

Aitken Turnbull said: "The interface between the internal street and the classrooms is particularly interesting. Many autistic children have a fear of "difference", including spatial or environmental differences, so thresholds can often feel threatening. The anterooms smooth the transition between the play space represented by the street and the teaching zone found in the classroom."

(5). Colour and finishes

The architects have chose muted 'earth' colours for the classroom, and allowing teachers to add stimuli as required. Finishes such as carpets and wall colours are clearly coded to support the spatial hierarchy.

Figure 4.18 Widows with shading shelf in classroom

Figure 4.19 Smooth threshold area

Northern School for Autism

Architects: Paul Hede, HEDE Architects

Location: Victoria, Australia

Area: 20424 ㎡

Project year: 2013

User: Students with ASD

Description: The Northern School for Autism is located in Australia， which is a new school for 144 students with Autism Spectrum Disorder. It is a school offering contact with a full range of support such as social workers, psychologists, trained teachers, and specialist art therapists. Its multi-purpose space can be used as a teacher training facility, parent or community learning space.

Figure 4.20 Aerial view of Northern School
(Source: www.a4le.org.au)

Highlights:

(1). Lighting

The classrooms are all light and naturally bright, which enables teachers to minimize the use of fluorescent lights.

(2). Playground

Playgrounds are inviting but discreet so that only a small number of children are playing together at any one time, enabling teachers to easily supervise and support students. The design of the playground offers generous bike paths as bike education which is a core program, as well as a variety of play equipment. The specialist wing structure provides purpose-built spaces for PE, cooking, art, and library. Bike trails and sand pits were provided in all play areas as these elements are highly regarded by students with ASD.

Figure 4.21 The early play area with its curved wall

(3). Classroom and learning space

Learning spaces around a central courtyard and provide individuals direct access to play for all learning areas. Learning areas are assembled around strong curved circulation route that is purposed non-interactive with leaning areas to reduce distractions. Every classroom has a quiet workroom, a discreet outdoor courtyard, a kitchen, and generous storage. A withdraw room which could be for quieter learning by 1 or 2 students or alternatively a calming room for an agitated or anxious student. The learning area has access directly to outside space for self-calming. The outdoor spaces were deliberately designed to be free from trees and landscaping due to student's propensity to eat or destroy them. The playground directly connects to each learning area as well as central toilets and passages.

(4). Colour and furniture

The whole school is decorated in earthy, natural tones to accommodate the needs of children who have the sensitivity to colour. In the learning space, there is a store for teachers to control the amount of furniture and equipment.

(5). Flexibility

The learning spaces are designed to be flexible and can be used as one large space or broken up into smaller groups for discreet learning purposes.

Figure 4.22 Natural light and lighting system

Figure 4.23 Classrooms access to outdoor space

The Garden School in London Borough of Hackney

Architects: Oliver Heath

Location: London Borough of Hackney,UK

Project year: 2016

User: 4-16 years-old learners with ASD

Description: The Garden is school in the London Borough of Hackney offering education for 4-16 years-old learners with autism. Oliver Heath Design were asked to give space at The Garden School a makeover. The new space is inspired by references to nature and is a space where children can play, relax and feel safe. It is a good example Biophilic design can improve well-being when incorporated into the built environment.

Figure 4.24 Perspective view of Garden School
(Source: https://www.oliverheath.com)

Highlights:

The spce can be divided into 3 key areas:

① A soft carpeted window seat providing a safe sense of prospect over the playground.

② A sensory interactive space where the children can touch naturally inspired surfaces to create sounds and gentle light.

③ A series of hexagons that the children can climb into for quiet retreat.

(1). Natural Light

The window seat offers safe views onto the playground with an abundance of natural light. This is an important consideration as optimizing exposure to daylight alone in main stream schools can increase the speed of learning by 20-26%.it can also improve attendance by an average of 3.5 days/year and test scores by 5-14% . It could therefore have a positive impact on staff and students at the garden.

(2) Multi-sensory room

The space is a multi-sensory feature which children can interact with, and control artificial lighting. When each of the natural surfaces are touched, the colours of the LED lighting discs will change softly and natural sounds (e.g. leaves in the wind) will be triggered. Touching two surfaces will cause overlapping sounds and two sets of lights to be illuminated. There are colour changing LED lighting disks suspended from ceiling; the colours of these change softly when the interactive feature is touched. The colours mimic natural tones we experience throughout the day i.e. dawn, midday or dusk (yellows, oranges, reds, blues and purples).

Figure 4.25 The window seat

Figure 4.26 Multi-sensory space

(3). Escape space

The playful built-in hexagonal seating provides somewhere for children to relax and restore their physical and mental energy. This can improve students' concentration, attention and perception of safety.

The designer said: "The first time we came into the space the children went directly into the hexagonal, cocoon-like shapes. One particular child, every time she's come in, she goes into that space. This is a child who actually seeks small, confined dark spaces, so it was fantastic to see her find something that fulfilled her need."

(4). Biophilic design

Research demonstrates that attentional capacity (which is essential for cognitive functioning) is restored when children/students engage with nature; this means they are less easily distracted and are more able to manage daily tasks. The school strives to improve the connection with nature. Natural elements through the textures, patterns and colours are used in the design, as well as the images of nature used on the wall coverings. Research has demonstrated that using nature inspired design in this way can positively impact perceptual and physiological stress responses.

Although many people may associate Biophilic design with the addition of plants to interiors,this space rich in sensory stimuli has been achieved without any plants.

Figure 4.27 Hexagonal seating

Figure 4.28 Escape in hexagonal space

The Learning Spring School

Architects: Platt Byard Dovell, White Architects
Location: Manhattan, New York, United States
Project year: 2010
User: Students with ASD

Description: The Learning Spring School is a 108-student K through 8th grade private day school for children diagnosed on the autism spectrum. It contains a full range of academic, athletic, and special needs spaces arranged internally as a vertical campus, designed to support the special social, physical, and educational needs of its students. The building facade features lineal sunshades. The subdued lighting is integrated as a feature into the facade and provides ambient light for the adjacent pedestrian walkway.

Fig 4.29 Perspective view of classroom
(Source: https://www.archdaily.com)

Highlights:

(1). Acoustic and tactile

Classrooms and corridors are finished with cork floors, bamboo casework, and natural wall fabrics, which can reduce the noises of environment,helping to produce a calm and intimate learning environment. At the same time,the natural sensory input is helpful to the process of sensory integration

(2). Transition space

Higher-occupancy spaces, including the gymnasium, library, and lunch room, as well as administrative functions, are located on the bottom two floors where the floor plates are the largest. Of the six upper stories, two are for lower school classrooms, two are for shared therapy and special education spaces, and two are for the upper classrooms. Classrooms are paired as suites, sharing resource areas, quiet study rooms, and toilets. To provide ample opportunity for informal socialization, seating alcoves off corridors are spread through the building. Circulation between the floors is through a glass-enclosed communicating stair.

Figure 4.30 Windows with aluminum sunshades

Figure 4.31 Seating alcove

(3). Lighting and shading

The aluminium sunshades, low-e coated insulated glass units, and zinc rain screen spandrels are used in the building to help to cut solar gain significant. Other environmentally friendly features include operable windows for natural ventilation. This project was the first building in New York State to receive a Gold rating under the rigorous LEED For Schools program. This accomplishment includes the provision of natural daylight and neighbourhood views for every classroom.

Figure 4.32 Exterior perspective

Figure 4.33 Interior perspective

Figure 4.34 Facade detail

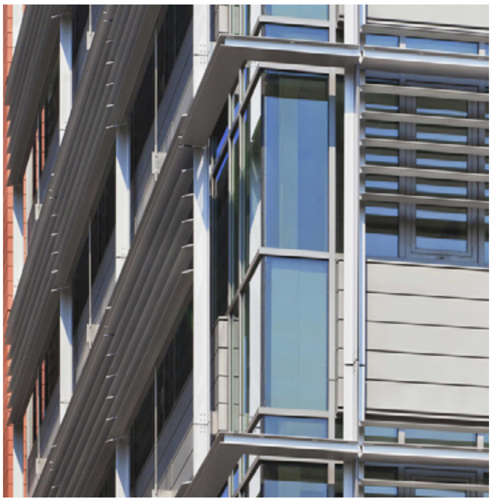


Figure 4.35 Corner detail

4.1.3 Residences

Sweetwater Spectrum Community

Architects: LMS Architects

Location: Sonoma California, USA

Area: 11331 m^2

Project year: 2013

User: Adults with ASD

Description: Sweetwater Spectrum Community is a new national model for supportive housing for adults with autism. Created to address a growing housing crisis for adults with autism, this new community for sixteen residents integrates autism-friendly design, universal design, and sustainable design strategies. The project includes four homes, a community centre, therapy pools, and an urban farm. Autism-specific design strategies promote calm and clear spaces that create a safe living environment. Practical sustainable design strategies promote health and wellness, reduce energy consumption, and offer multiple long-term benefits to residents, staff, and the community. Integrating current research on Autism Spectrum Design, spaces were designed to reduce sensory stimulation (ambient sound, visual patterns, odors, etc.), to connect to the natural world, and to create safe, comfortable, and predictable domestic environments.

Figure 4.36 The outside view of Sweetwater Spectrum Community
(Source: https://www.archdaily.com/)

Highlights:

(1). Spatial sequencing

A straightforward and consistent spatial organization provides clearly defined transition thresholds between public, semi-public, semi-private, and private spaces.

(2). Lighting

Integrating proper orientation, well-positioned windows, and tubular skylights, 100% of the primary residential and program areas are day-lit. Overall, 93% of all building spaces use daylight as their primary light source. High-efficiency lighting is controlled by switches and timers rather than occupancy sensors due to occupancy sensors could cause distraction of this specific population.

(3). Natural ventilation

The buildings orient to the prevailing winds, allowing 100% of the primary residential and program spaces to be naturally ventilated. A system of low velocity ventilation air is also provided to ensure healthy indoor air quality at all times, even when windows are closed. Ceiling fans are not appropriate for this project due to potential sensory stimulation experienced by residents.

(3). Material and finishes

A variety of materials ensure healthy indoor air quality, also interiors use advanced acoustical treatment to control ambient sound.

Harmless material: no VOC paints, adhesives and sealers, formaldehyde-free insulation and wood products, and non-toxic, vinyl-free flooring.

Durable materials: impact-resistant drywall, commercial grade doors, and cement board exterior cladding.

(4). Open space

The organic farm, orchard, and greenhouse support farm activities and projects for the residents and community volunteers while fostering biodiversity. Products from the farm and orchard are used daily by the residents and also sold at the local farmer's market. The generous variety of outdoor spaces connect Sweetwater residents to their environment, their community, and the therapeutic rhythms of the natural world.

Figure 4.37 Kitchen and dinning area

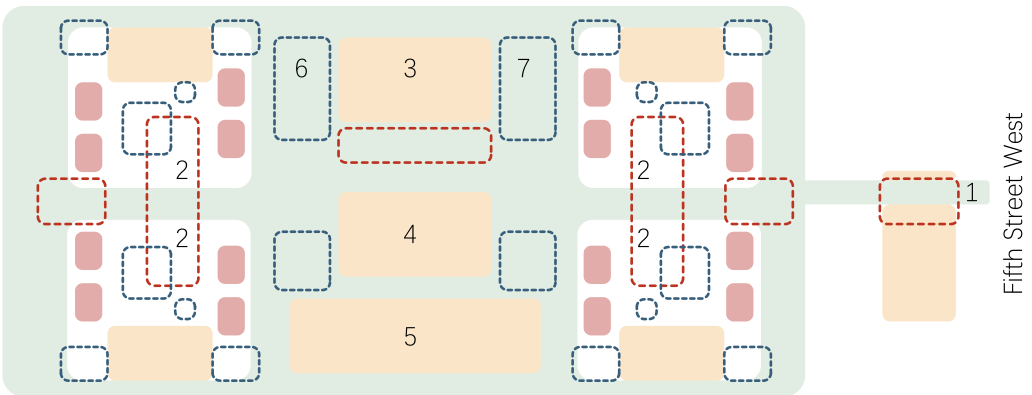
Figure 4.38 Urban farm

Design guidelines referenced by LMS Architects

- Ensure safety and security.
- Maximize familiarity, stability and clarity.
- Minimize sensory overload.
- Provide adequate choice and independence.
- Foster health and wellness.
- Enhance one's dignity.
- Allow opportunities for controlling social interaction and privacy.
- Ensure accessibility and support in the surrounding neighbourhood.

Design guidelines come from Arizona State University Stardust Centre Publication: Advancing Full Spectrum Housing --- Designing for Adults with Autism Spectrum Disorder.

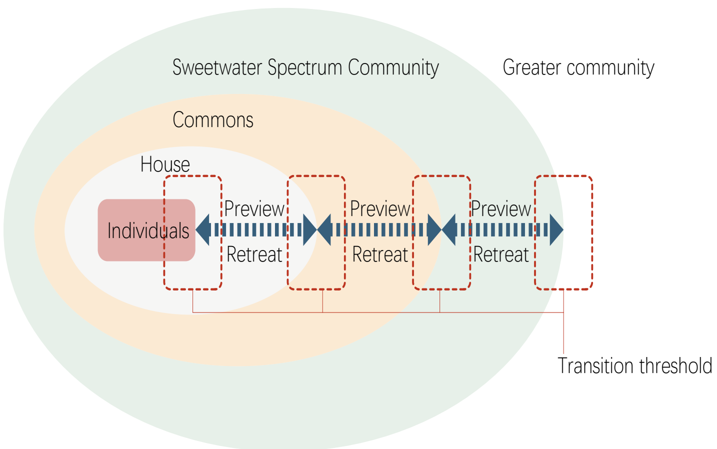
The space layout according to design concept



1. Entry 2. House 3. Community centre 4. Plaza and lawn
5. Therapy pool 6. Spas 7. Hammock garden

The use of transition area

Divide the space according to privacy: individuals, house,commons, Sweetwater Spectrum Community and the greater community, a transition threshold can be used at the junction of each space to help people with autism adapt to the change of two different environments in advance.



The Senior House in Hinnerup

Architects: Wienberg Architects , Frier Architecture
Location: Stadionalle 1, Hinnerup, Denmark
Project year: 2008 - 2014
User: Senior citizens with autism

Description: "How should people with autism live as they age?" The Autism Specialized Area question was investigated, and the result was four elderly homes that provide a safe and good environment for people with autism.

The senior house is located in quiet surroundings in central Hinnerup and consists of two-bedroom apartments with kitchen and spacious bathrooms. The house is next door to four other departments in the Autism Special Area.

The project was developed in collaboration with the self-governing institution Sofiefonden and the National Autism Association. The project was designed by Wienberg Architects in collaboration with Frier Architecture. Designers worked a lot with the spatial layout, materials and colours throughout the project. These are all elements designed to support the residential facility as a safe, intimate and personal space from where you can join in the communal living as you wish.

Figure 4.39 Outside view of the senior house
(Source:www.troldtekt.com)

Highlights:

(1). User involvement

In the process, there has been a great focus on user involvement of both people with autism and their relatives. For example, they liked that the kitchen has a window, dark slightly sheltered rooms, wood materials, lots of planting and the colour is green in general. These thoughts and ideas have all become part of the completed construction. This is reflected in the fact that the four older homes each have their own unique characteristics.

Figure 4.40 Unique characteristics according to needs

Figure 4.41 Unique characteristics according to needs

(2).Colour

For the Senior House, Ådalen and Engstien, a green arrival room has been constructed with both planting and green facade at the Senior House. The green colour is consistent throughout the building both inside and outside. About the choice of green, Mette Wienberg, who is one of the designer says: – Green is essentially an uplifting colour, and here it has been used both inside and out. The colour works well with the organic spatial layout, and strengthens the connection between the indoor and outdoor environments – supported by plants that create a harmonious whole.

Figure 4.42 Plants and green painting inside

Figure 4.43 Green facade

(3). Acoustics

White Troldtekt acoustic panels have been chosen for the ceilings in the communal areas, where they promote a good sound environment, which again creates a feeling of closeness and calm for the senses.

Figure 4.44 Special acoustic panels used in the ceiling

Figure 4.45 Special acoustic panels used in the ceiling

(4). Transition space

The residents have windows overlooking the corridor, while the communal rooms have large glass sections that break down the boundaries between the rooms. The entrance to each flat is set into a niche with a bench and a plant, and which functions as a safe transition zone in relation to the other residents.

Figure 4.46 A bench used as transition space

Figure 4.47 Windows which can see through

4.1.4 Autism medical centres

Edgecliff Medical Centre

Architects: Enter Architecture

Location: Edgecliff, New South Wales, Australia

Area: 150 ㎡

Project year: 2012

User: Children with ASD

Description: Edgecliff medical centre is a place providing service for autistic children in Edgecliff, Sydney. The project has a healing potential of space that was studied very closely through colour, indirect light and dynamic geometries. The result is a calming environment where the specialists can carry out their research and work on behavioural symptoms in young children. The patients are encouraged to play games, do quizzes and play in the informal environment of the centre.

Figure 4.48 The reception desk and overhead well-designed lighting.

Figure 4.49 The reception desk

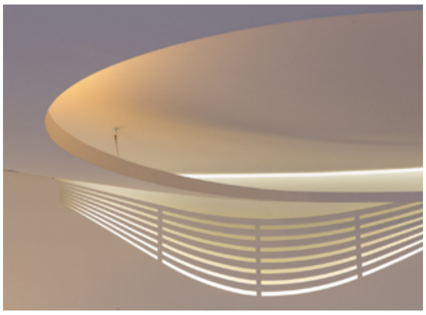


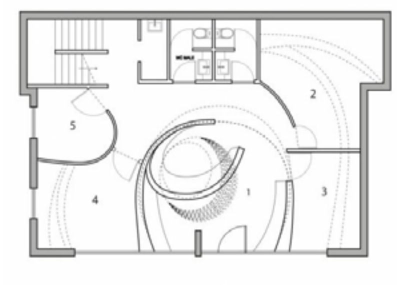
Figure 4.50 Wall structure

(Source: https://www.archdaily.com/)

Highlights:

(1). Space form

Considering the interior space for autistic children, design must be highly valued. Geometry circulates and unfolds not only promotes an atmosphere of calm, rest and relaxation but also prevents children from harming themselves on corners in severe circumstances. Right angles are most definitely avoided.



1. Receptionist
2&3. Office
4. Main office
5. Storage

Figure 4.51 Ground floor plan.

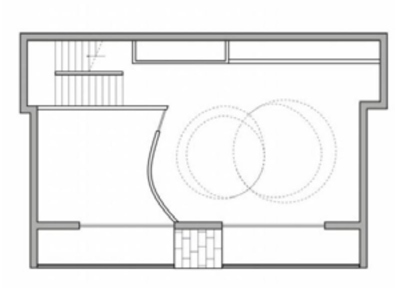


Figure 4.52 Second floor plan

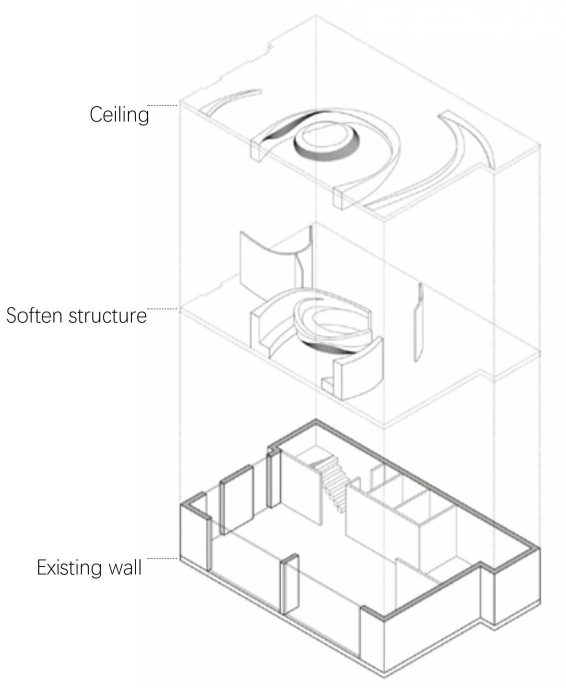


Figure 4.53 Exploded axonometric map

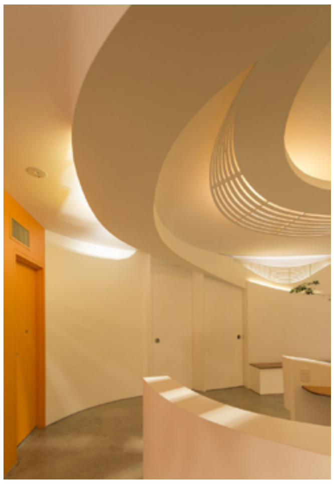


Figure 4.54, Figure 4.55, Figure 4.56 Furniture and architecture structures with soften edges

(2). Furniture

Not only using curved architectural structure to soften space, in terms of furniture, tables and chairs also with a soft edge. The central reception desk with soft lines, softens the space while preventing children from getting hurt. Curved exterior walls are used in both the office and the treatment room to break the rigid visual space. The indoor office desk is along the arc of the wall, while the tables and chairs in the treatment room are also smooth and the colour of the furniture is carefully considered.

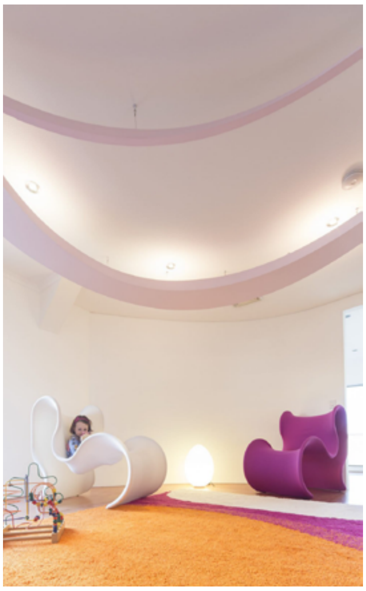


Figure 4.57 Furniture with soften edges

Figure 4.58 Reception desk

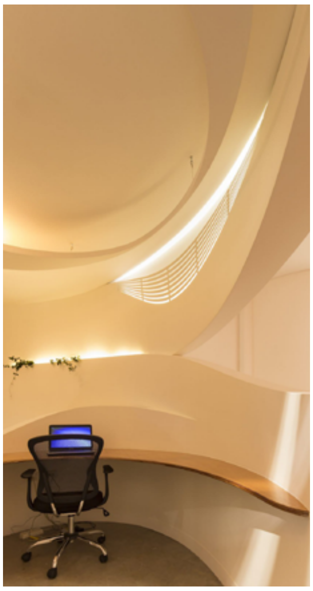


Figure 4.59 Office desk

(3). Lighting and colour

The partnership of light, optics, colour also played a pivotal role in shaping the overall feel and our emotions.

① Lighting: Using indirect lighting to avoid glare also provide an additional calming effect.

② Colour: Colours play an important role in shaping our emotions. Known for its healing properties, a fearless orange shade was chosen for the back feature wall. A fresh neutral base pallet was chosen for with warm and bold colours lighting.

Figure 4.60 The neutral base pallet

Figure 4.61 Warm lighting

Mitford Hospital Autism Inpatient Unit

Architects: NHS foundation trust, Paul Yeomans (Medical architecture)
Location: Mitford, Morpeth, Northumberland,UK
Area: 1998 m^2
Project year: 2017
User: Adults with ASD

Description: Mitford autism inpatient unit in Morpeth, Northumberland, is the first purpose-built care facility of its kind, and a building designed to tackle a very specific challenge. The residential unit serves adults with severely complex autistic spectrum disorders, for which a new healthcare methodology has emerged which looks beyond managing their conditions for the long-term to a much greater focus on helping them move back into the community.

Figure 4.62 Aerial view of Autism Inpatient Unit
(Source: Design for Autism-Design in Mental Health Network, Paul Yeomans)

Highlights:

(1). Circulation Space

Corridors should be multi-functional, acting as active circulation spaces, providing spaces for rest and informal activities, the spaces are broken up with area for seating, artwork and a various of different shaped volumes.

Figure 4.63 Activating circulation space with seating and spatial interest.

The length of the circulation area should be visually break up to prevent anxiety for these service-user. Using curving walls to make the transitions softer, encourage"flow" and reduce anxiety. Colour pattern are restrained.

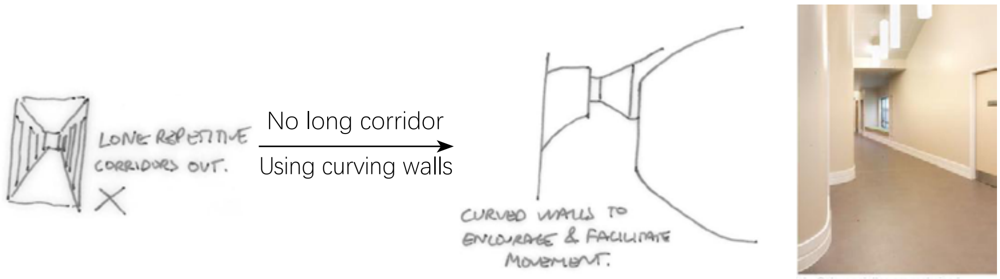


Figure 4.64 Instead of long corridor,curving walls were chosen to soften space.

(2). Demarcation of space

① Door: Thresholds can be used to demarcate space to reduce the great number of doors.

② Markers: Different colour and material markers, which easy to identify, can help will assist users with orientation.

③ Ceiling: Different ceiling levels will change the feel of the space.

④ Transition space: For a service-user that has difficulty engaging with outside space, a well positioned window or window seat can be transition area from inside to outside.

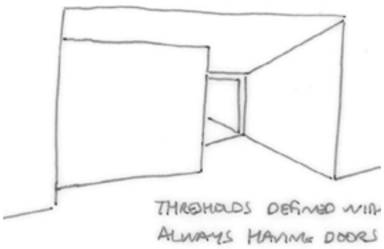


Figure 4.65 Thresholds replace doors.

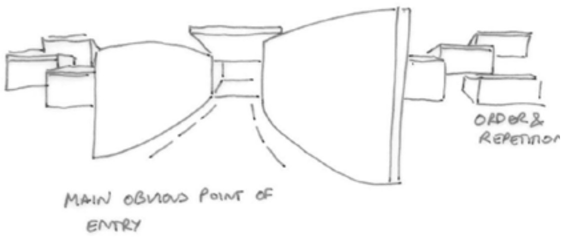


Figure 4.66 Identified point of entrance.

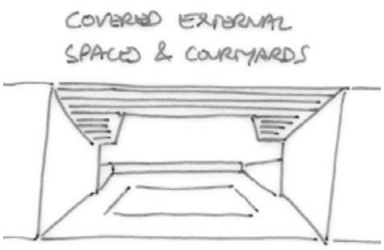


Figure 4.67 Ceiling level

Figure 4.68 Observation window

(3). Orientation and natural light

The orientation is crucial for the each room, the correct orientation(north east) can effectively minimize overheating and glare, both of which will cause problems for the patient group. The important spaces face east away from the main routes through the hospital estate, increasing privacy.

① Light: Fluorescent light should be avoided.
② Window: High level windows maximize daylight, whilst minimizing glare, adding a sense of lightness and space within the building. Instead of large window, which cause too much stimulus and feedback, small picture window is more suitable, it will provide direct views of outside landscape while minimize stimulus.

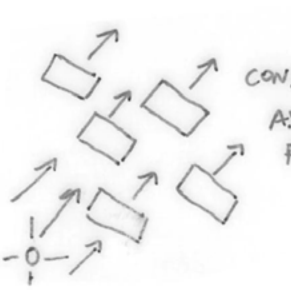


Figure 4.69 Consistent orientation of flat.

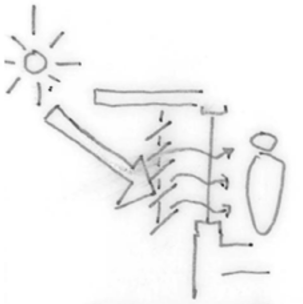


Figure 4.70 External solar control to diffuse bright sunlight.

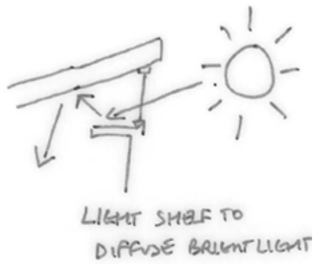


Figure 4.71 Light shelf to diffuse bright sunlight.

(4). Daily necessities

In each flat, cupboards and other daily necessities are allowed to be hidden so they become less of a target for the patient's attention. TVs and wardrobes can be taken out of the view by locking doors back in the place to remove the stimulation.

Figure 4.72 The display hidden in a cabinet.

Figure 4.73 The TV screens hidden in the closet.

Multisensory Room in Emergency Department of Careggi Hospital

Architects: Elena Bellini
Location: Florence, Italy
Project year: 2016

Description: Last July an autism-friendly waiting room was inaugurated in the Emergency Department of Careggi Hospital in Florence. It is the first example of a sensory waiting emergency room in Italy and one of the few examples in Europe. It represents one of the strategies to improve accessibility in Careggi Hospital. Design concept of the healthcare environment aimed at reducing distress in hospital and answering to particular needs of people with ASD. The relationship between architectural space and quality of life is studied to pay maximum attention to users' needs and to support the medical staff in their work by a specific program of training.

Figure 4.74 Video screening on the curved wall
(Source: www.ifworlddesignguide.com)

Highlights:

(1). Space form

The curved shape of the room welcomes you into a secure environment that provides containment and improves accessibility and quality of care.

(2). Technology interventions

A specific technological system supports sensory stimulation such as colours, music, videos and anything else people may want to make the room comfortable and reassuring. The main aim is patient's relaxation to ensure a better regulation of the arousal and fewer behaviour problems and to improve treatment accessibility, safety, and effectiveness.

① Acoustic Insulation: The environment is protected and sound-insulated by acoustic insulation inside the interior counter-wall.

② Light Cones: Immerse themselves in light therapy that has been tailored according to patient's sensory preference.

③ Interaction IPAD: Play with the room: customize the scenarios by changing the colours, music, pictures, videos, and anything else you may want to adapt the space to your needs. Communicate through a system of images showing primary needs and one's own physical and psychological comfort necessities.

Figure 4.75 Light therapy

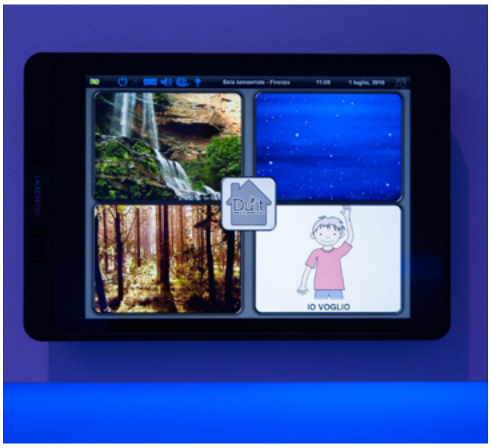


Figure 4.76 Interaction IPAD

④ Aromatherapy: Spread the sea breeze aroma all around you.

⑤ Video screenings: Project your favourite images and videos while you travel through your own dreams.

⑥ Video cameras: See what happens in the sensory room from both the outside and nurse monitor.

⑦ Vibrating platform: Enjoy the sound vibrations. Lying down to feel the tactile stimulation of the music.

⑧ Time timer: Use the manual timer to time your stay. Includes a visual indicator of the time and an audible alarm.

⑨ Armchair: Let patients be hugged and gently rocked in the “cocoon”.

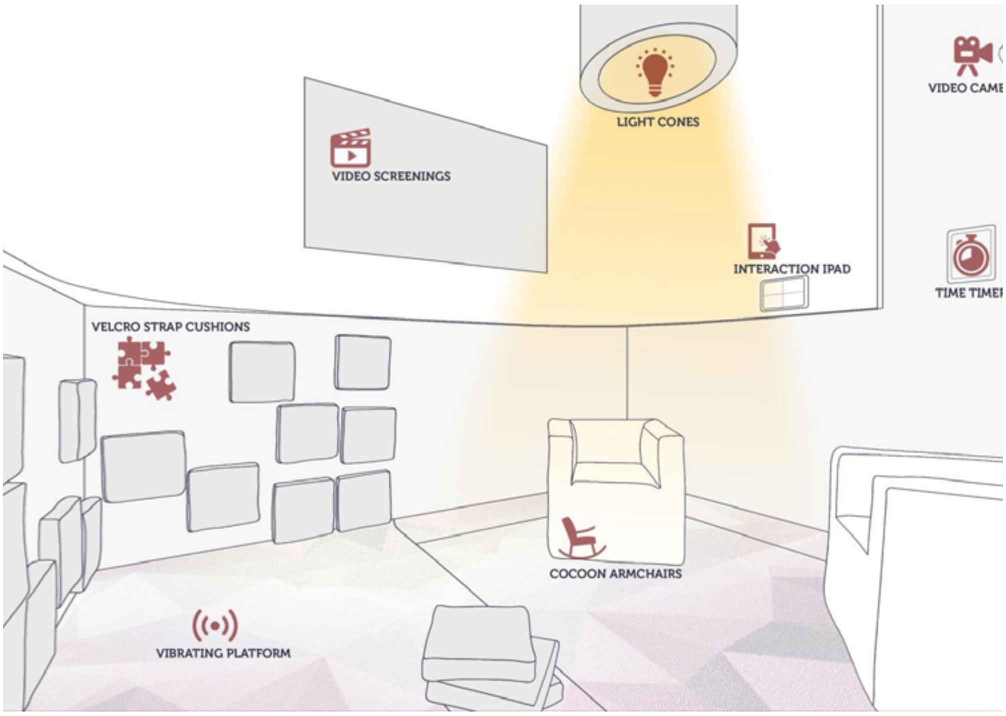


Figure 4.77 Technologies of the multisensory room

Autism Treatment Centre of San Antonio (ATC)

Location: San Antonio, Texas, United States
Area: 1860 m^2
Project year: 2019

Description: Autism Treatment Centre of San Antonio (ATC) is a private, non-profit,corporation offering services to people with autism and related disorders throughout their lives as they learn, play, work and live in the community. The new facility that would be completed in two phases. Phase I is a treatment and therapy centre, meant to work with children on developing sensory and social interaction skills through active therapy in a group lab, as well as one-on-one therapy. Phase II will be a school with curriculum and instructional methodology tailored to students with Autism.

Figure 4.78 Perspective view of ATC entrance
(Source: https://www.stantec.com)

Highlights:

(1). Natural Light

While natural lighting is often favoured over artificial, too much of either source can be distracting for autistic students. As a result, windowsills were placed higher, and light wells from the ceiling bring in additional natural lighting.

(2). Acoustics

The ATC incorporated LED bulbs to eliminate flickering, which also allows instructors to colour-tone rooms based on activity and needs – a kind of “mood room.”To enhance auditory focus and eliminate unwanted sound frequencies, the design strategy also included utilizing materials for the walls, ceiling and floors with high Noise Reduction Coefficient values. The mechanical systems were also placed carefully due to the unwanted stray noises that can come from equipment vibration and air velocity through duct work. Fresh air delivery was also a design consideration with an underfloor air distribution system, rather than forcing air out of the ceiling.

Figure 4.79 The light well

(3). Artificial lighting

LED bulbs also allows instructors to control to form different 'mood room'. Instead of having to paint individual spaces, LED lights can be used to colour-tune rooms to a vibrant orange to stimulate children's minds before an activity, a soothing blue for stress relief, or easily switch back to a neutral white, creating flexible space for both students and instructors.

(4). Outdoor space

The design also accounts for times when students become overstimulated and need to retreat and deflate. After witnessing students run away and hide in small spaces while under high stress in the research process, the design team also created special painting walls in multi-purpose areas that serve as an additional getaway zone while adding a fun visual element.

Figure 4.81 Interactive space

Figure 4.82 Painting wall

Burkhart Centre for Autism

Architects: Stantec Architecture

Location: H4MC+PM Lubbock, Texas, United States

Project year: 2012

User: ASD

Description: This project constructed a autism education and research facility that includes space for clinical facilities such as the Adult Transition Academy, Teacher Preparation Academy,and Outreach Program; research and support space, class labs, classrooms, academic offices, and a national branded cafe. To create a comforting environment, the Stantec team simplified the facility's design and considered lighting and acoustics in a thoughtful way, making sure all elements served a purpose

Figure 4.83 Perspective view of entrance
(Source: https://www.texastech.edu)

Highlights:

(1). Plan

The Burkhart Centre is comprised of four primary practice areas:

① Early childhood area for children through school age.

② Transition academy providing a safe environment for young adults to learn social, life and job skills, including a mock apartment and fast food restaurant.

③ Outpatient clinic with small therapy rooms and family consultation areas.

④ Several research-specific spaces.

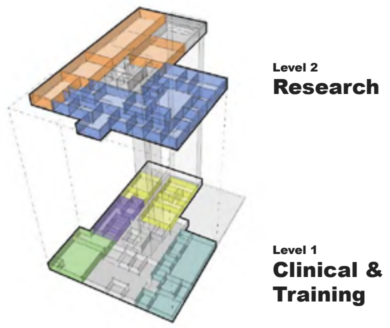


Figure 4.84 Layout of the building

Figure 4.85 Function zoning

(2). Wayfinding system

The centre has a good wayfinding system entrance,Started from the entrance,colour-coded floor patterns can lead clients to the four practice areas, The Burkhart Centre also Install tube lighting or tracks vertically along the main pathway. Lighting that runs in the same direction that one should move gives users something to follow without a blatant arrow pointing down the walkway.

Figure 4.86 The use of materials in the wayfinding system

Figure 4.87 The use of lighting in the wayfinding system

(3). Lighting and shading

In the outpatient clinic, the therapy room doors are labelled by colour – with warmer or cooler tones depending on individual needs. These patterns help create familiarity and a map in the minds of visitors. Area lighting is a good way to help define space

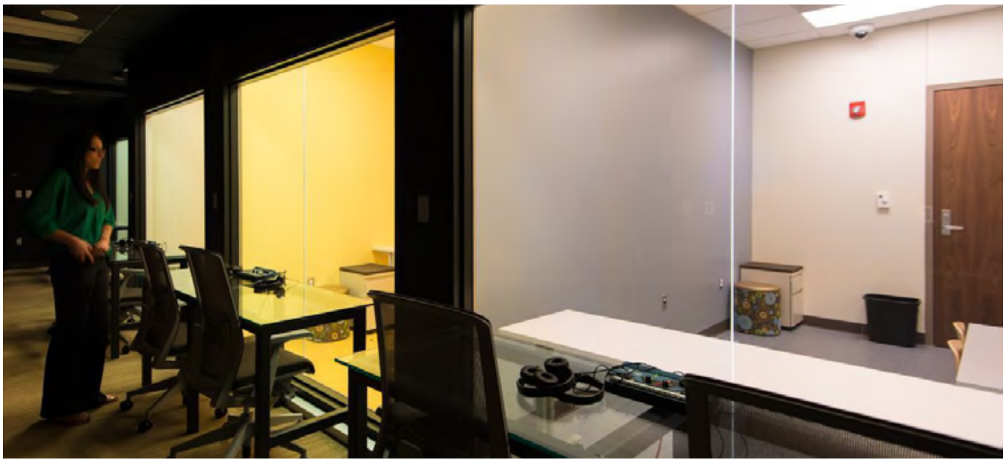


Figure 4.88 Lighting of therapy room

Figure 4.89 Lighting code for spatial division

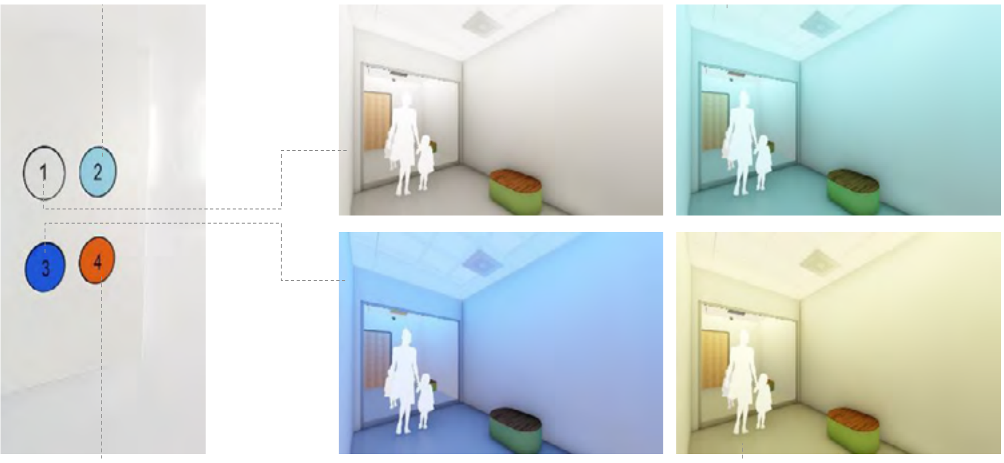


Figure 4.90 Controllable colour of lighting

4.2 Children’s hospitals

Emma Children’s Hospital

Architects: OPERA Amsterdam
Location: Meibergdreef 9, Amsterdam, Netherlands
Project year: 2005-2015
User: Children

Description: Traditional hospitals are not fit for children. The process of modernization pursued by Emma Children’s Hospital, expressed as a ‘metamorphosis’ in its programme, impacts deeply on relationships between patients, their parents, the nursing staff and the doctors. In the design, considerable attention was devoted to creating an ambiance that is not primarily medical in character. Instead, sick children experience the area as home, even if only temporarily. After all, their social lives take place in this interior for the duration of their stay. The key to the design, and an important area consideration in its elaboration, is the spatial quality of all intermediary areas. All corridors in departments offer views of the world outside, and all enjoy direct or indirect daylight. The entire network of connections is organized and easily legible, facilitating easy orientation for both the children receiving care and visitors.

Figure 4.91 Aerial view of Emma Children’s Hospital
(Source: http://www.dvdp.nl/)

Highlights:

(1). Acoustic ceilings

Ceilings which have a good acoustic performance are applied in the hospital.It creates calmer, healthier buildings where patients can rest and heal and medical staff can concentrate. It provides patients with great indoor acoustics and privacy, supporting them in their recovery as well.

(2). Wayfinding

Emma's children's hospital use the signage with symbols to help direct people through the hospital. By checking the symbols overhead and and underfoot, children can arrive the destination easier, like playing games. And, each department is elaborated to give it a specific character and meet its specific needs. Each department therefore reads as a separate house for a particular (age) group. Different departments were given their own identity, by using graphic symbols, colours, spatial illustrations and typography. It allows children to find their way through colour coding. Designers created at the same time an overall identity to express the guiding concept of "Metamorfose".

Figure 4.92 Signage with symbols

Figure 4.93 Signage with symbols

Figure 4.94 The use of colours pattern and coding

Figure 4.95 The use of colours pattern and coding

(3). Escape space

The escape space is located in the opposite of the social interactive area, allowing a child have a rest alone. The space is meant to be an area of solitude where the child can retreat to relax, and regain control of environment. Children can sit in their preferred poses and imagine they are in a cave environment.

Figure 4.96 Escape space

Figure 4.97 Escape space

(4). Technology intervention

In the teenagers ward, each patient has access to an iPad that's loaded with pre-populated content - all specifically selected for their age group and illness. Technology that facilitates communication between patients, their families and their care teams is a powerful healing tool. Solution on an iPad enables this type of information exchange. “We have functions in our application that create a relationship and communication between the patient and staff,” said George Frey, commercial director, “That makes the staff more receptive to what the patient needs.” Projectors are also provided in certain room to create an amusing atmosphere. Technologies create better sensory experience.

Figure 4.98 Technologies applied in the hospital

Nemours Children's Hospital Orlando

Architects: Stanley Beaman & Sears

Location: Nemours Pkwy, Orlando, USA

Project year: 2012

User: Children

Description: The hospital's philosophy is one that embraces children "across the continuum": from infancy to adulthood, Nemours cares for children with chronic conditions, as well as complex medical diagnoses and life-threatening illnesses. The children's hospital campus is designed to both reassure and inspire, engage and delight.

Figure 4.99 North facade

Figure 4.100 Landscape

Figure 4.101 Soft furnishing

Figure 4.102 Multiple seatings

(Source: https://www.archdaily.com/)

Highlights:

(1). Nature lighting

In Orlando's subtropical environment, intense sun and humidity were a major design concern. Extensive solar studies resulted in shaded outdoor spaces, and also helped determine the design and placement of sunscreens - blocking direct sunlight, while admitting abundant natural light to the interiors.

Figure 4.103 Glazing with blinds

Figure 4.104 Glazing with blinds

(2). Colour

Different colours are used in the interior environment, which can help children distinguish each architectural components well. Colourful furniture and wayfinding graphics punctuate spaces throughout. The colour of patient room accent lighting can be selected by the child, creating an ever-changing dynamic on the building's façade – an artful reminder of the children being cared for at Nemours. However, the colours occur in this hospital are too bright for the autistic children. Since they have different colour preferences, the idea of colours selected by children themselves can be borrowed.

Figure 4.105 The use of colour coding

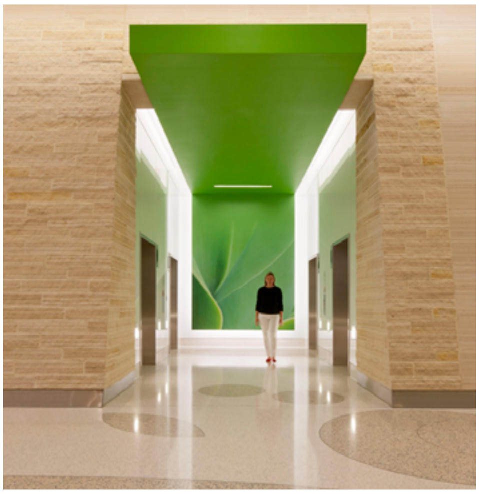


Figure 4.106 The use of colour coding

(3). Materials

A combination of specialty finishes and high-performance materials give the interiors a clean, modern aesthetic. The floor used is 3mm thick rubber floor, which made up of a covering layer of high wear resistance. Smooth surface treated with the PRO treatment to improve surface acoustic performance and cleanability. products also significantly contribute to LEED credits, as well as compliance with many other criteria set by schemes achieving the international environmental sustainability of buildings.

Figure 4.107 Rubber floor finishes.

Figure 4.108 Rubber floor finishes.

(4). Sensory intervention

Nemours Children's Hospital has opened a sensory room to help children with autism and other sensory issues. It helps them cope while they wait. The room includes a bubble column, wall toys and stimulation disks, a light dome, and a projector with design slides. A special projector displays shapes and a light dome on the ceiling reacts to the noise level. Also, soundproof headphones can be used to decrease anxiety. The purpose of this room is to help distract patients and provide them with calming objects. As part of the program, the staff is trained to reduce the use of unnecessary monitors and expedite tests and consults. "Their anxiety lowers, they calm (down) and they can have a really positive coping experience with their medical procedure," said Emily Bradley, a child life lead specialist.

Figure 4.109 New sensory room

Figure 4.110 New sensory room

Texas Children's Hospital

Architects: FKP Architects
Location: 17580 Interstate, The Woodlands , USA
Project year: 2017
User: Children

Description: To accommodate rapid population growth and to bring care closer to home, Texas Children's Hospital sought a full-service community hospital that could serve children in communities north of Houston. It is one of the winners of its 2017 Healthcare Interior Design Competition. The program honours outstanding originality and excellence in the design and furnishings of health care interior spaces.

Figure 4.111 Exterier perspective view
(Source:https://www.cannondesign.com/)

Highlights:

(1). Biophilia design

The interior design draws inspiration from the nature trails and play areas in the surrounding wooded neighborhoods. The "Spirit-of-the-Woods" theme FKP developed features informal paths, organic shapes and textures, diffused day-lighting and bright, playful colours. "We were able to create a warm, less institutional environment with an economical palette of materials," says Steve Kopp, AIA, senior project designer. "It distracts young patients and appeals to their parents."

(2). Wayfinding

Most visitors park in a remote garage and pass through the adjacent outpatient building to enter the hospital. To ease way-finding, FKP envisioned a winding blue stream in the terrazzo floor pattern to connect each building entrance to the welcome desk in the two-story lobby. An abstracted leaf in the ceiling above the desk indicates the specific location where visitors can get assistance. Young children intuitively understand the indirect stream is an invitation to explore. Nurse stations in clinical areas share many of the same way-finding elements, including the green leaf above each welcome point.

Figure 4.112 Outside view

Figure 4.113 Interior view

Figure 4.114 Interior view

Figure 4.115 Interior view

(3). Escape space

Just inside the main entrance is a grand staircase that simulates a tree house — a fun, central location for children and families visiting Texas Children's Hospital The Woodlands to gather. It is conceived to grow out of the terrazzo plinth, which also serves as a continuous bench. There's a fort at mid-landing and a secret hideout within its glass-tiled cylindrical base. This hideout can provide a private space when children experience sensory overload. Inside the cave, children can reorganize their emotions and calm down themselves.

Figure 4.116 The entrance hall

Figure 4.117 The entrance hall

(4). Safety

The floor in the corridor is carpeted. It not only promotes acoustic performance, but also reduce the risk of injury when children fall. Besides, there is effective edge protection around the chair leg. The sharp edge is no more a hazard to children. Even if they have aggressive behaviours, the chair leg avoids being a weapon.

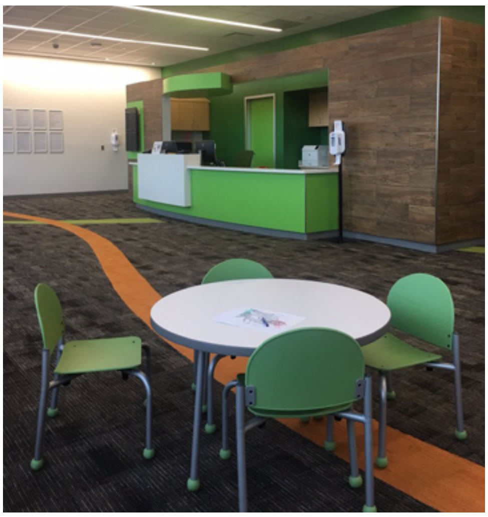


Figure 4.118 Protection of chair legs

Figure 4.119 Carpet and soft furniture

Randall Children's Hospital

Architects: ZGF Architects
Location: North Gantenbein Avenue, Portland, United States
Project year: 2012
User: Children

Description: The new 334,000 square-foot, nine-story Randall Children's Hospital at Legacy Emanuel consolidates previously dispersed pediatric care and creates a graphic identity for its campus in Portland. It is a great example of integrated design that transforms an environment and makes a potentially emotionally challenging experience as warm, inviting, and comforting as possible.

Figure 4.120 Exterior perspective

Figure 4.121 Landscape
(Source: https://www.archdaily.com/)

Highlights:

(1). Atmosphere

The overarching goal was to create a place full of inspiration, with a sense of unexpected discovery and thoughtful distractions, using art and environmental graphics to create destinations and enliven spaces. Based on proven research that children have a strong affinity for imagery found in the natural world, four regionally inspired colour palettes for interior finishes are used throughout the hospital to represent the geographic diversity of the Oregon and Washington regions it serves. The palettes were applied based on the function of the space; for example, the neonatal intensive care unit reflects a tranquil coastal palette, while the emergency department uses an active desert palette.

(2). Materials

The building envelope includes high-performance glazing and increased thermal insulation. The steel and concrete structure, aluminum curtain wall and interior materials – such as acoustic tile, gypsum board and cast terrazzo counters on nurse stations – have significant recycled content. Bamboo, a rapidly renewable product, is the standard for veneers, flooring and ceiling panels. Persistent bio-accumulative toxins like copper, mercury, lead, and cadmium have been minimized through specifications and material selection. Adhesives, sealants, paints, and carpets are all low or zero VOC.

Figure 4.122 Wood trees as landmark

Figure 4.123 Different themes in different area

(3). Wayfinding

The combination of regional colour palettes and animal imagery creates a wayfinding system that integrates building signage with directional arrows and graphics. Each hospital zone is themed to a region: soothing ocean blue or cheerful sun yellow in the neonatal intensive-care unit, lush mountain green in outpatient areas, desert orange in day surgery. Each hospital floor is assigned an indigenous animal found in its region that repeats throughout the floor in a variety of materials, such as eco-friendly architectural glass that animates the space and aids navigation. It is served as a way-finder. These whimsical pictograms also appear in surprising places, such as at eye level of a toddler standing at a nurse station.

Figure 4.124 At a child's height, animal shapes light up

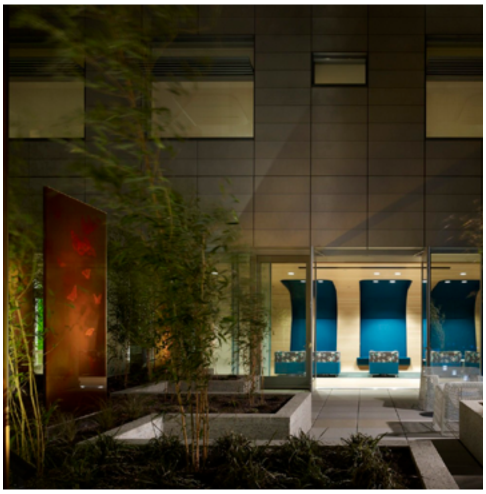


Figure 4.125 The interior garden room

(4). Sensory garden

A terrace garden on the third floor has been designed to provide a variety of environments for play, conversation or contemplation. fiberglass cone elements, topped with a coloured glass lens, also act as skylights to the NICU below. Other elements, art glass panels, pergola structures and plant and paving materials, have been chosen to create a restorative environment. An interior garden room is located at the east end of the terrace, offering a quiet place for introspection with access to a private outdoor garden.

The Royal Children's Hospital Melbourne

Architects: Billard Leece Partnership and Bates Smart Architects
Location: 50 Flemington Rd, Parkville VIC, Australia
Project year: 2011
User: Children

Description: The new Royal Children's Hospital is based on a care model that puts children and their parents at the centre of the facility. The therapeutic benefits of nature underpin the overall design, with a story deriving from the natural textures, forms, patination and colours of the surrounding Royal Park.

Figure 4.126 Exterior perspective
(Source: Australian design review)

Highlights:

(1). Lighting

The buildings̓ main facade floats like a tree canopy, adorned with sun-shading'leaf/ petals' in colours that change from red to green. The usage of solar panels makes the sunlight controllable.

(2). Atmosphere

The hospital's internal organizational spine, the broad, light-filled 'Main Street', terminates in a landscaped garden. Running the length of Main Street is 'Sky Garden', five delicate, mobile-like leaf canopies by artist Jade Oakley. These design strategies were directed towards how an ill child might feel, nullifying pain not just with medical care but also with normalizing environmental and experiential measures. Designers try to give a new interior experience for children which is magical, tactile and engaging.

Figure 4.127 Adjusted sun-shading panels

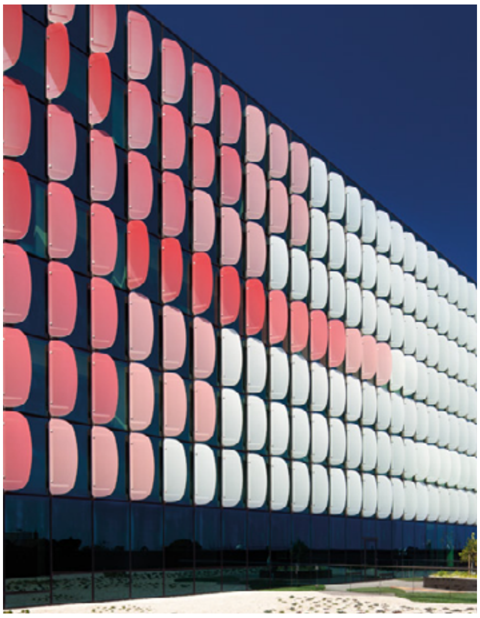


Figure 4.128 Adjusted sun-shading panels

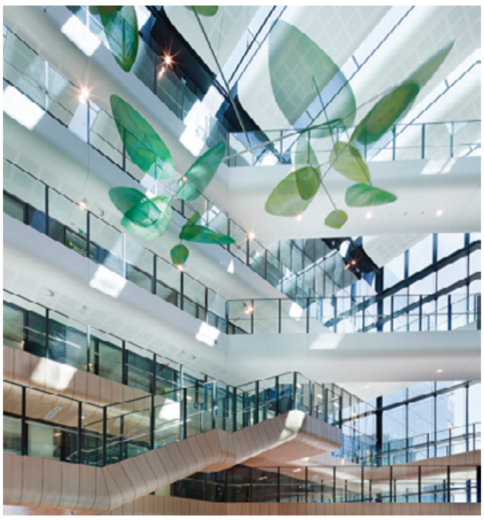


Figure 4.129 Leaf canopies

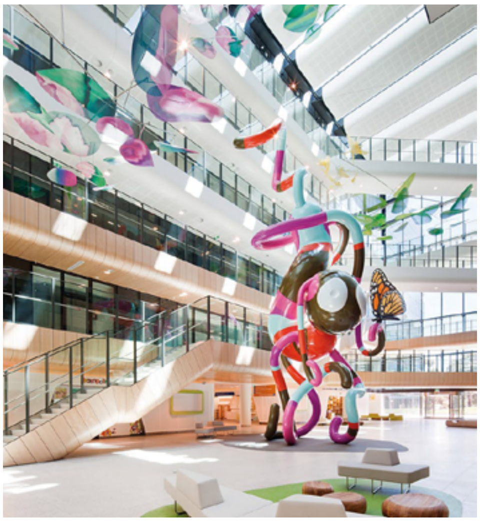


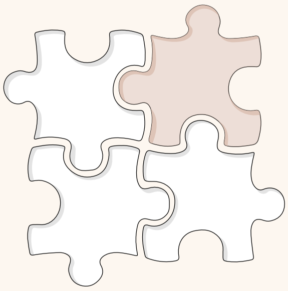
Figure 4.130 Artworks in the entrance hall

(3). Wayfinding

The hospital incorporates memorable visual cues in the design. The wayfinding solution at the new Royal Children's Hospital focuses on the integration of landmarks at key navigational decision points, the primary objective being to create journeys that are easily describable, in a simple sentence, using basic English. Specific areas within each level are described in relation to an appropriate animal, these markers help visitors navigate the vast scale of the complex, and each interior scheme relates in colour, texture and introduced artwork (many done by children) to the flora and fauna of eight Victorian landscapes, from Port Phillip Bay to alpine Victoria.

Figure 4.131 Memorable visual cues in the reception hall of hospital

Figure 4.132 Memorable visual cues in the waiting area of hospital



4.3 Summary of case study

Autism-friendly built environment

In this chapter, we analyzed different cases on the various building environment to understand how autistic people think about and reflect on their interaction with space. Combined with theory, the design by GA architect provides a multi-dimensional view on how to design for these vulnerable groups. It is embodied in all the cases. Five autism school, 5 autism medical centre, 2 houses specially designed for autism are chosen. After our analysis and comparison, we find some characteristics in common. Many practical design strategies on autism-friendly educational buildings and residential buildings can provide information on what the autistic users may need in the medical environment.

All the designs in the cases reduce decorations. They hold an idea that too many details might provide irrelevant stimuli, demanding attention that cannot be used for actual tasks. Still, the environments make users feel warm and welcoming. There is no environment that has a cold and impersonal atmosphere.

Since their unique sensory experiences play an important role in their perception of the environment. Many designs start from sensory. All the cases improve the environment from a sensory perspective. Autism-friendly designs focus on senses, which include acoustic, visual (colour&lighting), tactile, olfactory. For example, Difficulties in processing visual stimuli might increase autistic people's susceptibility to certain colours, patterns or lighting. To create an excellent visual environment, natural sunlight should be sufficient, and not excessive. Blinds and curtains are adopted to block the natural lighting which may cause glare. Controllable artificial lighting is also applied in many spaces, including 1 school, 1 apartment and 3 medical centre among the cases. Colours used in the design are calming and neutral， while the number of colours are limited generally. In the chart, we conclude all the sensory considerations, which have a lot in common. The aim is to address sensory challenges and create a neutral environment. From the summary chart, we can find all the senses are considered in the Learning Spring School.

Safety and equipment are also emphasized in the cases. In the Northern School for Autism, the amount of furniture and equipment is controlled by teachers in case of autism users' aggressive behaviors. In the Edgecliff Medical Centre, soft furniture is used to avoid sharp corners. As for the impact of equipment, fluorescent lighting is mentioned most. It has been almost avoided in most of the cases.

Escape space is frequently used in the cases. Escape space is a safe place where one can retreat from too demanding situations, offering the necessary sense of control and safety. Assistive technologies are also a positive intervention for ASD users, which can contribute to an autism-friendly built environment.

Medical environment	12. Burkhart Center for Autism Education and Research
	11. Autism Treatment Center of San Antonio
	10. Multisensory Room in Emergency Department of Careggi Hospital
	9. Mitford Hospital Autism Inpatient Unit
	8. Edgecliff Medical Center
Residential environment	7. Senior House-Hinnerup
	6. Sweetwater Spectrum Community
Educational environment	5. The Learning Spring School
	4. The Garden School in London Borough of Hackney
	3. Northern School for Autism
	2. New Struan School
	1. Advance School for Special Needs Children

Architectural and technological elements	Architecture design strategies	1	2	3	4	5	6	7	8	9	10	11	12
General environment	· Warm atmosphere	●	●		●	●	●	●	●	●	●		
	· Minimized visual distraction	●		●			●	●	●	●			
Sound	· Minimized noise exposure	●										●	
	· Acoustic structure or materials	●	●		●	●	●	●			●	●	●
Colour	· Mute and natural colour		●	●	●	●	●	●	●	●			
Lighting	· Sufficient natural lighting	●	●	●	●	●	●					●	
	· Controllable artificial lighting				●		●				●	●	●
	· No glare and reflection	●				●			●				
Smell	· Good ventilation	●				●	●						
Tactile	· Tactile intervention				●	●					●		
Space hierachy	· Simple layout	●					●						●
	· Sensory zoning	●	●							●			
	· Curved wall			●					●	●	●		
	· Multi-functional area		●	●						●			
Wayfinding	· Graphic symbols	●											
	· Colour-coding system	●	●							●			●
Equipment	· No disturbances from HAVC				●							●	
	· No flurescent lighting	●	●	●	●					●			
Safety	· Furniture safety			●		●			●				
	· Material safety		●				●						
Assistive technologies	· Multi-sensory room		●		●						●		
	· Sensory input program											●	●
Escape space	· Escape space	●		●	●	●					●	●	
Transition area	· Visual connection		●					●		●			
	· Sensory garden	●					●	●					
	· Thresholds spaces		●				●	●		●			

Figure 4.133 The presence of architectural and technological elements in different functional buildings

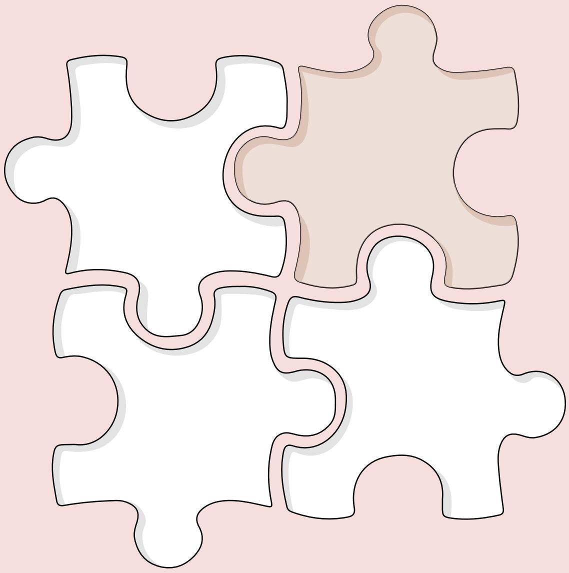
Environment of Children’s Hospital

We choose five representative children’s hospitals as a part of the case study. From the summary table above, the children’s hospital has referential value to the autism medical environment in many aspects, especially the hospital environment atmosphere, wayfinding, and safety. To decrease the tension and pressure of children in the hospital environment, all these five hospitals have a warm and home-like atmosphere. According to the literature review, people with autism also need a home-like built environment because they tend to feel nervous. In addition, graphic symbols are used in all these children’s hospitals in the wayfinding system. Easy-understand symbols and colour coding are a benefit for children and people with dyslexia to find the departments in the hospital. Different departments are given their own identity, by using graphic symbols, colours, spatial illustrations, and typography. The safety issues could be considered carefully in the children’s hospital. The edge protection around the chair leg is used in Texas Children ’s Hospital that even if they have aggressive behaviours, the chair leg avoids being a weapon. This design strategy can effectively reduce potential safety hazards for autistic patients with destructive behaviour and hypo-sensitive autistic people who unaware of danger.

As mentioned above, there are many aspects of the children ’s hospital environment that are also friendly to autistic patients, but there are also some aspects that are not suitable for autistic patients and cause a negative impact on them. For example, in children’s hospitals, various bright colours are used, but for hyper-sensitive autistic people, it is a visual distraction. It would cause visual overload and bring negative emotions. In summary, although some aspects of children’s hospitals will cause sensory overload such as the use of bright colours, in many aspects it has referential value for autism-friendly spaces.

Children hospital	5. The Royal Children's Hospital Melbourne 4. Randall Children's Hospital 3.Texas Children's Hospital The Woodlands 2. Nemours Children's hospital Orlando 1. Emma Children's Hospital					
Architectural and technological elements	**Architecture design strategies**					
General environment	· Warm atmosphere					`
	· Minimized visual distraction					
Sound	· Minimized noise exposure					
	· Acoustic structure or materials					
Colour	· Mute and natural colour					
Lighting	· Sufficient natural lighting					
	· Controllable artificial lighting					
	· No glare and reflection					
Smell	· Good ventilation					
Tactile	· Tactile intervention					
Space hierachy	· Simple layout					
	· Sensory zoning					
	· Curved wall					
	· Multi-functional area					
Wayfinding	· Graphic symbols					
	· Colour-coding system					
Equipment	· No disturbances from HAVC					
	· No flurescent lighting					
Safety	· Furniture safety					
	· Material safety					
Assistive technologies	· Multi-sensory room					
	· Sensory imput program					
Escape space	· Escape space					
Transition area	· Visual connection					
	· Sensory garden					
	· Thresholds spaces					

Figure 4.134 The presence of architectural and technological elements children's hospitals



5. Introduction of Autism-friendly Hospital Environment Research

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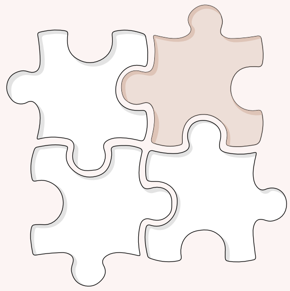


5.1 Summary of design considerations

5.1.1 General environment

People understand the world through the sensory system. For ordinary people, after the input of the complex information got from the sensory system, people can handle the information in time and in order, filter or block the unimportant information, finally the effective information will be retained. However, dealing with sensory input is very difficult for people with autism. They are very sensitive and can perceive details that are not noticeable for ordinary people but are unable to handle these sensory stimuli. In a sensory overloaded environment, autistic can't concentrate and even lead to repetitive behaviour, stereotypes or anxiety. Therefore, the well design of built environment is very important to ASD users. Non-distracting environment, the controllable environment and informal atmosphere are three key points for an autism-friendly building proposed by these publications.

Non-distracting environment

Considering difficulties faced by people with autism in the receiving or process of sensory input, and they are easy to fall in the feeling of sensory overload, the codes of Building Bulletin 77 and Designing for Special Needs, Richer & Nicoll, Khare & Mullick, Humphreys, Vogel, Scott, and Sánchez et al., all these authors clarified the importance of a non-distracting environment to autistic people, minimizing various stimuli helps to increase the attention of ASD people within the building. In their opinion, the built environment should be low sensory-stimulus as much as possible, reduce distracting settings from acoustic, visual, smell and tactile distractions. Sánchez et al. elaborated clearly in their article that the designer should carefully select colours, textures, patterns, acoustic properties of the different materials and constructive elements used in the autism-friendly environment. Humphreys pointed that it is better to minimise and limit complexity of detail, also Scott held the same idea, because of the fact autism users have difficulties filtering foreground and background information and they are often capable of perceiving details that are unnoticed by others.

The controllable environment

Control of architectural elements is another consideration of the non-distracting environment, the code Designing for Special Needs, Richer & Nicoll, Scott, Vogel as well clarified that increasing the control of the environment can not only help ASD users feel comfortable but also offer them the emotional sense of safe. It means that sensory experience can be adjusted during people use the building. For example, a dimmer can be used to control the intensity of lighting, allowing the interior to have different levels in different times, use window blinds to control the sunlight input.

Informal atmosphere

Building Bulletin 77 pointed that materials, special equipment and everyday items should avoid an institutional appearance. Vogel emphasized that make the atmosphere of the classroom feel at home can allow children to relax and retain more information, the homey atmosphere can be achieved by warm finishes, softer lighting and cosy furnishings. Ahrentzen & Steele suggested by the carefully selection of materials to create a warm family environment rather than creating an institutional atmosphere.

5.1.2 Autism-friendly criteria

Space hierarchy

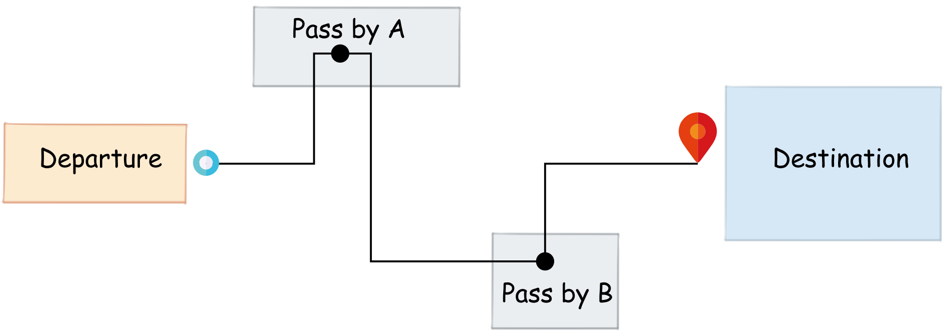
(1) Simple layout

The design consideration of a simple and clear layout has been emphasized by many authors, the reasonable zoning, direct route and clear spatial hierarchy can help people with autism understand the spatial structure and feel easy to use the provided service.

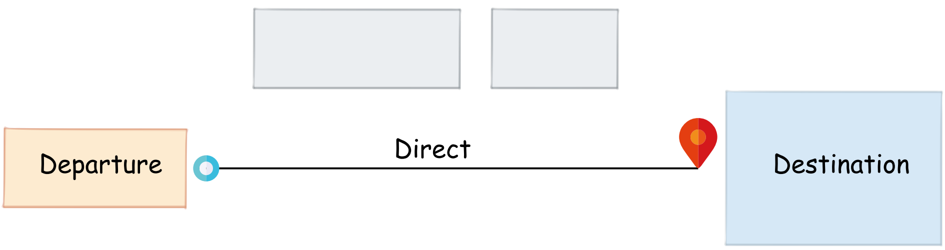
The published codes Building Bulletin 77, Building Bulletin 102 and Designing for Special Needs, the authors or institutions of these publication and Simon Humphreys, Scott as well, all suggested that the building designed for people with autism should have an ordered and comprehensible spatial structure. Humphreys said that if there are too many changes in routine and sequence make autistic people confused about space.

One of the key points proposed by Khare & Mullick in 18 autism friendly environmental design parameters for autism-friendly school is "Maximize comprehension", they pointed that "Clear layout, direct routes, clear zoning, simple forms, and no visual clutter assist pupil with autism to perceive the school environment easily"

✗ The complex layout and cross visiting flows can cause confusion.



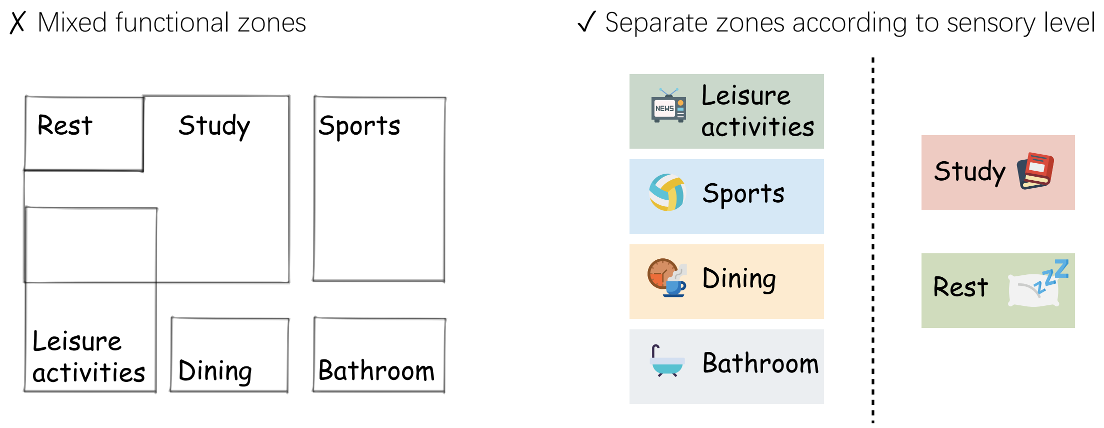
✓ The simple layout can help autism users find their destination easily and quickly.



(2) Sensory zones

Many autistic people have sensory issues, their over-developed (hypersensitive) or under-developed (hyposensitive) sense have an impact on how people experience different environments. To solve this issue, Mostafa highly suggested in her paper that building spaces should be organized in accordance with their sensory quality rather than their programmatic function, grouping spaces according to their allowable stimulus level, organizing and dividing space into zones of the high-stimulus and low-stimulus. This strategy is implemented in her design of The Advance School for Developing Skills of Special Needs Children, Cairo, Egypt and help autistic children to follow the schedule of school activities, children can study and learn skills in a quiet area and move to high-stimulus zone for group activities such as swimming and playing, gradually learn to adapt the various sensory environment.

Ahrentzen & Steele studied on residential buildings designed for autism, they also suggested similar design strategies that separate high stimulus areas (e.g. TV room, exercise room) with low-input transition zones to allow for sensory recalibration.

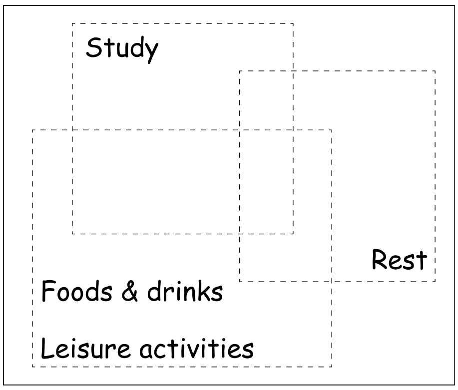


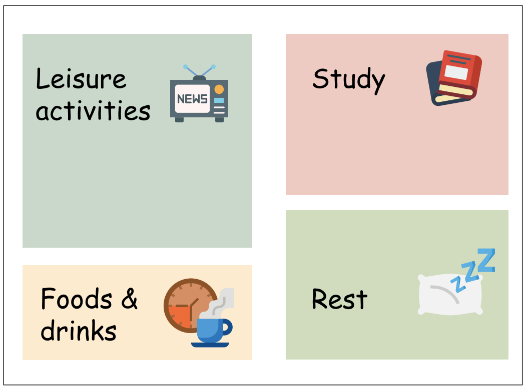
(3) Space definition and visual cues

Functional zoning is often emphasized in architectural design, the built environment shows different characteristics according to different activities in this area. Humphreys explained his point in “Distinction” that means there is a distinction between types of spaces for people with autism so that they understand expectations placed upon them. He made the distinction between spaces for work and leisure and living clearly when he worked on residential projects for autistic people.

It is easy for common people to quickly know the function of an area by the observation of the built environment or ask for help by related staff, but this simple matter probably can’t go well with autism users due to their weak spatial cognition and communication skills. Khare & Mullick suggested to “Maximize Visual Structure”, which means that organize visual environment through concrete visual cues and visual importance by incorporating colour coding, numbers, symbols, labelling, illuminated sign boards, highlighters etc. The different intensity of brightness of the light can be used to distinguish the functional level of the space. Use brighter lights in relatively open areas, and properly dim the brightness of the lights in a relatively private space. The presence of these visual cues to explain the definition and function of different space help autism users to understand the spatial structure and use its service.

✓ The functional area should be clearly defined and equipped with visual cues for the easy understanding of space structure.

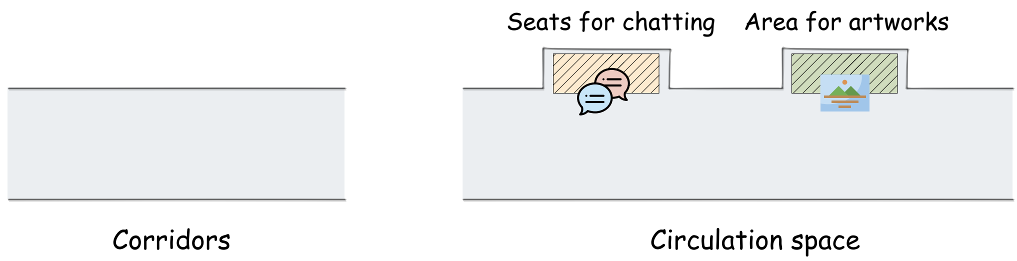




(4) The use of circulation space

Beaver suggested using multi-functional circulation space with storage, rest and social activities function to replace the boring corridor, he implemented this strategy in the design of school for children with special needs. As he stated in his article "We have banished the corridor from our buildings and even the word is now outlawed. Of course, there has to be a means of getting from A to B, but we prefer to call that the circulation space. It has to be an interesting space, not just a box shape and should be multi-functional." He pointed that the long corridor space can be broken into several pieces of different sizes for seats, storage space, or exhibition of some art works, giving people a space to rest, socialize and some informal activities. In this way, the institutional corridor can be turned into a social and activity space and might almost call it the focal point of the building. The circulation space not only has the traffic function, also becomes multifunctional and interesting. "There is no doubt that the children feel liberated by the sense of freedom this space offers them" said by Beaver.

✓ The multi-functional use of corridors can break the boring space form and institutional atmosphere.

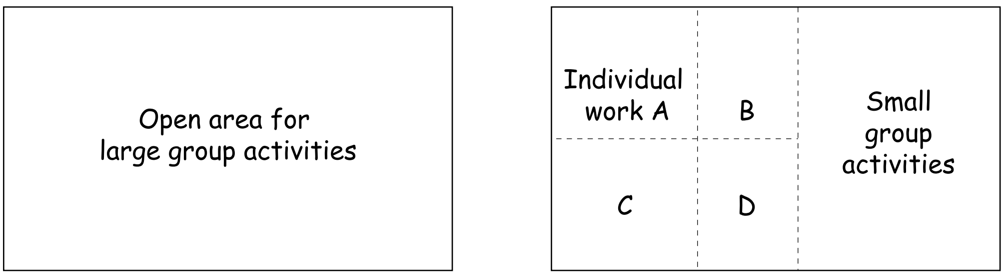


(5) The flexibility of space (especially for school)

Simon Humphreys thought that the preference of each individual is different. It is important that spaces are as flexible and adaptable as possible within the need to maintain sameness. The space can be adjusted according to the need of educational and treatment activities. Vogel explained the flexibility of space more in detailed in his paper researching on autism-friendly classroom, that is flexibility doesn't mean constant change, but rather being able to transform an environment on a moment's notice, rolling shelving units and furniture pieces that are easy to move are suggested.

People with autism have problems communicating and interacting with others, so it is necessary to provide them with some space to promote social interaction. The consideration of flexibility of space is usually applied in autism schools because the flexible classroom space can adapt to teaching activities of different sizes. The larger open space is used for group teaching activities, providing students with ample space for social activities and communication. Blocking the interference of outside helps students focus on learning and ensure privacy as well. Furniture, screens, or partition walls can be used to divide the space into small compartments for personal activities or one-on-one teaching. But using furniture as a partition to divide the space have potential safety issues, Richer & Nicoll, Beave and Sánchez et al. indicated that all the furniture and fitting in environment must be well anchored to prevent moving out of its space.

✓ The flexibility provides possibilities for activities of different scale.



Wayfinding

Wayfinding refers to the navigation systems inside the building that guide people to the current location and direction of different departments. The easy-understanding wayfinding can lead to more effective use of spaces and is particularly important in school, theatre, exhibition hall, hospital and other buildings with complex functions. Regards to some people with ASD have a weak spatial cognition ability, a good and reasonable wayfinding system is more important to them and can help to relieve the anxiety to find their way inside the building.

The simple layout and visual cues mentioned above are important parts of a good wayfinding system. The use of signpost with text and symbols, colour coding, numbers, symbols, labelling, different tactile materials and other varied wayfinding techniques can help autistic users navigate their way in built environment. Beaver proposed curvilinear design, which is an optional wayfinding strategy. In his opinion curved walls help children to move through the building rather than sudden corners because they like to follow the curve.

Sound

As Humphreys pointed out, people with autism often have to make an enormous effort to differentiate sounds and are more sensitive than other people to noises, the control of acoustic environment is especially important for them. Some of them have to work hard to distinguish useful sounds from background noises.

Mostafa proposed that acoustical environment should be controlled to minimize background noise, echo and reverberation within spaces used by individuals with ASD. The most effective sound insulation solution is to position spaces carefully, the area required quiet environments should be arranged in the place with fewer noises in the overall plan. But this strategy can't be applied in general since some buildings with public use or specific use have professional layout rules. In the other hand, the high quality sound insulation is the alternative way to avoid disturbance and distraction. The methods suggested by Beaver, Ahrentzen & Steele is to use sound-absorbing insulation in ceiling and walls to reduce noise levels, moreover, add carpet on the floor to reduce the impact of foot traffic and absorb noise from movements, use quiet system to minimize ambient noises. The continuous and hum noises from machines such as heating systems, ventilation systems, air conditioners, should be avoided as much as possible since exposed to such sound disturbances may lead to their anxiety and panic.

Colour

Colours play an important role in the 'feeling' of a building, people usually benefit from colour. The combination of cosy colour, lighting, furniture and other architectural elements can create different indoor atmospheres to adapt to different functional built environment. Colourful interior decoration rich users experience and have a positive influence on psychological, making people feel comfortable and warm. But for visually sensitive vulnerable groups, including people with autism, the visual stimuli caused by inappropriate use of colour have a negative impact on them.

The advice of neutral and calm colour scheme for interior decoration are carried out by many authors, including Building Bulletin 77 and 102, Christopher Beaver, Teresa Whitehurst, Khare & Mullick, Ahrentzen & Steele, Sánchez et al. They suggested using the colour scheme without various visual stimuli like bright and disturbing colours, large coloured area, can make ASD users feel peaceful, calm and help them use the service of building easily. The challenge faced by architects is to find a balance between the muted and soft colour scheme and an informal atmosphere, since the cool colour of finished and daily items usually have institutional appearance.

Moreover, the choose of colour is subjective, the preference can be different according to different individuals. Beaver suggested providing opportunities for people to choose the colour they prefer to use. Due to some of autistic people have weak cognitive ability of colour, the use of colour contrast is also important, some different and contrast colour should be used to highlight functional features or fittings to make it noticeable from the background.

Lighting

Nature lighting

Lighting can be generally divided into natural light and artificial light. Since natural light has been proven widely that it is good for people's health and mood, it should be provided as much as possible instead of artificial lighting. But the control of sunlight input is important for ASD users within building environment, because the glare and direct lighting produced by natural lighting is a kind of visual stimuli to them. Simon Humphreys emphasized that the dazzling sun, deep shadows or excessive contrast of light produce visual overstimulation. He pointed out the use of skylights and clerestory windows can help in getting diffuse lighting. Windows with adjustable blinds that allow the staff to control the intensity of the sunlight can be used.

Artificial lighting

Artificial lightings are ubiquitous in the built environment. The flicker of lighting is widely mentioned as a factor that has a large negative impact on people with autism, it may cause headaches and even lead to vision blurred because some of them have sensitive visual abilities and they are able to see these flickers which are usually unnoticed to normal people. Almost all authors indicated that visual stimuli from artificial light in the built environment should be eliminated, the lighting environment that is flicker-free, with diffuse and uniform lights is recommended. The glare produced by the source of light and reflection of materials should be avoided as well. This issue can be solved by installing a diffuser on lights, using an indirect light and using materials with non-glare surface. In addition, Richer & Nicoll suggested using light dimmers to allow staff to control the lighting within the room, which makes the architectural elements under control. As mentioned above, the design of lighting is an important part of creating a warm atmosphere. Vogel mentioned that soft and warm lighting can be helpful for a welcoming environment.

Smell

People with autism show abnormality in perception to smell, the strong odour brings them anxiety and panic. According to some autobiographies of autistic people described in the article of Kinnaer & Baumers & Heylighen, some people with autism cannot accept the smell of perfume, hair spray, exotic foods, the foul odour of toilet and garbage. One the on hand the source of some smells can be eliminated by keeping the environment clean and using the fragrance-free products (e.g., scent-free perfumes, air fresheners and soaps). On the other hand, as recommended by Ahrentzen & Steele, adequate ventilation, both natural and mechanical can promote the flowing of air and contribute to keeping the indoor air fresh and reducing unwanted smells, which help to reduce the negative effect of strong odour on individuals with sensitive sensory.

Natural ventilation is mainly achieved through windows, Beaver suggested that a suitable high-level window can help with ventilation and window on two sides for cross ventilation is recommended. In his opinion, windows on one side never work well. There is the need to get a balance of the conflict of different architectural elements that is on the one side the amount, position and size of window can help with ventilation, but it also brings the potential risks of poor sound insulation and safety issue.

Natural ventilation is the priority, but some cases where mechanical ventilation has to be used are also considered. Mechanical ventilation enhances air flow in the room and eliminates strong indoor odours. The air vent should be placed in a position to absorb clean air to prevent recirculation of the exhaust gas.

Tactile

Tactile is a means for people to perceive the world, through the contact of skin with the surface of objects, people can feel the unique properties of different things. With the continuous accumulation of tactile experience, it can also be transformed into visual information. For example, when people see soft velvet blankets, they can know that such materials have a smooth and comfortable feeling from past experience.

The impairment of tactile in individuals with autism has harmful effects on their everyday lives including social interactions. The most obvious and common behaviour of hypersensitive autism people is that they fear unwanted tactile contact, especially skin contact with others. They usually reject or feel hard to shake hands with others. The built environment should be able to provide enough space for movement and activities to avoid unnecessary physical contact. For example, when the waiting space is small and narrow, the seats are closely connected, it is uncomfortable and painful for autism users to seat closely to adjacent people with the risk of touching their arms.

On the contrary, one of the common symptoms of hypo-sensitive people with autism is they cannot feel the surrounding environment through touch, or even cannot respond to physical injuries in a timely manner. Some of them are unable to feel hurt when touching the objects with high temperatures such as hot water from the water dispensers and eventually causing burns. Higher pain thresholds make them have an urgent need for a safer environment. Mostafa suggested adding a fitting protect student from hot water.

Vogel recommended implementing materials like beanbag chairs, stuffed couches, carpeting, swings, clay, and water in the classroom as sensory inputs to help hypo-sensitive autistic students increase their tactile cognition. But this method is a kind of sensory therapy, which is mostly used in schools and treatment centres designed for people with special needs. For the built environment that people use every day, the surfaces of building materials, interior furniture and decorations should be smooth or soft, such surfaces make them feel comfortable. Some studies have shown that clay, glue, and rough materials can cause uncomfortable tactile experiences to them.

Safety

Building structure

All the articles mention the importance of safety for people with ASD. The building structure should be careful designed to prevent them from falling down, slipping on the floor, and easily opening the doors and windows. Vogel proposed in his paper that potential physical hazards in the classroom should be avoided as much as possible, such as wiring, open stairways, unscreened windows, loose flooring, toxic paints and etc. And the use of transparency in windows and doorways would ease transitions between space and make a child feel safe. Building Bulletin 77 indicated that safety precautions about doors, windows, glass, plaster and piped or wired services are required for an autism-friendly environment. Beaver pointed out the safety problem of windows. He suggested using mechanisms to restrict windows opening and making it can be controlled from a distance. Glazing should be made of safety glass, both on the exterior and the interior sides.

Materials

It is generally recognized that materials used in the environment including building materials, furniture, decoration and daily equipment, should be durable, easy-cleanable and free of chemical odours. In the view of Ahrentzen & Steele, it needs to pay particular attention to specifying products and materials to reduce exposure to toxic chemicals. Vogel stated that soft surface can reduce the potential risk of falling down injury.

Furniture

Two of the key points proposed by Khare & Mullick in 18 autism-friendly environmental design parameters for autism-friendly school is “Maximize safety” and “Maximize durability and maintenance”, the safety of furniture, fixtures, equipment, fittings and other items should be maximized, while the durability and maintenance of equipment, hardware, furnishing, fitting, furniture prevent damage and misuse by pupils. Mostafa thought that fittings to protect from hot water and avoidance of sharp edges and corners are examples of safety considerations. Beaver stated that fittings must be firmly fixed, otherwise, they could be pulled out of their place. Sánchez et al. had the same opinion that lighting fixtures and mechanisms, hardware, banisters, wall and floor tiles, etc. must be well anchored. Moreover, Beaver also said that jumping opportunities and foothold provided by furniture and fixtures such as bare pipes and radiators must be avoid, because people with autism, especially children may climb on it and fall down from high.

Equipment

Common equipment
Hum noises produced by machine is an unbearable noise for autism users in space. These constant noises stimulate their auditory nerves, making them unable to concentrate and even causing headaches. Common equipment in buildings, including heat, ventilation and air conditioning, should be free of noises and vibrations. Ahrentzen & Steele said that the appliances and equipment used at home should be not only easy to use but also quiet.

The radiator in the room may cause visual disturbances to the ASD suffers and there are security risks. Beaver pointed out that children might climb and fall off from radiators. Also Whitehurst suggested replacing radiators by under floor heating due to the safety issue and offering uneven temperature. If the radiators are inevitable, it is necessary to make them inaccessible to people with autism, especially children. Considering about the different temperature requirements of individuals, the temperature-adjustable heating system can provide a more comfortable indoor environment.

Professional mechanical
Different professional equipment in different building need to be considered carefully. For example, computers, projectors, loudspeaker in the classroom, refrigerators with hum sounds, vacuum cleaners with loud noise at home, medical equipment in hospitals, and a variety of alarms that greatly increase the senses pressure of people with autism. These sensory disturbances make ASD suffers unable to concentrate and may lead to anxiety. Overall, this criterion needs to be discussed in detail based on the different of the built environment.

Assistive technologies

As technology is used more and more widely, technology intervention plays an important role in autism therapy, such as interactive programs, virtual reality, music therapy, sensory therapy, etc. Richer & Nicoll recommended offering places for sensory experience, because such space can reduce stimuli and promote communication with others. Khare & Mullick also suggested providing the sensory integration experience in school's environment, multisensory stimulations offer opportunities for rolling, jumping, spinning, vibrations, music, different sensory experiences help them learn skills to adapt the sensory world. The codes Designing for Special Needs and Scott suggested using technology appropriately to aid the autistic learning experience. Beaver believed that multisensory room and garden can be provide for an autism-friendly environment. There are many multisensory rooms designed for autistic people, such as Snoezelen, MEDIATE, RDE, to help them improve communication and cognitive ability. Besides, interactive computers programs are popular with children on the spectrum. Such technology interventions are usually implemented in autism schools or autism centres where help ASD suffers to improve their ability to better integrate into society.

Escape space

As early as 1971, in the pioneering work of autism and the built environment, Richer & Nicoll mentioned the importance of a low sensory stimuli, quiet and private space for hiding and retreating, they called this space "retreat space". They provided a no-stimulus retreat box in which child could calm down. In 2008 when Mostafa carried on the intervention experiment to test impacts of architectural elements on children with autism, she found that it is important to establish an "escape space" in the classroom, the area should be in the lowest stimulation area of the classroom. Beaver recommended providing "quiet rooms" with simple decoration where a child can release the stress of the sensory experience, Khare & Mullick called it "withdraw space" where is a quiet area that keep autistic children away from unnecessary stress and anxiety. Scott noted that the requirement for a withdrawal space, which has a calming, therapeutic atmosphere for children with ASD.

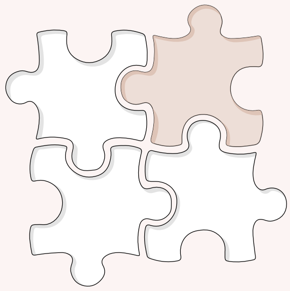
In general, a quiet space or a small divided area in a building can be used as an escape space. It is a place that allows people with autism to get rid of excessive stimulation and pressure and anxiety. Whenever ASD suffers are anxious and overwhelmed by overload sensory inputs, they can escape for space aid.

Transition area

The transitional space can help people with autism adapt to environmental change in advance. Scott mentioned that autistic children have a fear of ‘difference’ including spatial or environmental differences, they tend to become uncontrollable and anxious when the environment changes suddenly, a preview of next environment is especially important for them. Mostafa indicated that the presence of transition zones helps the user recalibrate their senses as they move from one level of stimulus to the next. It can be used in the separation of different functional spaces in the room, or in the junction of indoor and outdoor spaces. The transition area has no uniform form, can be a recessed threshold space where allows temporary staying for observation. A properly positioned window can serve as a transitional space because it offers a visual connection between areas.

The soft built environment is another kind of transitional space. It provides comfort and relaxation for autistic people, and the replacement of hard corners make the building space safer. Beaver mentioned that curved walls can avoid sudden turn of space, children like to follow curved walls to move. He designed curved walls for an autism-friendly school, and result in a pleasant achievement. The building assessment carried out by Whitehurst after the occupancy of school, showed that these curved surfaces are loved by children and occasionally, it helps them to navigate inside the building since children preferred to follow the direction of walls. She said that these curved walls provide visual guidance which are especially helpful for people with visual impairments.

Other authors expressed the similar design strategy of transition space, Vogel emphasised the “predictable of space”, Sánchez et al called it “imagination”, both of these opinions mean that ASD people need intermediate transitional spaces between two different areas where give them opportunity and time to adapt to the new environment and activities in advance and reduce the anxiety.



5.2 Definition of a prototype tool: 3STI

The prototype of Autism-friendly environment evaluation tool

The conclusions of the literature review and case study are outlined in a series of design considerations and design strategies for autism users within buildings. Although the current research is mostly based on the built environment of schools, homes, and autism medical centres, we think that the high ranking factors pointed out by these authors have the similar impacts on autistic children and adults, the research results are scalable and replicable and can be coped for other environments.

Resultant from the study, we summarized 6 characteristics of autism-friendly space, which are non-distracting, controllable, understandable, warm atmosphere, safe and predictable. Environmental characteristics are affected by following 12 architectural and technological factors that have an influence on the comforts and behaviours of autistic people:

About the space structure: “Space hierarchy” and “Wayfinding”
About sensory environment: “Sound”, “Colour”, “Lighting”, “Smell” and “Tactile”
About safety issue: “Safety”
About technologies: “Equipment” and “Assistive technologies”
About positive space interventions: “Escape space” and ““Transition area”

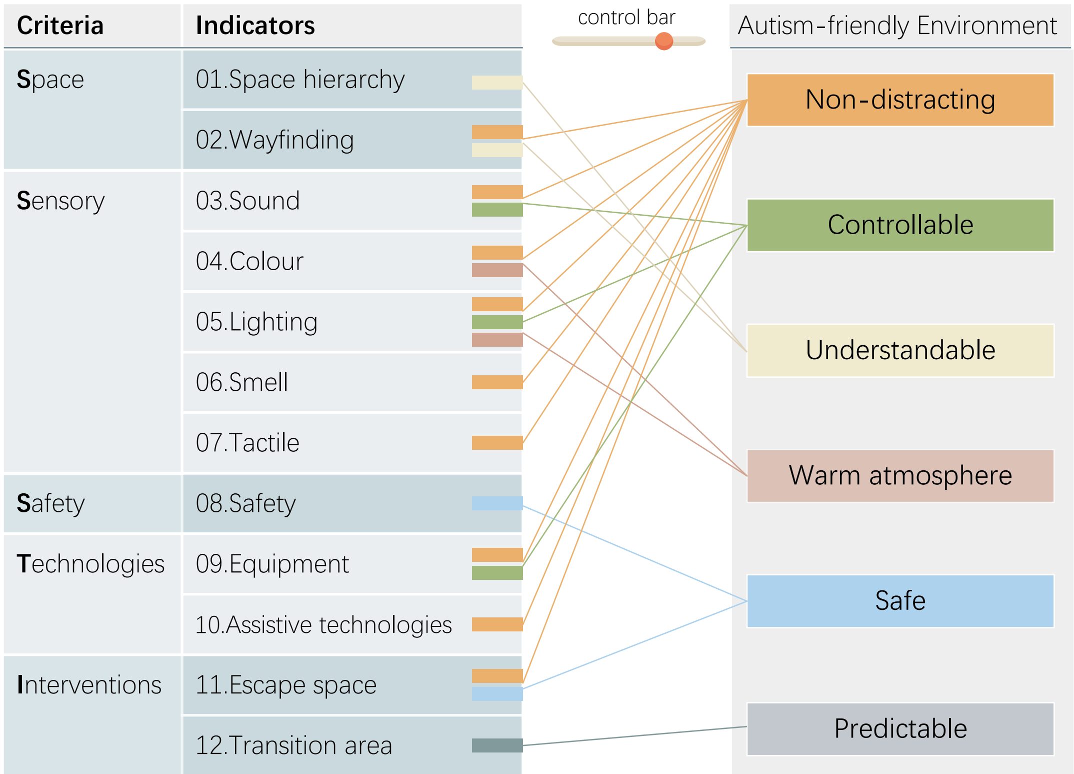
The presence of 12 criteria in the space determines the degree of accessibility of this space for autism users, it is like the controller to control the performance of the built environment. The positive presence can provide a comfortable environment for autism users, on the contrary, inappropriate design will bring them sensory stimuli and spatial pressure. Based on these conclusions, we propose an autism-friendly tool called 3STI.

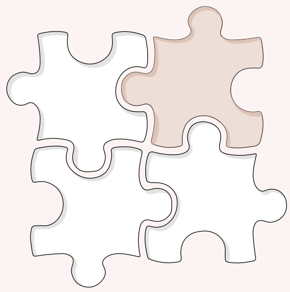
“3S” from Space, Sensory and Safety
“T” means Technologies
“I” means Interventions

The prototype 3STI is in general and clarifies what kind of environment ASD users need and which criteria can influence on the built environment, aiming at improving autism-friendly built environments. Considering that different building has its unique design rules, such as functional layout and interior decoration, subsequent research can be carried out based on this prototype. Through the analysis of each criterion, the tool can be converted into 3STI for specifically building, which means that the built environment on this criterion must meet both the needs of its own functions and the requirements of users with autism.

Our paper focuses on the different spaces in the healthcare building, the research results can present a group of suggested guidelines that can be used by architects to design hospital environments for autistic users, or to guide the reconstruction of the existing environment, and can also be used to evaluate friendliness level of the medical built environment.

3STI -- The prototype tool for autism-friendly environment





5.3 Introduction of autism-friendly hospital environment research

5.3.1 Scope of research

The great challenges faced by architecture designers of healthcare buildings are reconciling the need for patient safety, effectiveness, and efficiency, as well as the need to create a truly therapeutic environment. As people's requirements for medical quality and medical services continue to improve, hospitals must improve the quality of medical services, also improve the hospital environment and optimize the process of medical treatment, in the main time meeting the physiological and psychological needs of doctors and patients. To achieve this, the quality of the built environment is very important for healthcare buildings, where well-designed healthcare buildings can help patients restore health and have a positive effect on staff's performance and retention.

In Chapter 1&2, we studied the knowledge structure of autism architecture. We found that there is a gap in the research and actual needs. Most research on ASD-friendly built environments based on schools, medical centres, and homes environment. These spaces are designed to provide services for autistic people or other people with special needs, so designers will pay particular attention to ASD-friendly design. But in life, these people with autism will not only go to school and medical centre to study and treat, they also go to general hospitals for medical services. Existing medical building design guidelines propose to provide inclusive services for various groups of people including disabled persons, people with visual or hearing impairments, injured patients, elderly people and etc. Research on ASD-friendly medical environment is still lacking. The research in this chapter focuses on how to apply ASD-friendly design considerations to medical buildings so that this group of people can use medical services in a comfortable environment.

For people on the autism spectrum, visiting the doctor can be an overwhelming experience. Confronted by the beeping of common and medical equipment and the bustling noise of the reception area and waiting area. They're barraged by a flood of sensory stimuli: bright fluorescent lights, crinkling paper, the acrid scent of rubbing alcohol. In view of the current situation, the inclusive design of hospitals does not take into account the needs of these ASD users. Our scope of this research is to consider inclusive design for the neglected autism users, to propose ASD-friendly design consideration for hospital space so that they can use hospital service equally with all people.

5.3.2 Autism-friendly hospital environment research framework

(1) The list of official design guidelines

Many countries have published design guidelines for healthcare buildings, of which the series published documents by the UK's Nation Health Service Estates (hereinafter referred to as NHS) is authoritative and comprehensive. Its series of publications provide design guidance for new medical buildings, as well as advice for medical building renovations. The design guidance considers various functional spaces of hospital and the special needs of different users. Our research will base on this series of documents, the main references we used include HBN series documents：

Health Building Note 00-01 General design guidance for healthcare buildings;
Health Building Note 00-03 Clinical and clinical support spaces;
Health Building Note 00-04 Circulation and communication space;
Health Building Note 00-09 Infection control in the built environment;
Health Building Note 11-01 Facilities for primary and community care service
Health Building Note 12 Out-patients department
Health Building Note 12-01 Consulting, examination and treatment facilities

These documents provide design guidelines for the important space of the hospital, such as the entrance, reception area, waiting area, circulation space, consultation room and in-patient wards. According to requirements of these documents, a clear and relaxed medical space for patients who come to the clinic can be provided.

In addition, the NHS also published documents specifically about lighting, colour wayfinding and other detailed requirements, these documents will also become the basis of our research.

National Health Service: Lighting and Colour for hospital design;
National Health Service: Welcoming entrances and reception areas;
National Health Service: Wayfinding

(2) Focus areas

The Health Building Note proposed the visiting flow of patients in hospitals as following figure:

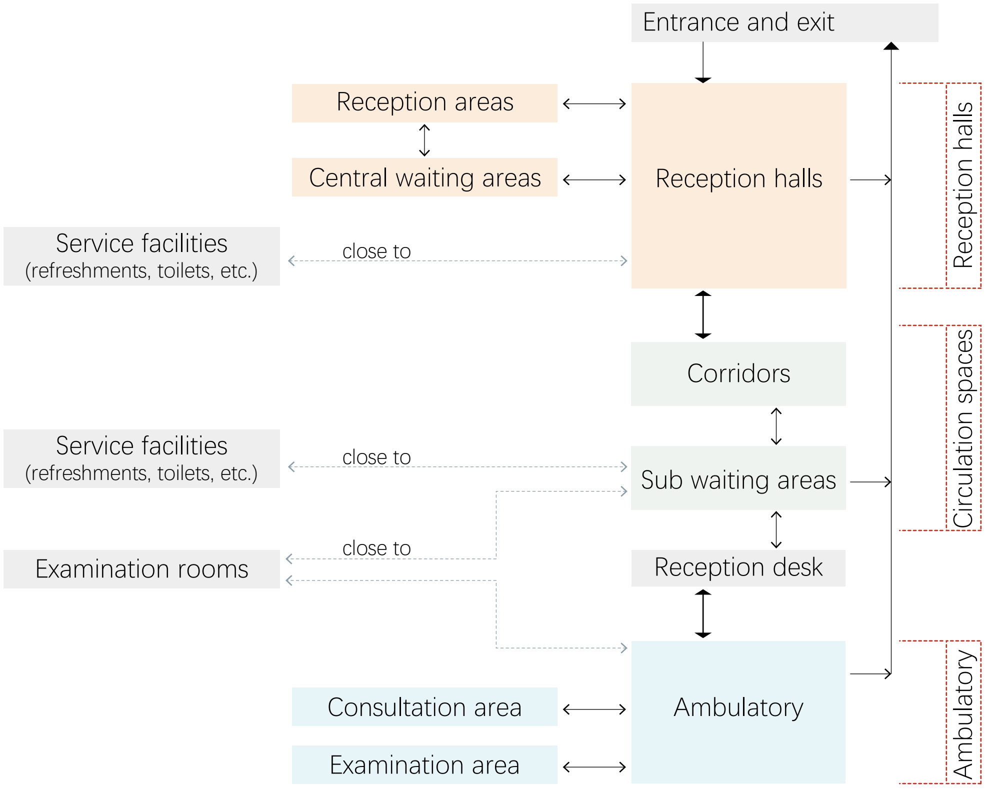


Figure5.1 Visiting flow of patients in hospitals

Based on the visit flowing of patients in the hospital, we focus our research on the following three areas and we think these three areas are the places where people use the most frequently in the hospital

I Reception hall

This is the first place visited by patients after entering the hospital. Its functions mainly include the reception desk for consultation information, waiting area and various auxiliary facilities.

II Circulation spaces --- Corridors and Waiting areas

The circulation space connects patients with doctors of different ambulatory rooms. After the patient knows the exact location of the required medical service at the reception area, they will go to the various clinics through the corridor and wait for consultation services in the waiting area near the clinic.

III Ambulatory spaces

Ambulatory space is the space where doctors provide medical services to patients, basic medical examination equipment also included in it.

(3) Requirements of hospital space from official design guidelines

Through the study of these design guidelines, we get detailed architectural design requirements for the reception hall, circulation space and ambulatory space of hospitals from the NHS documents. Not only some basic requirements that each space must meet, such as space size, location, privacy, and security issues are contained. There are also some patient-friendly architectural design considerations, which guide to provide a well-organized, effective, convenient, and restful hospital space.

(4) Discussion --- Adaptability for autistic people

After the understanding of the general requirements of focus space, we started thinking for ASD users. From the perspective of them, we try to find contradiction points where requirements of hospital space proposed by NHS that are incompatible with ASD-friendly design. These points have stimulation to ASD users from space stress or senses, finally lead to negative effects on people with autism. In addition, we also discussed the requirements that can be improved. These requirements do not negatively affect ASD users, but a more friendly design will help ASD patients to use hospital services. We categorize them and raise questions: how to solve the contradiction between the needs of NHS and autism-friendly design, and how to improve the requirements to make it more friendly to ASD users to provide ASD users a better medical environment.

(5) The application of the prototype in hospital

Based on the accumulated knowledge of the above research, we propose a prototype of a tool for achieving autism-friendly environment, which includes 6 characteristics of the environment required by autistic users and 12 criteria of architectural and technological elements that can have both positive or negative impacts on the built environment, named 3STI. The positive presence and performance of these criteria can create a comfortable and barrier-free indoor environment for them, support their daily activities and to use the services provided in this building. In this section, we will research on how to improve the performance of 12 criteria in hospital environment in order to make each of them meet both the requirements of the medical environment and the needs of autistic users.

(6) 3STI for Hospital

The results of the research are outlined in a range of design considerations and strategies can be proposed for an autism-friendly built environment where enables them to access medical services without barriers. After the research focusing on hospital environment, the prototype tool is transformed into "3STI for Hospital". It can be used to guide the design of hospital environments or the reconstruction of the existing environment by architects. The proposed design considerations can be developed as an auditing checklist for accessing the degree of autism friendliness and accessibility of medical buildings, which means that the tool can also be used as an evaluation tool, especially for hospital spaces.

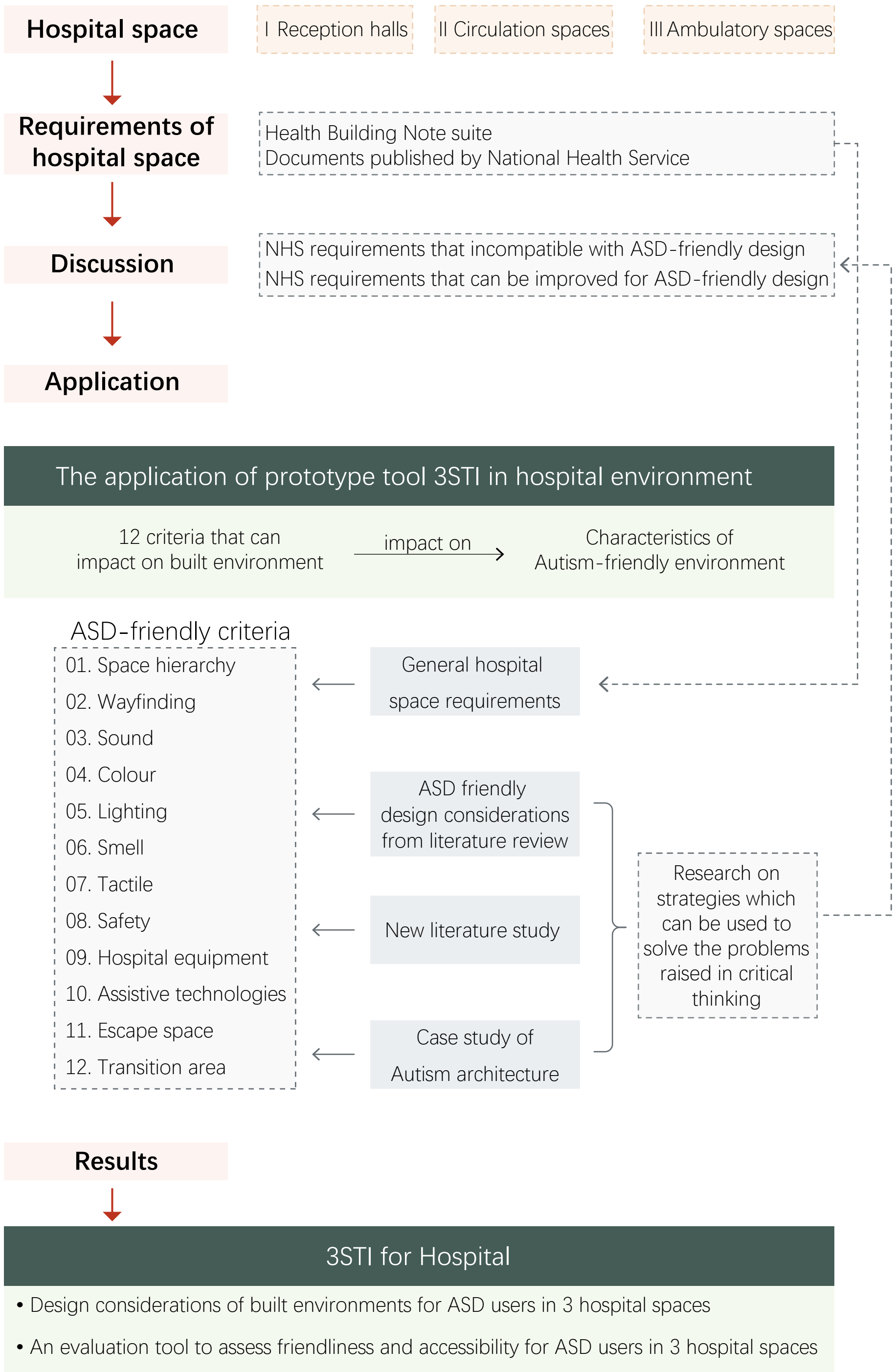
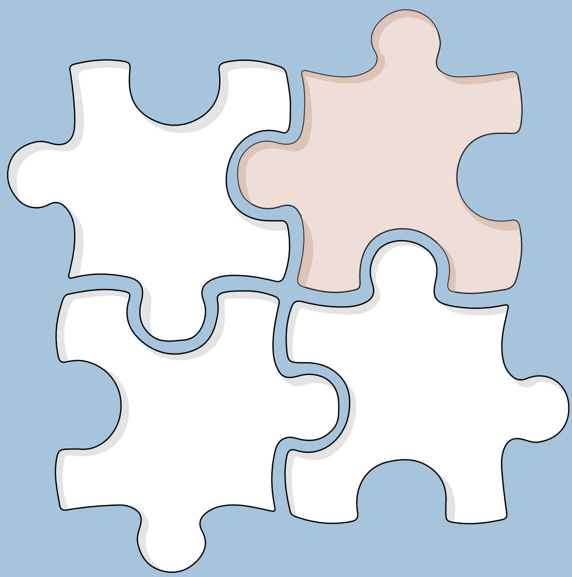


Figure 5.2 Research framework of autism-friendly hospital environment



6. Research on Hospital's Reception Hall

Author: Zhang Lu

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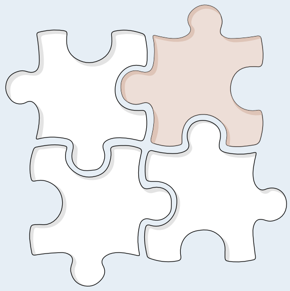


6.1 Official design guidelines for hospital spaces

1. Design requirements of reception hall

Space description：
The entrance and reception area is the first aspect of a hospital building that most users encounter and is also the natural hub of the hospital. It is particularly important, therefore, that it is both functional and aesthetically pleasing. Double-height space with plenty of daylight is a recommended way to create a pleasant atmosphere. The entrance can also play an important part in helping alleviate the fears and anxiety that patients feel on entering hospitals.

While the design of this area will play a vital part in ensuring patients feel welcome, greeting and assisting patients and visitors is even more important. The entrance and reception area are associated with arrivals and departures, waiting, meeting and socializing. It also offers information and assistance. When all these functions are delivered effectively they contribute significantly to the user's whole experience of hospital care.

In the reception hall, the impact of effective wayfinding strategy and signage system in reducing stress levels among patients and visitors should be emphasized. In addition, the design of interior spaces, through the use of materials, finishes, colours and contrasts for building elements, furniture and art work, can greatly enhance the hospital environment.

Summary of reception hall built environment requirements:
1. Reception area
2. Waiting area
3. Affiliated facilities
4. Location
5. Wayfinding
6. Colour
7. Lighting
8. Wall and floor finishes
9. Odor
10. Technologies
11. Connection with nature

Source:
Health Building Note 00-01 General design guidance for healthcare buildings
Health Building Note 00-04 Circulation and communication spaces
Health Building Note 12 Out-patients department
National Health Service Lighting and colour for hospital design
National Health Service Welcoming entrances and reception areas
Health Building Note is abbreviated as HBN below;
National Health Service is abbreviated as NHS below.

1.Reception area

(1) Reception desk

The reception desk is the first point of contact in the hospital. It should contrast clearly with its surroundings. This means that the receptionist and the reception area need to be the brightest part of the visual field.This should be immediately recognizable and not placed so close to the entrance doors as to interfere with the flow of people. An open counter, with a feature or sign at high level, is ideal. A clock should be plainly visible at the desk. The size of the desk and the number of staff should be appropriate for peak usage so that any waiting is brief and queues never form.

(*Source:Lighting and colour for hospital design/P63)*

(Source:Welcoming entrances and reception areas/P18)

(2) Accessibility

.The desk is also an important item of working equipment and should be professionally designed to suit the specific requirements of the hospital.Sections of the desk need to be of different heights for users seated in wheelchairs and those who wish or need tosit, some nursing babies or with small children.

(Source:Welcoming entrances and reception areas/P43)

2.Waiting area

(3) Seats arrangement

It is better to have a variety of seating arrangements: Sociopetal seating to encourage interaction. Sociofugal to promote seclusion.Fixed seating in rigid rows is negative and unsociable since it determines the way users face and limits opportunities to talk.Movable seats is also a good choice since they enable users to choose what suits them.

(Source:Health Building Note 00-01 General design guidance for healthcare buildings/P31)

(Source:Welcoming entrances and reception areas/P43)

(4) Special seats

Seats should be of different heights and some should have high backs and armrests for patients who are physically less mobile.Occupational therapists can advise on appropriate types of seating. All seating should be comfortable and pleasant to touch as well as to look at.

(Source:Welcoming entrances and reception areas/P43)

3.Affiliated facilities

(5) Affiliated Facilities

A number of different facilities may be associated with the entrance and reception area. The following are considered essential:

- toilets;
- nappy-changing, breast-feeding and well equipped bottle-feeding facilities;
- phones (including internal and public phones, text phones for deaf users, and a free phone for taxis) and information displays (health information, notices of events, access and travel information,local advertising);
- a cafeteria/lounge offering refreshments;

- an outlet for purchasing magazines,stamps, phonecards etc;
- parking ticket/change machine;
- a water dispenser;
- a card dispenser for bedside communication services (TV and telephone).

Many other facilities, some permanent, some temporary, may also be desirable. The larger the hospital and the greater the number of users the greater the number,size and scale of associated facilities. Such facilities can greatly enhance the user's experience of visiting a hospital.

(Source:Welcoming entrances and reception areas/P24)

4.Location

(6) Views connection and visual block

- The entrance is a transitory place that people pass through on their way to other areas, so views around and beyond the entrance should be clear and uninterrupted.
- The reception, information or help desk should be immediately apparent but not prevent people seeing the rest of the space or become an obstacle in itself.
- People should be able to see and read signs even when the entrance is very busy.
- Being able to see shops, cafés, toilets, cash machines and other facilities from the entrance makes people aware of them and reduces the need for signs.
- Being able to see staircases and lifts from the entrance helps people find their way more quickly.
- There should be no views from the entrance to patient areas to protect the privacy of patients.

(Source:Health Building Note 00-01 General design guidance for healthcare buildings/P30)

5.Wayfinding

(7) Wayfinding

- There should be a clear, uninterrupted route to the reception or help desk.
- Generous pathways prevent bottlenecks and confusion.
- Variation in materials on the floor can create pathways and help people move around a busy space in a more organised manner.
- Artworks, such as sculptures and murals,may become very effective and memorable landmarks for wayfinding.
- A signboard at this point indicating locations of current clinic sessions, including specialties, names of doctors, starting times and identity of clinic suites, will be helpful to patients and will reduce the number of enquiries

(Source:Health Building Note 00-01 General design guidance for healthcare buildings/P30)

(Source:Welcoming entrances and reception areas/P50)

(Source:HBN 12 Out-patients department/4.4)

6. Colour

(8) Colour scheme

- Colour can be used to further brighten the entrance and make it a refreshing place.

• Colour in the entrance should be bright, light, fresh and natural.

• Dark, dull and cold colours should be avoided as they will make an entrance seem inhospitable and austere.

• Too much colour here will detract from important signs.

• Colour can be used on floors to help identify routes.

• Destinations such as the reception, waiting area or a café could be further identified through the use of an associated colour.

(Source:Health Building Note 00-01 General design guidance for healthcare buildings/P30)

(9) Visual and colour contrast

• Visual contrast is as important as colour contrast, as some people with visual impairments confuse different colours of similar tone.

• Floor colours should contrast visually with wall colours. Monochromatic colour schemes should be avoided.

•Visual contrast may also be used to highlight specific features, for example lifts, stairs, doors,light switches and litter bins.

(Source:Health Building Note 00-04: Circulation and communication spaces/2.5,2.7,2.8)

7. Lighting

(10) Lighting

• Light control

Where the hall may be continuously lit,it is recommended to use energy-efficient fluorescent. At night, lower illuminance are needed to make the hall cheerful, so lighting controls should be provided with dimming, step-switching or programmable scene-setting.

(Source:Lighting and colour for hospital design/P62)

• Lighting noises

Standard frequency lighting can cause a hum in hearing aids. High frequency electronic ballasts will cure this problem.

(Source:Lighting and colour for hospital design/P18)

• Lighting of reception area

Since the visitor will be looking horizontally, the area needs a high level of vertical illuminance, particularly on the receptionist to provide a welcoming face. This is especially helpful to visitors who use lip-reading as a means of communication. For this purpose, lighting over the reception should be positioned between the visitor and the receptionist. Avoid heavy downlighting of the reception desk, as it can make the receptionist look sinister.

(Source:Lighting and colour for hospital design/P63)

• Lighting of waiting area

Waiting areas require a comfortable rather than a brilliant level of illumination.Users often read while waiting and spot lighting should be considered.

(Source:Welcoming entrances and reception areas/P42)

8. Wall and floor finishes

(11) Wall and floor finishes

- Highly-patterned walls and floors should be avoided.
- Floor and wall surfaces should minimise light reflection.
- Floor surfaces should be slip-resistant

(Source:Health Building Note 00-04: Circulation and communication spaces/2.11,2.12,2.13)

9. Odor

(12) Odor of smoking

All entrance and reception areas should be non-smoking. Clear signs informing users ofthis should be placed in advance of entering the building as well as within. In the entrance and reception area, signs should describe the location of smoking rooms in the building and areas outdoors.It is particularly important to make clear that smoking is not permitted immediately outside the hospital's entrance or nearby.Smoking in the open air is less disagreeable to non-smokers but should not be permitted near open windows or doors.

`*(Source:Welcoming entrances and reception areas/P45)*

10.Technologies

(13) Entertainment

Modern waiting areas often have television or computer screens to provide entertainment and information to patients. Lighting should be designed to avoid direct or reflected glare to those viewing the screen.Screens need to be placed where users may view them comfortably and without obstructing or interfering with the proper use of the entrance and reception area since TV and video displays attract attention and invite users to stand or sit in front of the screen. The noise from TV and videos and from broadcast sources such as background music may be unwelcome to some users and should only be heard by choice.

(Source:Lighting and colour for hospital design/P66)

(Source:Welcoming entrances and reception areas/P53)

(14) Notification of medical information

Broadcast announcements using a public address system may be necessary in emergencies.

(Source:Welcoming entrances and reception areas/P53)

11.Connection with nature

(15) Natural lighting

Windows are of key importance; as well as natural light, they provide an outlook, contact with the outside and access to sunlight about which patients are extremely positive.

(Source:Lighting and colour for hospital design/P8)

(16) Transition space

Bringing in external features of the entrance, such as paving or facing brickwork, into the main lobby area can be an interesting device to link the inside with the outside.

(Source:Lighting and colour for hospital design/P63)

(17) Landscape

Plants in an atrium or foyer soften hard edges and give visual pleasure.Plants also absorb much of the light falling on them, lowering the average reflectance of atrium surfaces.

(Source:Lighting and colour for hospital design/P64)

2. Detailed requirements of some criteria from NHS documents

2.1 Hospital wayfinding considerations

"Wayfinding: effective wayfinding and signing systems guidance for healthcare facilities", published by NHS Estates described general considerations of developing effective signs of wayfinding, they can be summary as following:

(1) Key factors of wayfinding signs

- Text

A "clear and uncomplicated" typeface, with a consistent thickness of stem, using upper-case for the first letter then lower-case for the rest of the word. The size of text is depending on positioning of the sign and viewing distance. Information should always be grouped using a logical method and be easy to understand. Signs can be ordered and grouped by alphabet, by function, by direction on directional signs or by floor. The important information should be emphasised to make it eye-catching.

- Symbols

Symbols have the potential to be a universal language, a symbol or pictogram can often be recognised and understood more quickly than words, but only if the meaning of the symbol is clear.

- Colour of signs

The colours used for text and sign background should contrast with each other and also with the predominant colours of the environment. The contrast between the text and the background colour affects the visibility, noticeability and legibility of the sign. Never use yellow with white for signs because it has a very low colour contrast, black text on dark colours for signs have the same problem.

Using a large number of colours (more than five) may make it difficult to differentiate between them, especially for colour-blind people, or when lighting conditions are poor.

- Key information

Key information emphasised using bold type, separated using lines or different colour to make it can be easy-catched by eyes.

- Positioning of signs

Careful consideration needs to be given to the positioning of signs, as it can greatly influence the noticeability, visibility, and legibility of the text on the sign, and the effectiveness of the wayfinding system as a whole. Far above eye-level sign are not comfortable to read, so low-down signs are easily obscured.

- Illumination of signs

Artificial light can be provided around your site to ensure signs are noticeable and legible at all times of the day.

(2) Wayfinding and colour-coding

"Lighting and colour for hospital design", which is a report based on an NHS Estates Funded Research Project, described general considerations of wayfinding and colour-coding, they can be summary as following:

Signs can be presented in different colours for different parts of the hospital, although the colours should be chosen so that the signs are readable. Small areas of colour (for example, in skirtings and cornices) can highlight different areas. Finally, large areas (walls and floors) could be in different colours in different parts of the hospital.

Consistency is vital in the design and implementation of all elements of wayfinding. Large areas of strong colour should be used cautiously and colour blindness should always be taken into account when planning schemes.

Different tones or shades of the same colour should be avoided in coding, for example light blue and dark blue. People can become confused if the same words are used blue.

Identify why, and for whom, the colour-coding will be of use. Colour-coding for patients and visitors should be easy to comprehend with only a few colours. Colour-coding for the benefit of hospital staff can be slightly more complicated; staff should preferably be briefed on the issue.

Colour-coding should not dominate the visual environment. Try to limit the use of colour in a space (for example, on one wall of a corridor, instead of the whole corridor) or to specific features such as signage.

Contrast is vital for legibility for all in signage. Clear spaces around or near signage optimises recognition.

2.2 Hospital colour scheme considerations

Lighting and colour for hospital design, which is a report based on an NHS Estates Funded Research Project, described general considerations of the use of colour, they can be summary as following:

(1) The use of colour scheme

Limit the colour palette: a lot of differing colours may lead to visual confusion and a feeling of unease.

Coordinate colours of all finishing materials (floors, walls, textiles and even noticeboards) for colour harmony.

Do not overuse one particular colour. Blue and white tend to be preferred colours, but their overuse can lead to monotonous depressing environments.

Do not overuse one particular colour. Blue and white tend to be preferred colours, but their overuse can lead to monotonous depressing environments.

Colour controls light and reflected illuminance, so maximise this by using light colours wherever possible including exterior surfaces.

(2) Colour contrast

Help visually impaired and elderly patients by visually marking the changes in floor grade or slope, limiting usage of extreme patterns, and using pale, matt floor finishes.

Use contrasting colours for doors, their leading edges, door furniture and frames. Colour contrast need not be yellow and black.

Consider coloured handrails attached to a wall at waist height, colour contrast at dado-rail height and use colour-coding on floors.

Provide colour distinction between adjacent surfaces for enhanced visibility.

Improve the visibility of architraves, door frames, skirting and doors by colouring them differently. This will especially help visually impaired and elderly patients.

2.3 Hospital lighting considerations

Lighting and colour for hospital design, which is a report based on an NHS Estates Funded Research Project, described general considerations of the use of light, they can be summary as following:

(1) Task illuminance

For the overall hospital environment, artificial lighting should be capable of providing the required levels of illumination at all times, well even and lit. Different illumination for different tasks is equally important. For example, if the task is critical in terms of accuracy and perhaps the detail is small, such as when applying stitches to an open wound, then lighting will need to be at a higher level, or illuminance, than for a less visually critical task such as moving equipment around the ward. Also if lighting is to enable patients to read and the patients are elderly with perhaps poor sight, then a higher level of illuminance will usually be necessary than if the patients are teenagers.

The following table indicates typical illuminance level for different tasks.

Tasks	**Illuminance (lux)**
Circulation areas (corridors from night to day)	50–150
Reading (from casual to critical)	200-500
Examination/treatment (from minor to critical)	500-750

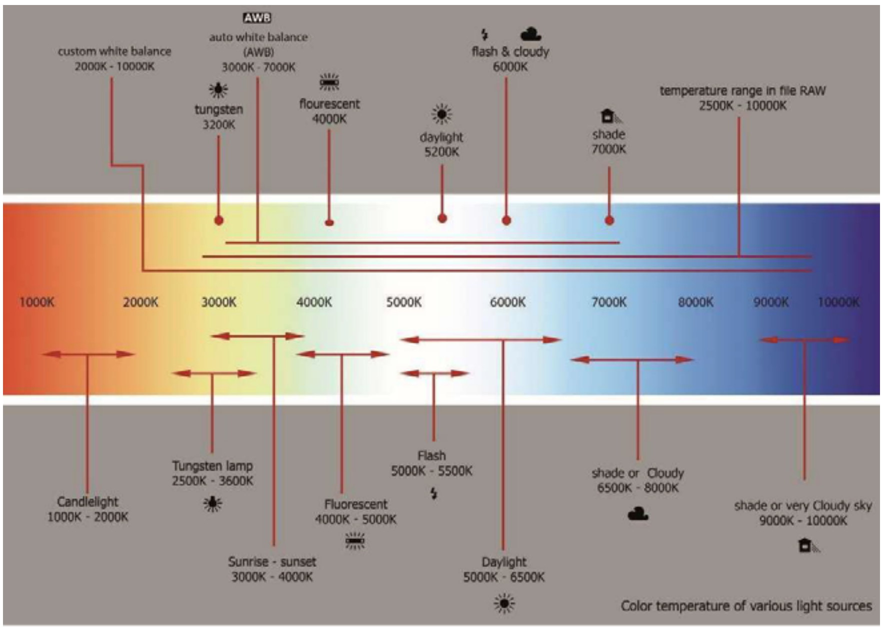
(2) Lighting appearance

Lighting appearance is concerned with the colour appearance of the light. Electric lamps, particularly fluorescent lamps, come in a range of different colours, ranging from those that give a cool to those that give a warm appearance – this is described by a lamp's "correlated

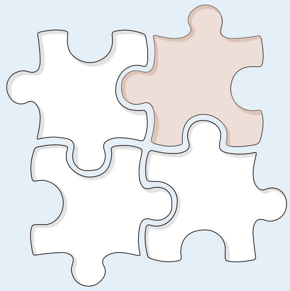
colour temperature" (CCT) and is measured in degrees Kelvin (K).

On balance, since most areas of hospitals have daylight at some time, it is preferable to use a lamp colour that blends reasonably well with daylight but does not appear too cool at night. For this, a light with a CCT of 4000 K is recommended.

Colour temperature chart



(Source: Designing for autism spectrum disorders, Gaines K, 2016)



6.2 Discussion

Discussion: Reception hall

The reception hall is a meeting point where many patients, companions, visitors gather. It is inevitably filled with huge traffic, relatively concentrated noises. For most cases, the reception hall is the space with various sensory stimuli that is easily lead to stress and anxiety on autistic patients. In HBN, we have seen some considerations of special needs, including people in wheelchair and people with visual impairments etc. but ASD users are not included. This group of people are sensitive to the built environment, so some specific considerations need to be proposed to meet ASD-friendly built environment requirements. The key to designing for autism seems to revolve around the issue of the sensory environment and its relationship to autistic behaviours (Mostafa, 2014). Regarding to HBN, we proposed critical thinking to discuss the sensory stimuli in the reception hall.

Multi-sensory overload

The reception hall is the first important space for patients when they enter the hospital. It has the functions of consulting, socializing, waiting and circulation, which means it has a complex built environment with all kinds of sensory input to ASD users.

Visual and acoustic stimuli are the biggest trouble the ASD users will meet. HBN mention, "*Modern waiting areas often have television or computer screens to provide entertainment and information to patients*." The noise from entertainment equipment can bother oversensitive users. These sensory stimuli can lead to negative impacts on ASD users, therefore the location of devices need to be carefully considered, a clear wayfinding signpost is needed to assist navigation between different places.

It is the same case with visual stimuli. Visual connection with illuminated screens is unwelcome to some users with autism. HBN emphasize, *"Colour in the entrance should be bright, light, fresh and natural."* It is certain that bright colours can lift the atmosphere in the entrance area. However, based on the results of research, orange and yellow are prone to brain excitement in children with autism, leading to some behavioral and emotional problems. These bright hues may cause agitation in certain individuals with autism when ASDs see colours with greater intensity than others. (Mostafa, 2014). To create a kind of uplifting atmosphere and an identity of the modern hospital, many hospitals prefer using the materials steel and glass. The smooth surface of those materials can cause glare so as to generate a kind of new visual stimuli.

With regard to view connection in the reception hall, *"Being able to see shops, cafés, toilets, cash machines and other facilities from the entrance makes people aware of them and reduces the need for signs.", "Being able to see staircases and lifts from the entrance helps people find their way more quickly"* are suggested in the HBN. Such a design can let all the users understand the space easier. However, it has the possibility to make autistic users suffer from sensory overload. Excessive way-finding instructions, and facilities out of order may also distract autistic patients.

It is said in HBN, *"The reception hall should contrast clearly with its surroundings."* Usually, the reception desk has a colour contrast or pattern contrast with surrounding to emphasize the location. The aim is to be apparent while it has the possibility to make autistic users anxious and irritable.

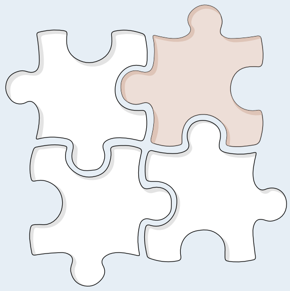
The hospital is a large public building, in such a complex environment, there are many unavoidable sensory stimuli that people with autism cannot bear, sensory stimuli from vending machine, cafeteria, people's communications and movements, falling and hitting of objects, outside traffic. These stimuli can cause anxiety and discomfort to people with autism. ASD users are likely to occur stereotype behaviours and become irritable and anxious when they cannot cope with such sensory overload environments. A protective strategy needs to be proposed to help them distract from sensory stimuli and keep them calm when they are sensory overload.

Complex of space

The entrance hall is the most public space in the healthcare space. Due to the complexity of the reception hall. The autistic users may not be able to adapt sudden changes of the surrounding environment. Sensory processing difficulties lead them to lose themself and cannot read the space. And wayfinding systems fail to enable them to respond to space.

Safety

In the part of the wall and floor finishes, one of the guidelines mentions, *"Floor and wall surfaces should minimize light reflection".* Rough surfaces are a method of avoiding glare and sound reflection. But some surfaces may hurt the autistic users which become safety risks. In the summery of HBN, there is a point--*Artworks, such as sculptures and murals, may become very effective and memorable landmarks for wayfinding*. Arts and plants can be used to decorate the interior environment, contribute to a non-institutional atmosphere, be used as landmarks to help patients to remember this space. But these objects may have potential safety issues for people with autism. In addition, the hard edges of furniture and building structures also have potential risks. ASD users may run to these sharp corners and hurt themselves.



6.3 3STI principles in hospital environments

The general environment of hospitals

Patient-friendly hospital environment

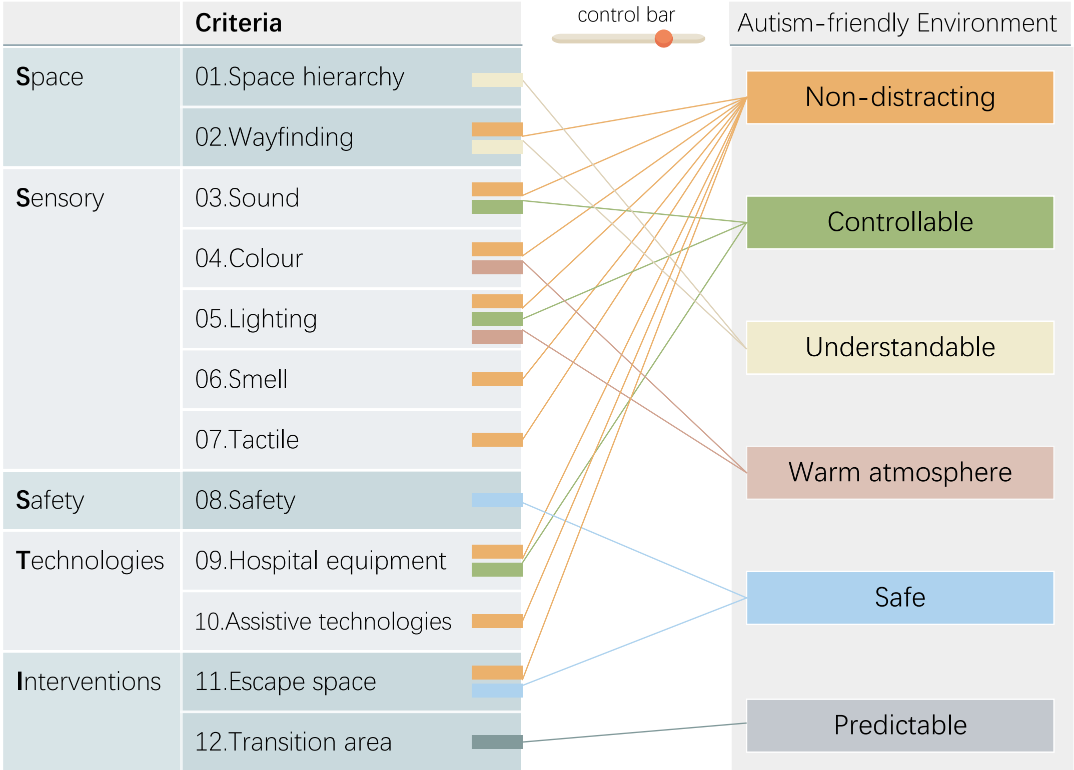
From the research of design codes from NHS documents we learned that the building of hospitals should provide a patient-friendly setting up to allow individuals to overcome medical issues. Patients in a healthcare facility are often fearful and uncertain about their health, their safety, and isolation from normal social relationships. The large, complex environment of a typical hospital further contributes to the stressful situation. Stress can dampen a person's emotional and spiritual resources, impeding recovery and healing. The architecture design for therapeutic environment play a very effective role in reducing patients stress in therapeutic environment where is potentially full of stress and the patient is stress-prone mentally. Healthcare architects and researchers have identified four key factors which, which can measurably improve patient outcomes:

- Reduce or eliminate environmental stressors
- Provide positive distractions
- Enable social support
- Give a sense of control

The requirements of ASD users

These key points of a patient-friendly medical environment can be achieved by architectural design solutions. But this is not enough for ASD visitors. The hospital should be designed with inclusiveness as much as possible to meet the special needs of various groups for the built environment. More strategies should be taken into consideration about their sensitivity to architectural elements, the limited ability to understanding and adapting to space and poor physical control of balance. In the following, we describe the characteristic of the hospital environment needed by ASD users according to the 3STI prototype.

3STI for Hospital



The characteristic of autism-friendly environments

- **Non- distracting**

This aspect mainly considers sensory stimuli of space. Sensory distractions have negative impacts on them and may make autism users unable to use the hospital environment and hospital services. The sensory interference, including sound, colour, light, smell, and tactile need to be reduced. As the toilet and vending machine are needed near where people are waiting, but the air freshener used in the toilet, the noise sounds and blinking lights of the machine, and the crowds of people can easily cause sensory overload to them. These sensory issued need to be reduced by appropriate architectural design.

Moreover, the orderless environment is also a kind of visual disturbance. The untidy space where medical equipment and daily necessities are randomly placed and exposed to the public is not friendly to the ASD visitors. This disturbance can be eliminated or reduced by offering enough storage area. The overnumbered advertisement papers on the wall may make patients confused about wayfinding signposts. Instead of attached to the wall or everywhere, leaflets can be put together in the notification board.

Finding a balance in temperature may be challenging for individuals with ASD, the unstable and uncomfortable temperature and humidity (e.g., too warm or cold) can be alarming and painful. The overheated environment might direct increase indoor odours that make the environment unpleasant for smell sensitive people. It is necessary to offering visitors an indoor space with a comfortable and uniform temperature.

There are potential possibilities that people may touch each other when sitting adjunctly in waiting area, but hyper-sensitive autistic people usually dislike being touched by others, The offering of flexible chairs is a kind of solution, people can move the chair to a private area or put the chairs together and wait with the escort. However flexible chairs have the risk of safety, it may be used as a weapon or as a foothold to climb. People may fall down from high, and even fall out of windows and balconies, especially for autistic children with limited physical balance. Therefore we suggest, also as suggested in NHS documents, seating arrangements should allow individuals space for waiting alone, and group seating for relatives and friends to sit together and keep other parties separate. All the seating should be fixed on the floor or each other to make it uneasily movable.

Highlights:

√ Low-sensory stimuli (sound, colour, light, smell, and tactile)
√ The providing of enough storage space to avoid untidy and orderless environment
√ Comfortable and uniform indoor temperature
√ The providing of both individual seating and group seating

- **Controllable**

The challenge for ASD users is the uncertainty in the space, architectural elements can be affected by many uncontrollable natural factors and it is important to make the built environment under control. Take lighting system as an example, season, weather, and time of a day can affect the indoor light level and temperature. By the use of adjustable intensity lighting system can balance the change of natural lighting. It can be used to increase the lighting level and keep the room bright on cloudy days and reduce the brightness appropriately at night to create a suitable environment for rest. The audio system is the same, the level of broadcast and loudspeaker can be appropriately reduced when the general environment is quiet and the sound in the middle level can be heard clearly. The gentle and slow-in voice can reduce the frighten of ASD users within building. When a TV screen is provided where people are waiting, instead of shutting it down, it is better to put this equipment in a cabinet with a sliding door, so that it can be removed out of sight when necessary.

On the other hand, more important, the design solution is not "one size fits all", personal needs and preferences are important considerations when designing for sensory elements of the built environment. Especially the ability of hyper-sensitive and hypo-sensitive groups of autistic people to accept architectural elements is different, so they have different needs of the interior environment. In this case, the brightness and colour adjustable lights can adapt to the needs of individuals. It can be used in some private space to make the lighting greatly bright or keep a dim lighting environment. The controllable building elements not only increase the flexibility of environments, is also a way to reduce the uncomfortable sensory experience and help to control the emotional stability of ASD visitors. It makes hospital environments better adapted to the needs of different group of people, also provide ASD users with a better spatial experience.

Highlights:

√ The control of audio system
√ The control of lighting system
√ The control of hospital equipment

- **Understandable**

The medical environment contains a lot of information such as various text and symbol signs, colour coding departments, visual information from electronic screens, sound information from loudspeakers. Common visitor can understand the information cloud and find the target message they need quickly or ask the hospital staff for help, but this is not easy for people with autism. When ASD users enter the hospital, they have to extract effective information from various information while bearing the sensory stimuli from the built environment and the crowd of people. Their limited ability to understand and communicate skills makes them prone to collapse when they cannot handle the simultaneous input of senses and information. Therefore, a legible space hierarchy and wayfinding system are particularly important to help them quickly understand the space and navigating to the services they need. Not only ASD users, everyone prefers a building that is easy to navigate but, ASD users usually need clearer, detailed and easily understandable information.

Highlights:
√ Legible space hierarchy
√ Easy-understandable wayfinding

- **Warm atmosphere**

The home feeling atmosphere can allow people to relax and retain more information. But generally speaking, the atmosphere of the hospital is usually boring and institutional due to its functions, which may frighten the visitor with autism and make them nerves when searching for medical service. The change in interior design can offset this feeling. Warm colour scheme and lighting, cosy furniture, materials with interesting textures, thoughtfully placed works of art, and plants and decorations can help to convert a conventional hospital into a cosy and informal gathering place.

- **Safety**

People with autism tend to have unnecessary movements, weak physical balance, chew on non-food items and frequently put the hand into mouth, all these common behaviours make them have an urgent need of safe environments. Especially hypo-sensitive users, they can't feel the sensory input and lack of awareness to realize that they are or will be in danger. Safety issues include the safety of building structures, materials and furniture. Any place with potential risk should be avoided, such as the sharp corner and hard edge of wall and furniture, the slipping floors and unstable decoration objects. The clear and easy-understandable safety signs are needed when some obstruct can't be removed.

In addition, for people with autism, the challenge for the hospital is not only to provide a safe built environment but also to ensure the emotional safety of them. Although the sensory stimuli can be reduced through architecture design, there are still many unavoidable sources of stimulus in hospital, sudden crowds of people and noise, sudden alarm, outside noisy traffic, etc., which can cause them to fall into anxiety and aggression, even hurt themselves or others. Helping them to keep ASD users calm, an escape space can be implemented in the hospital environments, where is a relatively quiet and personal space can provide them with a sense of safety that can help them to calm down as soon as possible.

Highlights:

√ Safety of building structures, materials and furniture

√ Emotional safety

- **Predictable**

Many autistic people have a fear of "difference", including spatial or environmental difference. There are various functional spaces in the hospital, and each space has its own unique built environment. When people visit hospital, they inevitably cross between different spaces. Ordinary users can easily and quickly adapt to changes in the surrounding environment, but ASD users are different. Changes of built environment, especially sudden and obvious one, may cause them anxiety and fear. Making the space predictable, offering them an opportunity to preview the unknow space can help ASD users adapt to change of space in advance, which can be achieved by providing a transition area between two different space or adding a visual connection of next space.

Discussion about hyper- and hypo-sensitivity

Based on the previous study, we know that people with autism can be majorly divided into 2 categories being either hyper-sensitive or being hypo-sensitive to sensory stimuli. The senses of hyper-sensitive people are too acute, they can be over-responsive to sensory stimuli. Conversely, hypo-sensitive people appear to be under-responsive, as if certain sensory information goes unnoticed or certain senses are impaired.

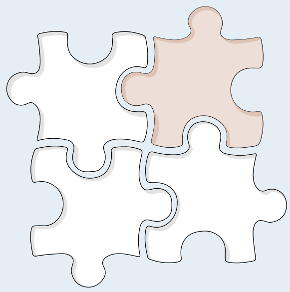
Because they have two distinct needs for the built environment, the requirements cannot be met in the same space. The healthcare environment should be an inclusive, easy-to-use and comfortable building environment for all users. So we consider reducing the sensory stimuli in the space for hyper-sensitive people and enhancing the safety level of the space for hypo-sensitive people. The reasons are as follows:

- **About sensory environment**

Loud noise, bright light, wet materials, strong odour, flicker screen and movement can make hyper-sensitive users feel distressed, uncomfortable and even painful, these sensory inputs may cause their meltdown. It is like a computer that freezes because too many processes are ongoing at once. While hypo-sensitive users don't respond to sensory information and they usually need or seek for strong sensory inputs to stimuli themselves. Sensory therapy is often used in autism medical centres to enhance sensory input and help hypo-sensitive autistic children to feel the world. But for general hospitals, it is important to reduce such stimuli barriers to help hyper-sensitive autistic people use medical services easily and comfortably.

- **About environment safety**

Considering that hypo-sensitive users can't feel the sensory input, which makes the safety issue of the environment especially important. For example, they probably don't feel pain after a hard fall, hurt by sharp corners of furniture and wall, don't scream out when touching extreme hot water, like unnecessary movements which may lead to slip down or fall down the stairs. Therefore, the selection of materials and safety of building structure and furniture (e.g., tables, chairs, doors, and windows) need to be carefully decided.



6.4 3STI principles in hospital environments:

12 criteria proposal

Introduction

1. Space hierarchy

Space hierarchy is important for the spatial experience of autistic users in the reception hall In the literature review on the articles, Mostafa(2008), Claire Vogel (2008), Andrew Brand(2010),Christopher Beaver(2006),all of them emphasize the importance of space hierarchy. In the classroom environment. Mostafa (2008) track the progress of attention span in the study group after implementation of the spatial sequence intervention, a general pattern of improvement was observed. Similarly, it goes for hospital entrance space.

1. Spaces in the reception hall

The entrance and reception area is associated with arrivals and departures, waiting, meeting and socializing. Entrance space is a complex hall include several key elements, (Figure 6.1), including reception desk, waiting area, playing area, cafe and bar etc. All the spaces are connected closely in the hall and form the overall impression of one hospital. The sudden change and publicity of this area pose high level of stress on ASD users. They have to cope with a variety of physical attributes in hospital and, as a result, their stress is manifested in adverse behaviourss--They prone to cry and escape the hospital. Organization of a space can reduce the level of stimuli and help them understand a space empowering them to be an informed user. A good space hierarchy works out on promoting wayfinding and providing areas of comfort and relaxation. Combining the ASD-friendly requirements with the hospital requirements in the HBN, we explain this criterion through following aspects.

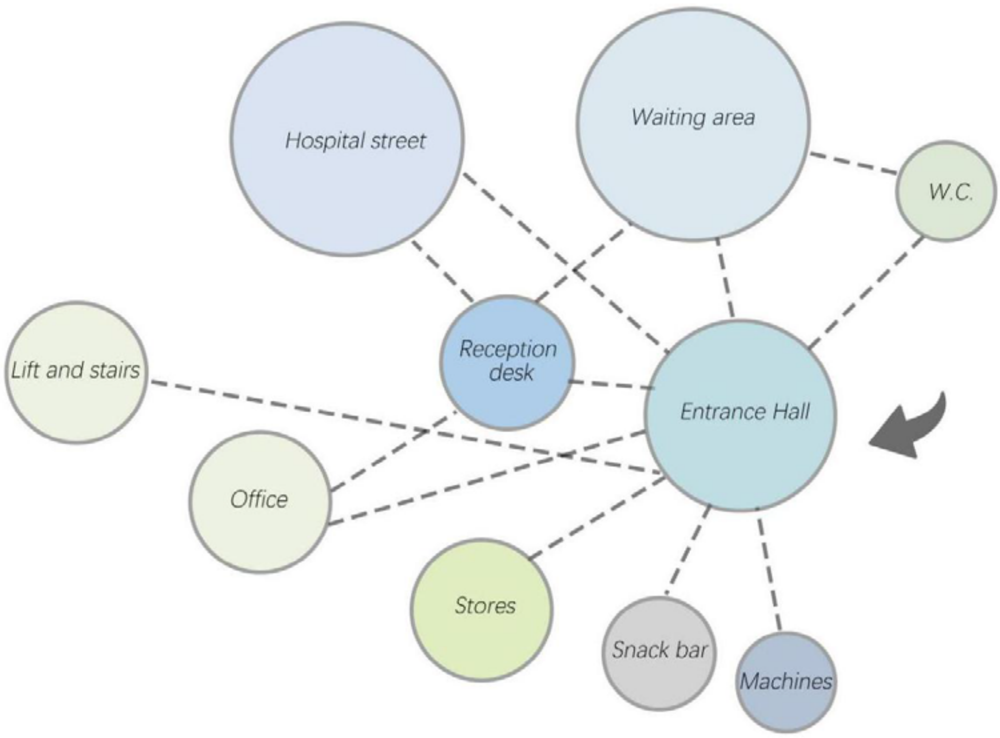


Figure 6.1 Function bubble diagram in the reception hall (Source: author)

2. Strategies of space hierarchy

2.1 Simple layout

The space of entrance hall should be straightforward and easy to navigate. This is because individuals with autism have difficulty forming mental maps of spaces they travel through. Individuals with ASD tend to thrive in environments that are laid out in orderly, predictable way. Building Bulletin 102 mentioned, simply layout can make people with ASD calm down. According to the articles of Rachna Khare and Abir Mullick (2008), complexity is not harmonious; it causes stress to everyone. For low functioning children with autism, confusion easily takes-over, with complexity in layout. Reception hall in the hospital are often large, wide-open volumes of space that can be extremely difficult for individuals with ASD to understand. Individuals have difficulty processing information from the environment because of the large, unsegmented amounts of stimulation and information they experience. Such open plan spaces should allow for circulation routes that minimize distraction. Layout should be optimized as simple as possible. It can also help establish routines for ASD users. In this way, autistic users can be easier to read this complex space.

Usually, simple layout also means organized space, without “invalid” negative building space, such as narrow passage between enclosed space (Figure: 6.2), If autistic users step in, they may feel huge sense of anxiety and fear, even lose their way.

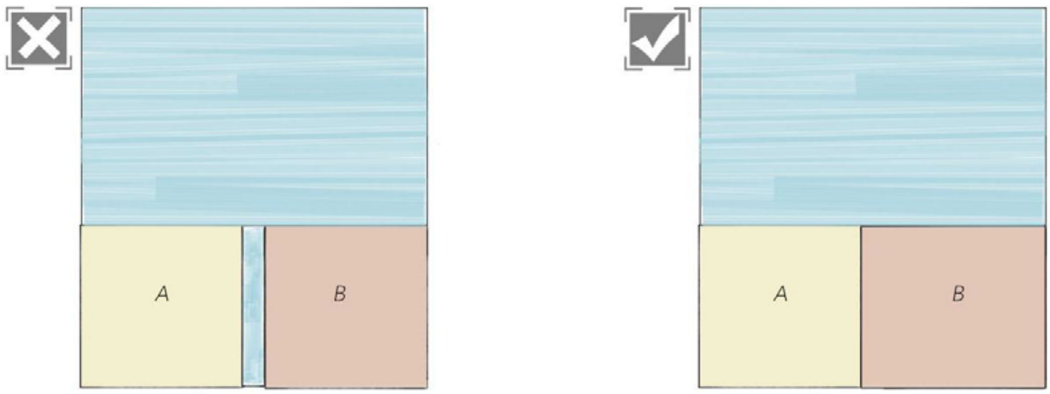


Figure 6.2 “Invalid”building space (Source: by author)

2.2 Space zoning

When space is within another space, if these two spaces have differences in the sensory perception, sensory change will lead to a bad experience to the autistic users. In the autism-friendly classroom design, it is recommended to access from circulation spaces, not other classrooms which cause disruption and disturbance. The same goes for the healthcare buildings.

Spaces should be divided into high-stimulus zones and the low-stimulus zones. For

ASD users, who are oversensitive to many stimuli, it is very important that there are no overlaps between high-stimulus zones and the low-stimulus zones within one hospital and that they should be clearly separated. This separation aims to give users control over their activities in the hospital, without imposing activities in which they are unwilling to participate. If such spaces overlap, it would lead to the situation that e.g. a person who wants to be alone and go to his/her quiet escape area (*See 11, Escape Space*) must first go through a communicating area, etc. to reach the desired room. Such a case would lead to resistance, withdrawal, reduced interaction, etc. (Figure 6.3)

Figure 6.3 high-stimulus zone and low-stimulus zone should be separated (Source: author)

Mostafa stated high-stimulus zones should locate as far as possible from the low-stimulus zones. The application of the concept of sensory zoning also reduce the problems of distraction and diversion (Mostafa, 2008). Keeping the sensory atmosphere of each area as coherent as possible, could allow a more continuous circulation from one space to another as well. Given the complexity and publicity of entrance hall, it is hard to define each zone whether it is high-stimulus or not, for it may change according to time. Even so we can divide reception hall into different zones, with each zone having only one function or activity. The individuals will begin to associate an activity with a specific area or zone, which will then ease transitions between activities, protect routine patterns, and promote predictability.

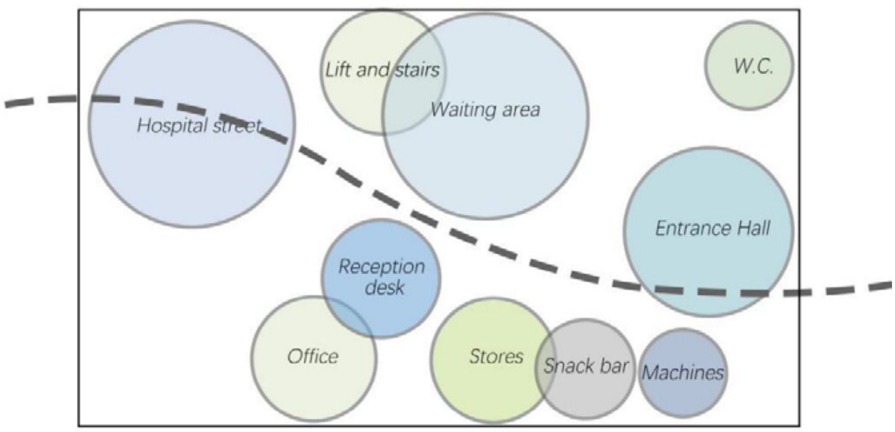


Figure 6.4 Space zoning protect routine patterns (Source: author)

These concept of zoning and circulation can be enforced and enhanced using visual cues. Due to the ASD users think in pictures, such cues have a powerful associative and communicative effect on autistic perception. (Mostafa, 2008) Patterns, colors or abstractions may be used to communicate to the children the character of various zones and spaces. Visually distinctive landmarks may be used at the hub of each zone, indicative of its character.（Figure 6.5, Figure 6.6）In the case of Hackensack Meridian Health, reception hall area is enforced with the use of curved ceiling and blue finishes on the floor. And in the hall of Hyogo Pref. Kobe Children's Hospital, all the key areas in the hall are characterized by different boundaries. Areas can also be clearly defined by furniture placement, and other physical or visual dividers.

Figure 6.5 Hall of Hackensack Meridian Health (Source: archdaily)

Figure 6.6 Hall of Hyogo Pref. Kobe Children's Hospital (Source: pinterest)

When we divide the reception hall, reception desk belongs to high-stimulus area. The feature is its high density of people flow since it is a space all the people will arrive. The toilet, stairs and elevators are also high-stimulus areas. Affiliate stores, snack bar can be close to each other, which have some stimuli more or less. Often, these are considered in-between places and are used as a place of rest or conversation.

Waiting area can split into several groups. Some belongs to high-stimulus areas, some are low-stimulus space. They should be separated. From HBN, we have known that single form of seating is unwelcome to everyone, for it cannot meet need of seclusion and communication together. For ASD users, single group of seating may be hard to give them the chance of withdraw to stay alone. Thereby, It is suggested to have a variety of seating arrangements: Sociopetal seating to encourage interaction(high-stimulus) and sociofugal to promote seclusion(low-stimulus). In the entrance hall of Sheikh Khalifa Medical City in Abu Dhabi (Figure 6.8), arc-shape seating and cocooning seating are provided in groups to meet different needs.

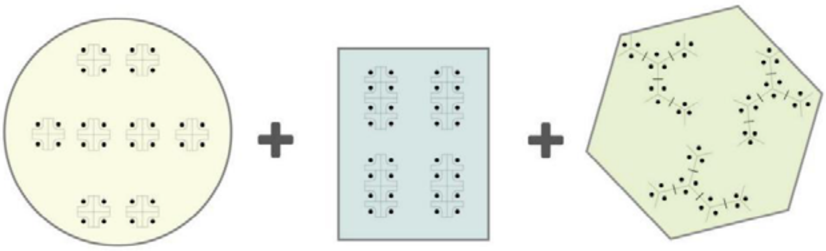


Figure 6.7 Group seating (Source: author)

Figure 6.8 Hall of Sheikh Khalifa Medical City in Abu Dhabi (Source: archdaily)

2.3 Space continuity

Spatial continuity is a tool to organize the different zoning to form an overall impression of the hospital. One of the biggest challenges people with ASD experience is how they perceive the environments they interact with. Contrary to the manner in which typical people perceive space, most people with ASD perceive their surroundings in pieces rather than as a whole. Because of this challenge, it is important to organize or group objects, fixtures, and equipment in such a manner that they make up a whole. The continuity provides comfort for users with ASD, giving their preference for order. The repetition of the architectural forms in the walls, ceiling create a uniform setting that eases comprehension. The neutral color scheme also enhances the continuity of the space. In the entrance hall of John R. Oishei Children's Hospital (Figure 6.9), circle elements and blue path can serve as aid to space continuity.

Figure 6.9 Hall of John R. Oishei Children's Hospital (Source: archdaily)

2.4 Interactive space

Space for social interaction is vital in all the ASD-friendly buildings, including hospitals. Providing spaces that communicate autistic users' purposes and the expected behavioursss within the setting is important to help a person with ASD fit into an environment and contribute in a productive and meaningful way. There is a misunderstanding that people with ASD are unwilling to communicate with others. In fact, fear is the main reason instead of indifference. People with ASD are at risk for failure in social competence because social skills may be lacking. (Odom et al.1992). Hobson (1986) reported a series of studies demonstrating that children with autism cannot discriminate emotional and social cues nearly as well as their typically developing peers of comparable mental age.

Designing spaces that respect the social inhibitions common in people with ASD means creating environments that help them overcome their "mind-blindness,"(Frith, Uta, 2001) the lack of ability to understand the way others think and behave, read body language, facial expressions, etc. Providing opportunities for one to look and see what is going on in a space is one way to help them overcome their mind-blindness. This can be achieved in several ways such as the design of homelike space, inside play area and providing opportunities for prospect and refuge (*See 11. Escape Space*). In the Great Ormond Street Hospital (GOSH), a colorful, underwater-themed outdoor play area is provided for children staying or visiting the hospital. It brings together special lights and sensory elements, as well as Disney favorites Mickey Mouse and Goofy. Though it is not dedicated to the autism, it is also a good design example for the autism-friendly hospital playing area. (Figure 6.10)

Figure 6.10 Hall of the Great Ormond Street Hospital (Source: archdaily)

3. Design considerations of ASD-friendly space hierarchy in reception hall

- Layout should be optimized as simple as possible.
- "Invalid" negative building space should be avoided.
- Space zoning is useful in hospital, which means to divide reception hall into different zones, with each zone having only one function or activity.
- Waiting area can split into several groups.
- Boundaries serve as a means of communicating information.
- Areas should be clearly defined by furniture placement, flooring, finishes.
- The repetition of the architectural forms and the predictable arrangement of modular seating enhance space continuity
- Homelike space and inside playground promote communication.

02. Wayfinding

Wayfinding refers to the process of organizing spatial and environmental information to help users find their way. Wayfinding is of great importance for users on a first visit to a hospital. It is more important for autistic users who may have difficulties even after several visits.

1. Difficulties faced by people with ASD

HBN and NHS documents state that wayfinding systems in healthcare facilities should be available for all users. Some key considerations were listed to help people with visual impairments and people who are deaf or hearing impaired to find their way in hospital space. ASD people is also vulnerable group people who need special help, the inclusive design of wayfinding system for autism people should be came up with.

Many people with autism spectrum disorder (ASD) have a hard time figuring out how to get from one place to another. The Weak Central Coherence (Happe, Frith, 2006) theory attempts to explain the reason of problems ASD individuals meet during the navigation in one building area. Central coherence is the ability of a person to view and process information as a whole. Upon initial inspection of an image, typically developing individuals will perceive the image in its entirety, looking at the context as a whole rather than focusing on specific elements of the stimulus and thus often neglecting the finer details of the image. Clinical observations suggest that ASD individuals do not focus on the whole image but rather on its finer details, paying attention to specific features of the image and thus exhibiting weak central coherence (Happe, Frith, 2006).

There are also data that display a number of navigational impairments in ASD: autistic groups were slower at learning spatial regularities, less efficient in their foraging behaviour, less able to learn locations based on allocentric representations, less likely to sufficiently explore an environment, and more likely to revisit locations that they have already explored. In the study by Morag et al. (2016), they mentioned individuals with learning disorders and autism raised the need for maintaining a similarity in the interior spaces across multiple floors.

Figure 6.11 Wayfinding system (Source: pinterest)

Thereby, designers need to put to task to enhance the wayfinding of autistic individuals in order to keep them safe and diminish their frustration. Given the above, the detailed design plays a vital role in giving the overall cognitive map.

2. Wayfinding aid strategies

2.1 Signage schemes

It is emphasized the impact that signage system has in reducing stress levels among patients and visitors and the positive contribution this makes to their overall experience of visiting a hospital. spatial and environmental information to help users find their way. Wayfinding signs in the entrance and reception area should reflect the hospital's overall wayfinding strategy. HBN provide many guidelines on the wayfinding system. They are needed to provide information to everyone, including autistic users. HBN provide many general guidelines on the wayfinding system. We don't present excessive introductions here, just underline some parts which are most crucial. Signs are needed in the entrance and reception area to indicate the following:(Figure 6.12, Figure 6.13)

- toilets.
- nappy-changing, and bottle-warming facilities.
- Appointment machine
- the hospital's smoking policy and provision.
- cafeteria/lounge facilities (including 24-hour waiting and refreshment facilities, designated to the entrance and reception area)
- the alternative entrance.

Figure 6.12 Signage in the Hospital Sant Joan de Déu entrance hall (Source: behance)

Figure 6.13 Special signage (Source: pinterest)

ASD-friendly signage design should be clearer and understood easily. Simple symbols, used consistently, may be more appropriate than letters. It has been found that individuals with autism, although sometimes unable to communicate with conventional language of the spoken and written word, can communicate well using pictures (Grandin, 1996). It can be applied to signage schemes where pictorial language can be displayed in parallel with written language. Sanchez, Vazquez, and Serrano (2010) conducted a literature review of previous studies to find the design criteria that were cited as supporting adults with ASD in the built environment, noting that pictograms or photographs used as pictograms could be useful in wayfinding. When continuously viewing and understanding a pictorial sign with written words next to each symbol, eventually some written words may begin to be understood by association.

Various colours and themed symbols can be used to indicate different functions in the hospital. Some research pointed that children having sensitivity to colour. Ludlow et al. (2006) conducted an experiment to test the effect of using coloured overlays on a reading exercise with children with ASD. They found that children with ASD were significantly more able to read faster with a coloured overlay than a white page (Ludlow et al. 2006), suggested that this could have implications for the design of signage. In a way similar to pictorial signage, textural signage is proposed as a communicative tool capitalizing on the tactile.

Figure 6.14 Theme colour in wayfinding (Source: pinterest)

The signage strategy in the Royal Children's Hospital in Melbourne (RCH) is a good case. Designers have created a fun and lyrical pictorial signage system that likens the RCH to the natural world. As patients move through different floors in the hospital their journey takes them from 'underground' at the lower ground levels through to 'sky' on the top floor. Specific areas within each level are described in relation to an appropriate animal, for example, 'Koala Ward' exists on the 'Tree Tops' level (Figure 6.15).

Figure 6.15 Signage strategy in the Royal Children's Hospital in Melbourne (Source: archdaily)

2.2 Colour-coding path

A large number of researches pointed that children having sensitivity to colour. Ludlow et al. (2006) conducted an experiment to test the effect of using coloured overlays on a reading exercise with children with ASD. They found that children with ASD were significantly more able to read faster with a coloured overlay than a white page (Ludlow et al. 2006), suggested that this could have implications for the design of signage.

Sanchez et al. (2011), and Vazquez and Torres (2013) all advocate for the use of colour coding. In particular, Sanchez et al. (2011) suggest the use of colour coding to help people with ASD. Also, Irish (2013), in a case study approach describing a new school for children with ASD and other disabilities, used colour coded doors to help children with ASD to navigate the school environment. There is no doubt that it can apply to the medical environment.

McNally et al. (2013) suggest the use of colours or artworks to create "neighbourhoods" in the school. Vogel (2008) research data gathered from parents, teachers, and therapists of children with ASD, as well as adults with ASD, to create a set of interior design standards for schools. She uses examples such as making evident "paths" with coloured tape or printed footprints

For hyper-sensitive autistic users, their vision is looking down most of the time. The pattern on the floor will affect their act of moving. Floor assistance can be a tool to help them navigate. It is beneficial to the hypo-sensitive users as well, since they always take long time to respond to directions to move. Under the guidance of colouring pathway, orientation is easier to recognize. Colour-coding path include not only colouring path, but also contrasting floor materials such as carpet or wood, finishes. As three cases illustrated (Figure 6.16, Figure 6.17, Figure 6.18), colour-coding path has become a frequent strategy in the recent years, even in hospitals for typical developing individuals. In the entrance hall of Akron Children's Hospital, beige colour flooring indicates the direction of the stairs and blue flooring leads to the clinical department. It is notable that generous pathways may prevent bottlenecks and confusion for the ASD users. In this circumstance, too many stimuli contribute to adverse effects. Effective but minimized colour scheme is recommended.

Figure 6.16 Akron Children's Hospital (Source: archdaily)

Figure 6.17 Children's Healthcare of Atlanta entrance hall (Source: pinterest)

Figure 6.18 Hall of Texas Children's Hospital (Source: archdaily)

2.3 Landmark nodes

Landmark is important in the wayfinding. Both Mostafa (2008) and Vogel (2008) underline that. Predictable, permanent landmarks help individuals with ASD orient themselves in a given space. These types of features may also trigger memories that help people recognize appropriate behaviourss in settings and make connections to where they have been and what they have seen. All of these triggers are important in communicating how an individual on the spectrum should act in different settings. Significant architectural feature or artwork that is visible from a distance in several directions can become a memorable landmark for orientation. For individuals with ASD, these nodes can be helpful for them to pause, gather their thoughts, and make decisions about which way to go. Hall of Akron Children's Hospital (Figure 6.19) is a good example. The tree-like column can be a mark of waiting area. If an autistic child is lost in the hall, he remembers his parents are waiting under the tree. Through the location of the tree, they will find the way successfully with interest. Likewise, modern sculpture is also incorporated into the hall of The Royal Children's Hospital (Figure 6.20) in Melbourne. It is not only served as an element to identity the hospital. When you are navigating the entrance hall, the connection between the landmark and the space around is built in the mind of all the people, including the ASD users.

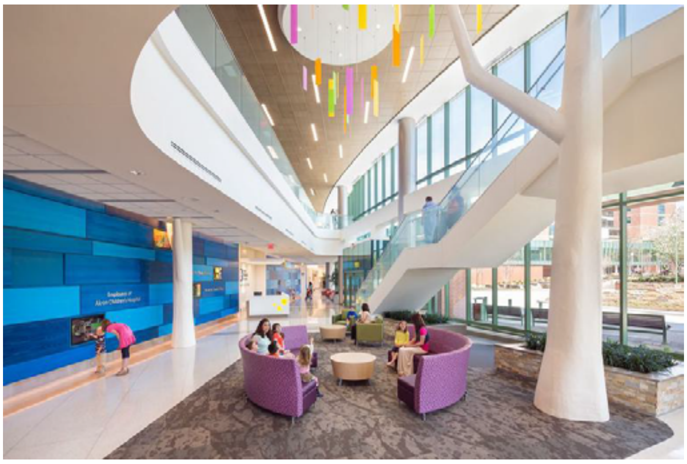


Figure 6.19 Akron Children's Hospital (Source: archdaily)

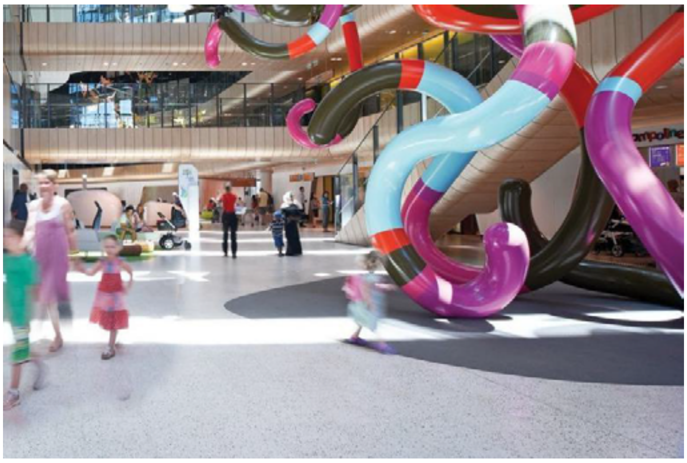


Figure 6.20 Hall of The Royal Children's Hospital, Melbourne (Source: archdaily)

3. Design considerations of ASD-friendly wayfinding in reception hall

- ASD-friendly signage design should be clear and understood easily.

- Signs can be the combination of text and easy understandable pictograms, well positioned on the wall, floor, ceiling or notice boards. Printed footprints and colour track line on the floor can make great contribution to navigate.

- Various colours and themed symbols can be used to indicate different functions in the hospital.

- Colouring path, but also contrasting floor materials such as carpet or wood are good aid to wayfinding.

- Colour-coding should be easy to comprehend with only a few colours, otherwise will cause confusion.

- Landmarks can make the environment memorable and easier to navigate.

- Tactile wayfinding can also work in the hospital environment.

- If it's possible, navigation technology (phone application or interactive program) can be used to assist wayfinding.

03. Sound

There is a large body of literature that spells out the acoustic problem that is pervasive in hospitals the world over. Hospital noise levels have been rising consistently since the 1960s. The background noise levels in hospitals rose from 57 dB (A) in 1960 to 72 dB (A) today during daytime hours, and from 42 dB (A) in 1960 to 60 dB(A) today during nighttime hours (Busch-Vishniac et al. 2005).

Further, many studies indicate that peak hospital noise levels often exceed 85 dB (A) to 90 dB(A) (Aaron et al. 1996). Noises from alarms and certain equipment that exceed 90 dB (A) are comparable to walking next to a busy highway when a motorcycle or large truck passes.

1. Difficulties faced by people with ASD

Difficulty in auditory processing is one of the commonly reported sensory impairments. Unusual responses to sensory stimuli are experienced by up to 90% of individuals with autism spectrum disorder (Ben-Sasson et al., 2009). What other people take for granted can be very painful and cause unwanted intrusions.

Edward T. Hall, in his “Theories of Proxemics” states that acceptable levels of noise in the environment vary. Typically developing people are generally able to adapt to varying levels of acoustics. However, hyper and hypo-sensitive users have different behaviours react to sound inputs, the presence of symptoms and reactions vary in severity, according to the condition of individuals. Following Table X.X lists the common symptoms of autistic people when facing various sound stimuli.

Table 6.1 Acoustic stimuli
Hyper-hearing
• Easily distracted by background sounds; • Easily frightened by sudden unpredictable sounds (e.g., telephone ringing, sirens) and has unpredictable reactions to sounds as if it is a threat (e.g., scream or cry to sound); • Often covers ears when the disturbing noise is painful; • Sometimes makes repetitive noises to block out other disturbing sounds.
Hypo-hearing
• Seems oblivious to sounds of surrounding activities; • Seeks or creates for sounds to stimulate themselves (e.g., enjoy crowds, sirens, like the ‘noisiest’ places, bang doors, make loud rhythmic sounds);

For hyper-sensitive autistic individuals, a slight variation of decibel may send them into a panic. This sensitivity to noise in those with autism is explained by many autistic individuals. Temple Grandin, PhD, who is one of them states, “Some of the sounds that are most disturbing to autistic children are the high-pitched, shrill noises made by electrical drills, blenders, saws, and vacuum cleaners.”

Regardless of the underlying cause, hyper-sensitivity has been associated with anxiety and stress surrounding perceived noxious auditory stimuli, resulting in strong reactions (Jastreboff and Jastreboff, 2000). Illustrating this, hyper-sensitive children are frequently reported to cover their ears to block out sounds, as well as exhibit anxious or distressing reactions to some sounds (Jastreboff and Jastreboff, 2000).

Intense and atypical responses to auditory stimuli can result in increased stress. Due to the fear of the hospital environment, autistic patients may want to flee the hospital and affect the effective communication between doctors and patients. These adverse effects have been reported to influence the overall quality of hospital experience. For that reason, noise could be one of the most important sensory challenges. ASD-friendly hospitals can solve the problem from such three aspects as follows.

2. Environment noise

In the reception hall of the hospital, the sources of noise are from both inside and outside, generated by patients and visitors and adjacent traffic noise. If it is surrounded by noisy environments, harmful noises may be heard inside. And as a place with the greatest number of people, sounds of conversation and movement are inevitable. The loud noise levels in hospitals also come from mechanical equipment in use—lighting, heating, ventilation, and air conditioning (HVAC) equipment, telephones, computer printers, ice machines. Particularly, the fluorescent lighting, which can produce noise levels of 50 dB. (Manlove, Elizabeth E 2001). The sound of hospital communication devices, such as loudspeakers, audio calling and the next patient “call” system is one of the most common contributors to unwanted sound within the built environment. Alarms and loudspeakers sometimes occur suddenly and harshly.

3. Acoustic strategies

3.1 Methods of reducing noise sources

To start with, the location of the reception hall in a hospital should have the least amount of distractions possible. This issue should be considered from the beginning.

According to the literature review, fluorescent lighting should be avoided, as its flickering and buzzing can bother an individual with auditory or visual hypersensitivity. The use of alternatives for fluorescent lights that do not emit noise is ideal. Many articles on design in autistic classroom design point out, incandescent lamps are best used. Noise control of the air conditioner, ventilation system, or other mechanical systems should be addressed. To establish an autism-friendly hospital, new equipment purchases should be based not only on function and price but also on auditory impact.

While this is not currently or prominently noted, it must become a requisite specification. Other associated facilities, such as the vending machine can be mute. Regularly changing single-use sensors and establishing routine times to inspect, clean, and maintain equipment helps keep everything working properly. It also reduces the frequency of alerts related to technical malfunctions, like a low battery or loose connection.

Soft furnishings also play an important part in deadening sound within a unit. Bean bags in the waiting area, cushions and so on assist in deadening the sound as well as creating a homely atmosphere. In the waiting area, by adding felt pads under the furniture legs (chairs, tables), the scratching sound can be minimized. Double-glazing windows can effectively block the outside noises.

Since the high flow density and welcoming atmosphere in the entrance and reception floor, it is recommended to have a separate reception area close to the main reception hall. The individual space has minimized noise disturbance under a more strict noise control. For example, all the equipment has to be mute to create a relaxing sound environment.

Highlights

- The location of reception hall
- Non-buzzing lighting
- Noise control of equipment
- Alternatives of alarm
- Soft furnishings
- Double-glazing windows

3.2 Sound absorbing strategies

Sound-insulation/sound absorption materials should be used in architectural components, such as windows, walls, floors, ceilings.

The structure of walls around an environment can greatly affect the sound qualities within the space. Our modern fireproof construction is hard to create a sound-insulated environment. The steel and concrete frame transmits the waves of sound throughout the building. Usually, walls are constructed of thin, lightweight materials to keep a project economical. These walls are made up of a single row of studs sandwiched between two thin pieces of drywall. In order to increase the amount of sound insulation, walls can be alternatively constructed with two layers of staggered studs, one-layer housing sound-absorbing insulation and the other becoming an airspace with two sheets of drywall outside each stud. This greatly dampens the sound's ability to travel through walls. Additional insulation can be achieved by staggering drywall seams so that they don't line up between the two layers. Two seams in the same location will allow sound to travel through them. Placing the second layer of drywall to cover the first layer's seams is also an effective way to reduce the travel of noise between spaces.

Reverberation is a common problem found in typical hospital environments. The main way to decrease Reverberation Time (RT) within the reception hall in the hospital is through finish selections. Hard surfaces should be avoided on walls, floors, and ceilings to reduce noise and reverberation. These hard surfaces are significant contributors to the reverberation time within a space. Acoustic panels and acoustic tiles attached to the wall can be a good way to break such hard surfaces.

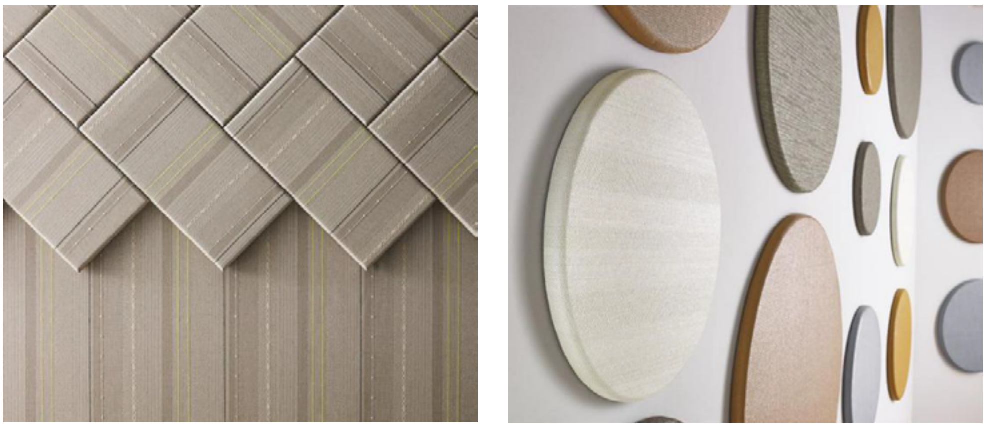


Figure 6.21 Acoustic panels and acoustic tiles (Source:www.xorelartform.com)

We have also found that rough wall finishes, such as fair-faced brickwork with raked joints, can be very successful at breaking up reflected sound waves and reducing noise levels; but should only be used in locations where there is no risk of self-harming. Wood products also tend to have more absorptive properties than many laminates. Curtains and wall-mounted cork boards are simple ways to reduce the noise level. Sound-absorbing panels can also be suspended from the ceiling to reduce the number of hard surfaces in the reception hall. Besides for acoustic ceiling panels, sound-absorbing drop ceiling tiles provide effective noise control. Offered in a wide variety of materials, sizes, and designs, acoustic ceiling tiles are an easy solution for improving the acoustical qualities of any space. In the University of Utah Hospital, the ceiling clouds system is used, which creates a modern appearance combined with noise reduction and reverberation control in healthcare environments.

Sound absorbing drop ceiling applied in the healthcare buildings

Figure 6.22 Hall of Huntington Hospital Emergency Department (Source:e-architect.co.uk)

Figure 6.23 Fiberglass Shape Cloud in the University of Utah Hospital (Source:pinterest.it)

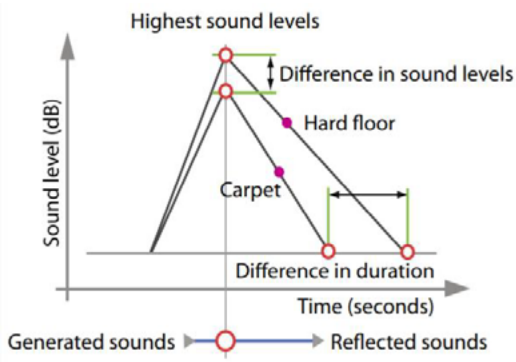


Figure 6.24 Sound level comparison between hard floor and carpeted floor (Source: Balta-carpets)

Carpeting is generally regarded as superior to hard surface flooring from the standpoint of noise control. Carpets on the floor will reduce the impact of foot traffic as well as provide opportunities for decorative treatments. Carpets if used can be thicker. There is some objection raised about carpeting in hospitals. It is stated that carpeting provided a breeding ground for bacteria which may become embedded in the pile of the carpet and cause infection. We found that numerous tests for bacteria levels in hospital carpets have generally concluded that, when the carpet is properly maintained, there are no significant differences between carpeted and non-carpeted floors. Oversized casters are generally recommended for heavy equipment which is used in carpeted areas.

Carpeting applied in the healthcare buildings

Figure 6.25 The Shirley Ryan AbilityLab (Source:pinterest)

Figure 6.26 American-Sino Hospital, Audong Clinic.(Source:pinterest)

Highlights

- Additional insulation in the wall layer
- Sound absorbing ceiling
- Carpet
- ✗ Simple wall layer
- ✗ Hard surfaces

3.3 Sound masking strategies

Sound ‘masking’ works on the principle that disturbing noises can be reduced by a constant noise in the background. Music or a television playing in the background quietly can help, or relaxation tapes with soothing sounds.

Ear-plugs and ear-muffs are one kind of sound masking, which block sound transmission to the ears (Pfeiffer et al., 2019). Ikuta et al. (2016) conducted a pilot study on the effectiveness of noise-canceling (NC) headphones in children with ASD of varying intelligence. Although participants in this study had difficulty using the NC headphones when they had hypersensitivity to human voices in the beginning. The research did find, however, that behavioursal responses improved for children who perceived environmental noises as noxious (Ikuta et al., 2016). Additionally, a single case design study identified an increase in attention to tasks for a child with ASD and auditory hypersensitivity when wearing the headphones (Rowe et al., 2011). In the waiting area of the reception hall, the provision of ear-plugs and ear-muffs can be a great help.

The sound of water or other sounds imitating nature landscape can also act as sound masking, which can be introduced in the entrance hall. A person with autism may respond to such sounds differently. Creating a trickling stream in water features can relax by a simple act of listening and viewing. To establish a water fountain in the reception hall can have the same effect.

Music is defined as a complex of expressively organized sounds composed of some key elements: rhythm, pitch, harmony, and melody. Research shows that certain types of music induce relaxation and positive responses, which reduce activity in the neuroendocrine and sympathetic nervous systems, resulting in decreased anxiety, heart rate, respiratory rate, and increased temperature. The music preferences of individual patients is an important factor in the effect of music on patients, as not all people are likely to prefer the same types of music due to differences in age, culture, and peer group (Juslin, 2008). Generally, sedative music that is suitable for music intervention tends to have no accented beats, no percussive characteristics, a slow tempo, and a smooth melody. Music should ideally be selected by autistic patients based on their preferences.

Highlight

- Ear-plugs and ear-muffs
- Sound of water
- Music

4. Design considerations of ASD-friendly sounds in the reception hall

- The staff should help to keep the noises at a lower level.

- The sound of equipment in the reception hall is as mute as possible.

- A hum caused by standard frequency lighting should be considered. High-frequency electronic ballasts or using incandescent lamps will cure this problem.

- Hospitals should consider enhancing the acoustic performance of the building by using suspended ceilings, sound absorption materials, cavities, sound resistant plasterboard or acoustic tiles.

- Hard surfaces should be avoided on walls, floors, and ceilings to reduce noise and reverberation.

- Carpets can be used in non-clinical space.

- The provision of ear-plugs and ear-muffs in the waiting area.

- The sound of nature, such as water, can be introduced.

04. Colour

Of all the human senses, vision is a very powerful sensory in providing information about the world around us. The visual senses provide us with information about the world around us, not only physical information about the shape, size, and colour of objects, but also the feelings of comfort, security, stimulation, and much more. Colour is a very important factor that affects the visual environment. The correct use of colour can help people make sense of their surroundings to enhance the sense of spatial hierarchy, assist space navigation, and create a comfortable indoor environment.

1. Difficulties faced by people with ASD

HBN and NHS documents state that colour design in hospitals needs to reflect the wide range of their users. Some key considerations were listed to help elder people, people with visual impairments, people in wheelchair and young people have a better visiting experience in the hospital. Although the ASD population is not specifically marked in the documents, some colour design considerations, especially strategies related to visual impairment people, can be generalized. But it's widely known that people with autism may be more sensitive to colour, bright colours can be painful or distracting for the visually hypersensitive ASD people. Therefore, some additional requirements need to be discussed to create an ASD friendly hospital space.

Anna Franklin et al. (2008) design experiments to examined colour perception in children with autism. The result indicated that the colour memory and search accuracy of children with autism were significantly lower than children with cognitive abilities. Children with autism are less accurate than the control group children when they detect coloured targets on a coloured background.

The perception of colours by people with autism differ from the neurotypicals due to the defect in their sight because of chemical imbalances and neural deficiencies (Creedon, 2006). Autistic people with a hyper-vision can see the stuff that normal can't feel or usually ignore while people with hypo-vision can only identify the outline of objects. Following Table X.X lists the common symptoms of individuals with ASD when facing various colour stimuli.

Table 6.2 Visual stimuli: colour
Hyper-vision
• Sensitive to colours, especially bright ones; • Can't bear too many colours in sight • Respond to appearance of certain objects or colours by disruptive behaviours.
Hypo-vision
• Fascinated with reflections and bright coloured objects • Has trouble in figuring out the objects, as they only see just dark and outlines; • Cannot identify a figure from the background;

Therefore, hyper-vision autistic people see colours with greater intensity than neurotypical people. For this group of people, red appears nearly fluorescent, vibrating with intensity. hypo-vision autistic people see muted colours, they perceive every colour as grey. (Creedon, 2006).

Figure 6.27 A neurotypical view compared to hyper-sensitive (Source: author)

Figure 6.28 A neurotypical view compared to hypo-sensitive (Source: author)

2. Colour aids for people with autism

2.1 Harmonious colour scheme

Quantity of colour is one of the considerations in the design of the physical environment. Many researchers propose minimized colours are beneficial to ASD users, which can reduce visual stimuli effectively. Verghese stated that large amounts of colour overstimulate individuals no matter the colour temperature or preference. Using a lot of different colours may lead to an environment that is too visually busy, leading to confusion and unease for ASD users. As the most public space in the hospital, the reception hall has the most colours. A harmonious colour palette scheme is needed.

As HBN mentions, one approach to a harmonious colour scheme might be to use colour combinations in which the main hue remains the same but there are different versions of it (Figure 6.29). A single tonal scheme could include a deep blue for a door, a soft white with the same blue as a pale tint, and a flooring material that has a mid-saturation or chroma of the blue with dark and light flecks in linoleum. Alternatively, a scheme could also use strong opposite colours to emphasize the signage and wayfinding system. Fittings like switches, controls, buttons of alarm and area with risk of danger should be highlighted in contrast colour with the background. The area of opposite colours should be paid attention in case of distracting the ASD users. Designers can also coordinate colours of the building and existing finishes with paint for colour harmony. If appropriate and possible, try to coordinate colours of materials such as flooring with other finishing materials used. For example, the colour reference of the floor material could be given to a textile manufacturer to be incorporated in colourways for curtain designs.

Figure 6.29 Example of colour scheme (Source: by author)

2.2 Neutral and calming colour

In many children's hospital, as listed in the case study, the colour is usually bright, bold and diversity to create a welcoming and playful atmosphere. However, for the hyper-sensitive autistic they would respond physically to certain overstimulating colour. People usually don't like over-saturated colour spaces or monotonous, colourless space. Maxwell (2000) mentioned in his paper that students strongly dislike pure white walls. The preference for colour schemes much depends on the different preferences of individuals, as some people like pink and some people like yellow. When Beaver was designing a home environment for people with autism, he thought it was a good idea to encourage people to choose the colour for their room from an approved range, since there are neutral colours, calming colours, disturbing and stimulating colour (Beaver, 2008). Temple Grandin reveals in her autobiography, that she enjoyed having bright colours in her classrooms. But these colours may be too stimulating for some ASD people.

In general, there is a limitation of research. Because most papers that research on the effects of colour on autistic people are based on the built environment of classrooms and homes, especially classrooms designed for children with autism. The main function of the classroom is to help autistic children to improve their learning and communication skills. In some classrooms, colour decoration is used to provide a living and cheerful learning atmosphere or to assist education.

However, considering hospitals, a large public building with complex functions, an inclusive colour scheme should be the first choice, and should not be based on the preferences of individuals or some groups. Thereby, neutral and natural colours are a safer colour scheme.

From the previous literature we already know that people with autism are sensitive to sensory stimuli, colour is great influencing factors of visual stimuli in hospital space. We try to find some colour design strategies that can eliminate colour disturbance to ASD while providing non-institutional and low sensory stimuli environment,

Beaver (2006) stated colour palette should be chosen to provide a pleasant environment, but not over stimulating. Soft and cool colours can help with calm down. Other authors Humphrey (2008), Vogel (2008), Khare and Mullick (2008) all proposed that a neutral and calming colour scheme is recommended for an ASD-friendly built environment.

GA architects focus on projects related to people with special needs, especially for autism friendly architecture. They made an experiment to see the colours the ASD patients prefer. They conclude:

- Subdued and colours mixed with grey were favoured by the children with autism
- A predominant preference for colours in the Blue/Green hue sectors was notable
- A balance between colourfulness and greyness is seen to be popular.

Besides, they also proposed several ASD-friendly design considerations, considering about colour, they suggested that low arousal colour should be chosen for interior, without complicated or fussy patterns. Bright colour as red and orange should be avoided, In the meanwhile the surface shouldn't have high reflection.

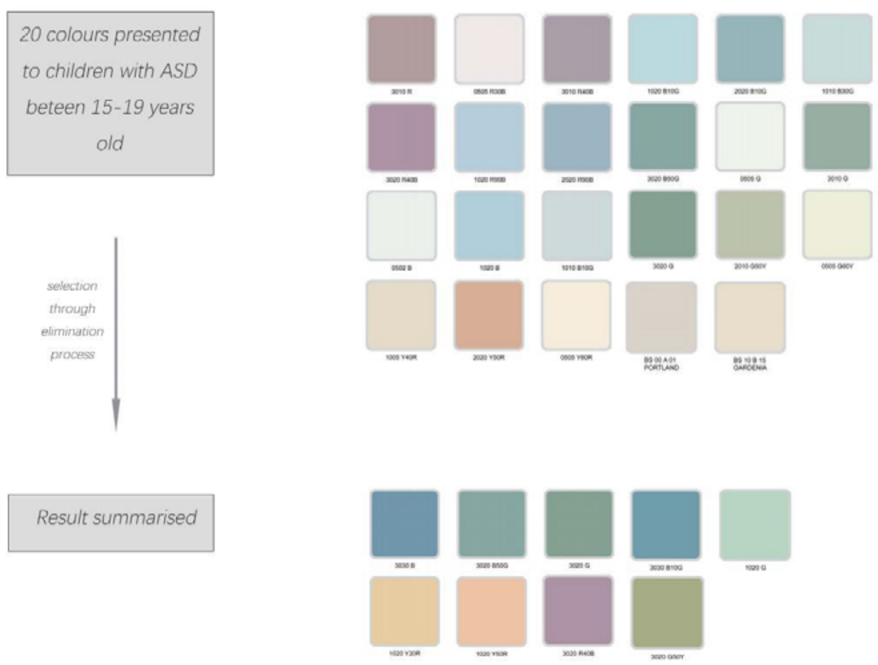


Figure 6.30 Colour palette presented to children (Source: GA Architect)

According to ASD-friendly colour scheme requirement, we find out 3 hospital where unsaturated blue and green hue are used in the entrance hall as good examples. (Figure 6.31, Figure 6.32, Figure 6.33)

Example of calming colour scheme in the hospital environment

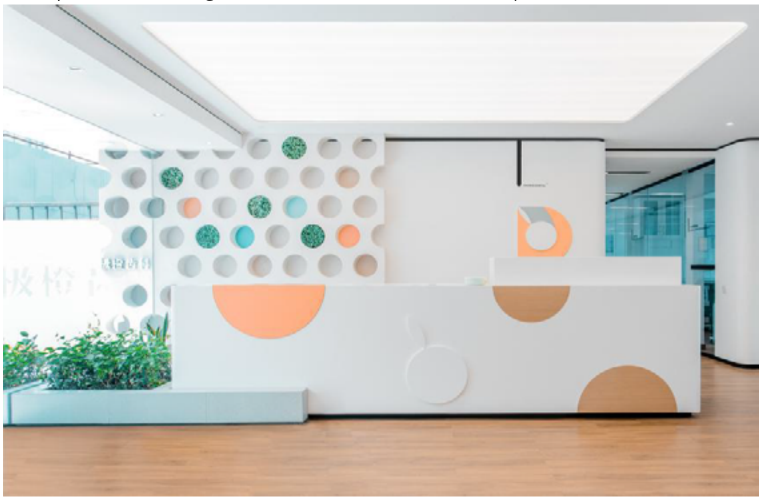


Figure 6.31 Entrance of Rigi clinic (Source: archdaily)

Figure 6.32 Entrance hall of Shengavit Medical Center (Source: archdaily)

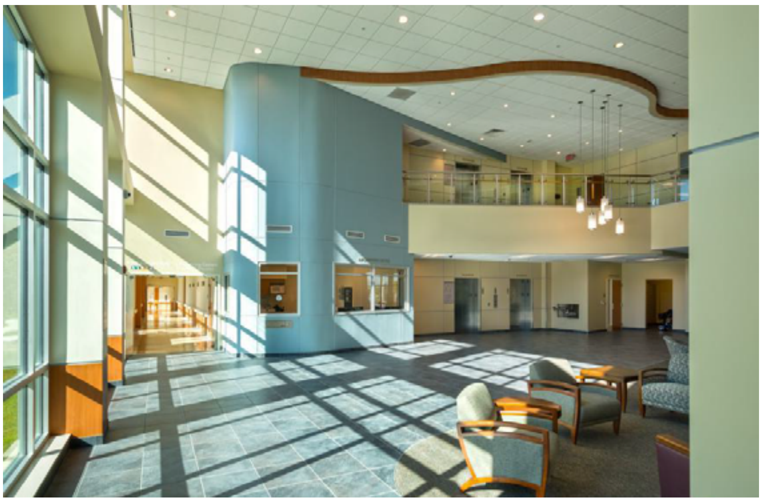


Figure 6.33 Entrance hall of Western State Mental Health Hospital (Source: archdaily)

3. Design considerations of ASD-friendly colour in reception hall

- A neutral and calming colour scheme should be used for reducing visual stimuli of ASD users. A well colour scheme can contribute to a non-institutional atmosphere.
- All finishing materials, including floors, walls, fittings, noticeboards and wayfinding signposts should be in harmony colour.
- Limit the number of colours. A lot of different colours may lead to visual confusion.
- When using contrast colour, try to avoid bright colours as red and orange. If in some unavoidable situations, such as bright colours for emergency signs, appropriately reduce the saturation of bright colours. For example, use red instead of bright red, yellow instead of bright yellow.
- Large areas of strong colour should be used cautiously, especially strong and bright colour should be avoided.
- Highly patterned materials should be avoided.
- Reflective materials should be avoided.

05. Lighting

Lighting is one of the most important components of design and one of the factors that most greatly influence how a healthcare space will be perceived. This is partially because lighting allows various elements in an environment to be seen. (Fielding Randall,2006)

1. Difficulties faced by people with ASD

1.1 Hyper-vision and hypo-vision users

It is widely understood that those on the autism spectrum typically experience abnormalities in sensory integration and how they process visual experiences. How visual stimuli are experienced in an autistic individual may vary greatly from a person without autism and lead to uncomfortable symptoms including light sensitivity. Research (Howe and Stagg, 2016) has found more than half of autistic adolescents have visual processing deficits, including sensitivity to light. Other analyses have noted that hypersensitivity to light and photophobia increases with autistic traits as well (Sperandio et al. 2017). Good lighting design can largely improve the experience of autistic individuals in the hospital.

Table 6.3 Visual stimuli: lighting

Hyper-vision
• Dislikes bright lights and sunlight;
• May be frightened by sharp flashes of light,
• Easily distracted by fluorescence lighting, can see a 60-cycle flickers of lights;
• Respond to appearance of glare lighting by disruptive behaviours;
Hypo-vision
• May be fascinated with bright lights, reflections, and glare;
• May stares at the sun or a bright light bulb.

Individuals on the spectrum with hyper-sensitivities may appear to notice everything in the environment and intensely focusing on the most minute of visual details, often feel overwhelming by the effects of the surrounding environment. Contrary to visual hypersensitive individuals on the spectrum, visual hypo-sensitivity is almost like possessing a visual impairment. Those with visual hypo-sensitivity may disregard people and objects in the environment, as if they are not there at all, or only see the outlines of objects. Some individuals may also enjoy bright colours and bright lights, things that would be overwhelming, even terrifying for an individual with visual hyper-sensitivity (Kristi, 2017).

1.2 Impacts of light stimuli on ASD users

In the perspective view of ASD users, bright lighting can make environment visually-disorienting then may provoke their strong or painful responses to light. This is further compounded by the intensity of the light, the specific wavelengths and any harsh glare. As a result, the brain becomes confused, hindering one's ability to process light stimuli (Robin, 2013).

Certain types of lighting, specifically fluorescent lighting, have been shown to have a particularly negative effect on individuals with autism. Approximately half of the autistic individuals experience a severe sensitivity to fluorescent lighting. One study found that the use of fluorescent lighting increased the stereotypical repetitive behaviours of children with autism, which may be attributed to a hypersensitivity to fluorescent light flicker (Coulter, 2009).

1.3 See the world in their eyes

Based on research on visual sensitivities of people with autism, we try to simulate the views in their eyes in order to have a more intuitive acknowledge about the research results.

Figure 6.34 The glare in common people's eyes compared to hypersensitive people (Source: author)

2. Lighting aids for people with ASD

For the reception hall of hospital, we mainly consider reducing the visual stimuli that may threaten the sensory of hyper-sensitive users. All forms of light in the hospital can be categorized as either natural or artificial light. While natural lighting is often favored over artificial, too much of either source can be distracting for autistic students. The following factors should be considered with regard to lighting at the entrance and reception area:

2.1 Natural lighting

Research has shown that ultraviolet light enhances healing by increasing protein metabolism, decreasing fatigue, stimulating white blood cell production, increasing the release of endorphins, decreasing blood pressure, and generally promoting emotional well-being. Natural light has been suggested to provide psychological benefits.

Environments that only have artificial illumination and lack natural light increase stress and discomfort. It has been found natural light is much more beneficial than artificial light for improving attitude and performance. (Edwards et al.2002) Light wells from the ceiling can bring in additional natural lighting. Clerestory windows can be installed in some cases in order to provide extra natural light but minimize distracting views from the window.

Clerestory windows

Figure 6.35 Entrance hall in Riley Hospital for Children at IU Health (Source: archdaily)

Light wells

Figure 6.36 Entrance hall in New Hospital Tower Rush University Medical Center (Source: archdaily)

An extensive use of natural light is important, the amount and variability of light provided by daylighting may make life difficult for autistic individuals since its chronically high level of arousal. Having too many windows in a space is likely to result in an overabundance of natural light, for that it is sometimes difficult to control lighting and outside information input. Therefore, in the entrance hall of hospital, the area of glazing needs be considered carefully. And it is vital to get a balance between natural lighting, outside view and visual distraction. Some studies prove that curtains, fitting blinds can be used to reduce the effect of dazzling sun, deep shadows or excessive contrast which produce visual over-stimulation and control the solar gain(Andrew Brand, 2010). Windows with adjustable blinds can allow the staff to control the intensity of the sunlight and diffuse the direct light to make it softer.

Blinds in the Clerestory windows

Figure 6.37 Entrance hall in Pordenone hospital (Source: archdaily)

2.2 Artificial lighting

The transition from outside to inside should not involve a sudden change in the level of lighting. Illuminance levels in entrance hall should be carefully graduated. Near to the entrance, light levels need to be high so that the reception hall looks welcoming from the outside and so that autistic people can adapt on entering from the bright outdoors. Signage and lighting need to work together to be effective. The front lighting of signage ensures maximum visibility. Colour design and lighting should also work well for wayfinding system. Area lighting can be distinguished according to functions. Different area lighting is also a good way to help define space.

2.2.1 General

Non-flickering source

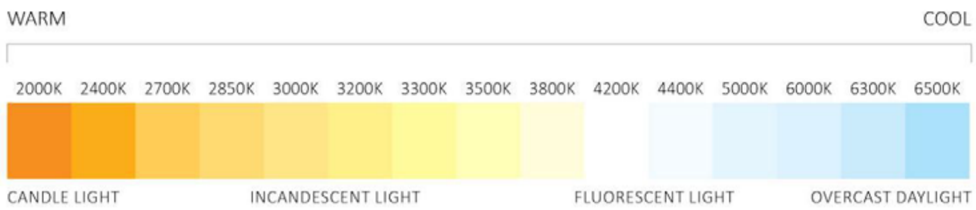
Beaver specifically states that traditional fluorescent lights should be avoided as those with ASD are more sensitive to the flicker of these lights. Flicker as a repetitive flashing stimulus can become overwhelming to autistic users who have difficulty focusing their attention. Approximately half of the autistic individuals experience what is classified as a severe sensitivity to fluorescent lighting. In fact, one small study found that the use of fluorescent lighting increased the repetitive behaviourss of children with autism, which may be attributed to hypersensitivity to fluorescent light flicker. Another small study reported similar results noting that fluorescent lighting increased the frequency of stereotypical repetitive behaviourss in autistic children. Incandescing lighting, halogen is preferred over fluorescent lighting (Beaver, 2006; Vogel, 2008a; Whitehurst, 2007).

Colour temperature

Winterbottom and Wilkins (2009) examined classroom lighting in UK schools (normal school), identified that lights with a colour temperature of 3500K as being preferred in classrooms for students. Teachers reportedly favour soft lighting because they observe more relaxed behaviour and better academic focus under dim lighting. Although this paper didn't research on ASD children, we thought that his findings provide us with useful information, and we will use them to discuss.

Angela Bourne (2013) observed that in a home for seven men with autism, the men preferred to keep the light levels very low. They also kept their blinds closed in their bedrooms and partially closed in the living areas. It appeared that they did not like brightly lit spaces.

But this does not mean that everyone likes the warm colour and dim lighting space. Light intensity and colour temperature, just like colour, depend on the preferences of individuals. For hospital buildings, an inclusive colour temperature should be the first choice, and should not be based on the preferences of individuals or some groups. A light with a correlated colour temperature (CCT) of 4000K is recommended in HBN requirement. From the research, we know that CCT of 3000K-3500K colour can emit a “soft warm” light, which is considered can be good in both physical environment and psychological atmosphere. In many studies on the effects of light on people with autism, they have mentioned to provide them with a non-institutional, soft and home feeling atmosphere as much as possible. We thought that correlated colour temperature between 3000-4000K, soft white light with a bit warm feeling, can create a comfortable and calm environment, which is friendly to all kinds of users in the hospital.



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igure 6.38 Colour temperature scale (Source: elementalled.com/correlated-color-temperature)

Dimmer controls

Children with autism are especially susceptible to mood changes due to lighting. Lights with mellow colors, like blue, can help a child relax and become creative. For this reason, it is important that lighting is controllable。

Dimmers should also be installed on all the lights to allow control of the level of lighting （Beaver, 2006), to adjust light levels based on the occupants’ comfort or needs. Dimmers controls offer a high level of comfort for the individual and achieve many of the energy standards. Autistic users will be more comfortable when given the control to adjust light levels to their personal comfort. Dimmer light levels will also shift the color temperature to a warmer appearance. Dimming the lamps will also reduce the energy draw and use less power to operate. Greater areas of control will help to break up the space into smaller working environments and anticipate the need for flexibility in the space. Integrating dimmer controls with day-light sensors will achieve a balance between electric light sources and natural daylight.

Dimmer to adjust different lighting levels

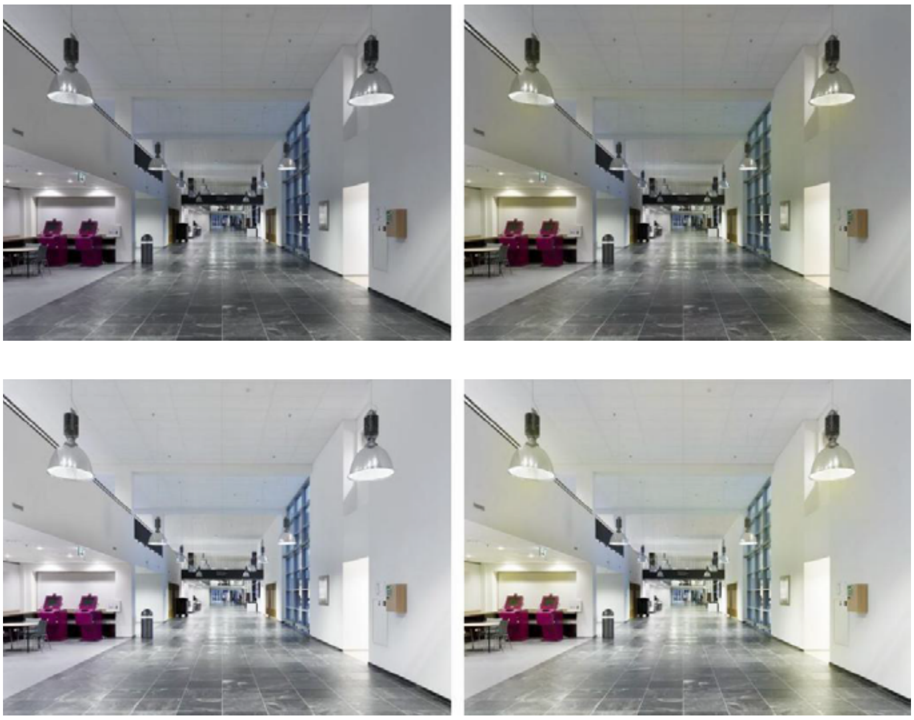

Figure 6.39 Dimmer on lighting (Source: lightlive.com, edit by author)

2.2.2 Reception area

The reception area needs a higher level of vertical illuminance to provide a welcoming atmosphere and make sure that the level of vertical illuminance will not make autistic users anxious. The reception desk should be well illuminated so that its position and purpose are instantly recognized from the entrance doors. Lighting of reception desks should be positioned so that the receptionist's face can be clearly seen by autistic people. The reception area should also avoid heavy downlighting of the reception desk, as it can make people with autism feel unsafe.

Figure 6.40 Entrance hall in Beaches Hospital (Source:Pinterest)

2.2.3 Waiting area

Waiting in a hospital can be a difficult and stressful time, both for patients and for those accompanying them. Good lighting design can provide a visually calming environment. Waiting areas require a comfortable rather than a brilliant level of illumination. Users may read while waiting and spotlighting should be considered.

Modern waiting areas often have television or computer screens to provide entertainment and information to patients. Lighting should be designed to avoid direct or reflected glare to those viewing the screen.

2.3 Glare and reflection

Glare occurs when one area of the visual environment is brighter than the general brightness of the rest of the environment. Glare can come from artificial or natural sources, and the reflection off surfaces is also considered glare. Glare from the light reflecting of surfaces may distract the attention of autistic users and blur the lines of definition in the architecture and furnishings.

Using a glazed or frosted glass will allow natural light to enter the space without creating sharp shadows or glare and will also diminish visually distracting views. (Humphreys Lee, 2005). Some window coverings, like blinds, create what is described as "pattern glare." (Winterbottom et al. 2009). Other sources of glare can come from many surfaces, such as display, screen, wayfinding boards. To reduce glare on wall-mounted white boards, Winterbottom and Wilkins recommend mounting the board so that it tilts away from the wall by five to ten degrees. In the meanwhile, we should pay attention to the selection of materials. The low-reflective and matte materials are recommended. It is proved that using matte surfaces, such as matte paint, carpet, or wall coverings made of fabric, will reduce glare.

Frosted glass facade to reduce glare

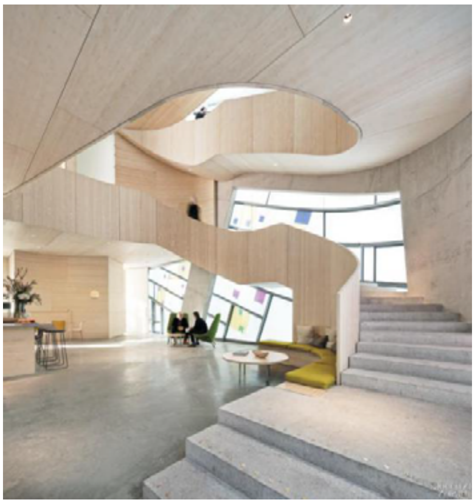

Figure 6.41 Maggie's Centre Barts (Source: Pinterest)

3. Design considerations of ASD-friendly lighting in reception hall

- A sufficient amount of natural light should be introduced.
- Curtains, fitting blinds can be used to reduce sunlight glare and control the solar gain.
- Illuminance levels in entrance hall should be carefully graduated.
- Signage, colour and lighting need work effectively. Wayfinding and other signs and
- landmarks need illumination enabling them to be seen and read from a distance
- Fluorescent lighting, which emits a low hum and flickers, is avoided
- Colour temperature of the lamp source should be 3500K to 4000K.
- Artificial lighting has high-frequency ballast and dimming control.
- The reception area needs a higher level of vertical illuminance.
- The reception area should avoid heavy downlighting of the reception desk.
- Waiting areas require a comfortable and calming illumination.
- Spot lighting should be considered for reading people in the waiting area.
- The hospital can use a glazed or frosted glass will allow natural light to enter the space without creating sharp shadows.
- The hospital uses matte surfaces, such as matte paint, carpet, or wall coverings made of fabric, will also reduce glare.
- Lighting should be designed to avoid direct or reflected glare to those typical views.

06. Smell

Odours play a critical role in connecting us with the world around us. Chemical receptors in the nose tell us about smells in our immediate environment and the sense of smell can help people to identify danger in our life, such as smoke, escape gas or food that is burnt. And research shows that smells create physiological reactions that we are not aware of, driving a host of unconscious behaviours and emotions.

1. Difficulties faced by people with ASD

The people with autism show abnormality in perception to smell. Olfactory sensitivity in autism spectrum has been confirmed in researches that people with autism are highly responsive to various types of smell. (Chris Ashwin, 2014） Smell might be a hidden source of discomfort and even anxiety for some persons with ASD. It might be a faint smell to most while it might be a very powerful smell for persons with ASD.

Compared to ordinary people, the smell sense of hyper-sensitivity individuals is enhanced and strengthened. Everyday smells, such as spicy food, scented shampoos or petrol may overwhelm people with autism, sometimes they may react in unsafe behaviours to avoid that smell. But hypo-sensitivity individuals on spectrum vice versa, they have a lack of smell and may not be able to identify things based on smell. Following Table X.X lists the common symptoms of individuals with ASD when facing various smell stimuli.

Table 6.4 Smell stimuli
Hyper-smell
• Cannot tolerate some smell of objects even it can't be unaware at all by others; • May refuse to go to a place with scents products. • Dislikes people with distinctive perfumes, shampoos, etc;
Hypo-smell
• Has no sense of smell and fails to notice extreme odours; • Tends to seek out for strong smell like curry powder, herbs, flowers, essential oils and perfumes for stimulation experience; • May licks or sniffsthings to get a better sense of what they are, as a means of exploring environment and gaining information.

Moreover, the autism individuals have a different "sniff response" (Figure 6.42). compared with typical developed individuals. A study (Rozenkrantz ET AL.,2015) shows, the children without autism changed the way they sniffed the bad odours within 0.3 of a second. They very quickly took smaller sniffs of the bad smells and larger sniffs of the sweet smells. The children with autism, however, continued sniffing without any changes. In other words, the unpleasant smell, usually harmful, damage the health of the autistic users more than others.

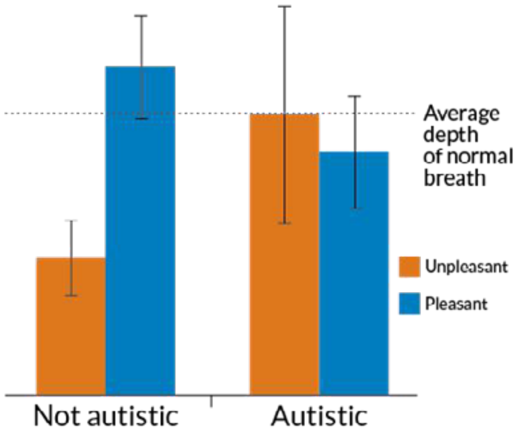

Figure 6.42 Result of Sniff response (Source: Journal Current Biology)

2. Smells in hospital

Many people will complain about the hospital smell. The main source of the smell is the disinfectant which hospitals prefer to use to make the place clean and free from bacteria and viruses. Another potential sources of odours could be garbage disposal areas, food waste areas, toilets and laundries, bedpan storage and medical waste storage. In addition, the chemicals and drugs also emit special odour.

3. Olfactory aids for people with ASD

The cause of "hospital smell" is multiple such as disinfectant, various medicament, etc. It is inevitable but some solutions could help to reduce the olfactory stimulus for patient with ASD.

3.1 Well Layout

Usually, the toilet should be visible from the entrance. Toilet/washroom may tend to emit peculiar smell which have a negative impact on patient with autism. If possible, the location of toilet could keep a distance from the special waiting area in the entrance hall. If there is a smoking room, the smoke from the smoking room and outside smoking area should not enter the entrance hall.

There are some dining spaces, such as restaurant, bar near the entrance. It is recommended to avoid selling food with strong smell. Designer can try to locate the coffee and bar far from waiting area in the entrance hall. Some autistic users will be distracted by smells, even cause headaches.

Highlight

- Location of toilet
- Location of cafe and snack bar
- Location of smoking area

3.2 Nontoxic Materials

The form of a building and its materials play an integral role in smell ambiance, and when trying to create a specific atmosphere, smell might be used more readily combined with other sensory elements to achieve the effect. People with autism often have underlying health issues that are exacerbated by environmental chemicals. To make things worse, people with autism might not be able to cough up, or hold breathing for an unpleasant smell from coming into their system. There are large number of publications addressing environmental chemical exposures and autism. A study about some volatile organic compounds (VOC) associate with autism. VOC include a large group of chemicals that become gaseous close to room temperature and are released from products or processes. It is suggested that select specifying low or no VOC finish products and coating. (Ahrentzen, Steele 2009).

3.3 Well Ventilation

In the hospital, smells from medical disinfection liquids, such as alcohol exist, will trigger the emotion of anxiety and remind them of some bad experience. That is the reason why some patient with autism may dislike the smell of volatile agents. Good ventilation can avoid this institutional smell as much as possible. First, we need to maximize the use of natural ventilation to ensure air quality. Natural ventilation creates fresh indoor air conditions and avoids excessive stimulation of strong indoor odours for ASD suffers. Adequate ventilation reduces unwanted smells that can negatively affect individuals with hyper-reactive (extremely sensitive) sensory processing. In the design of hospital environment, a suitable high-level window will help with ventilation. In addition, Extra mechanical ventilation may also be required in the reception hall.

3.4 Fragrance-free environment

Ari Ne'eman, co-founder of the Autistic Self-Advocacy Network in the United State, states the rise of fragrance-free policies at many public institutions. A common source of indoor air pollutants is fragrant consumer products, such as air fresheners, cleaning supplies, and personal care product. Air fresheners can add more confusion to sensory input. It is suggested that people refrain from wearing scents such as perfumes, colognes when in hospital.

4. Design considerations of ASD-friendly smells in reception hall

- Toilet/washroom keep a distance from waiting area.
- Dining area keep a distance from waiting area.
- Select specifying low or no VOC finish products and coating.
- Air quality should be fresh by maximizing natural ventilation and extra mechanical.
- Plants and fresh flower can be placed in the entrance hall.

07. Tactile

Nerves under the skin's surface send tactile information to the brain. Pain, temperature, and pressure are all perceived through the sense of touch. The tactile sense tells a person what an object feels like. Beside, stactile experiences are evaluated simultaneously with other sensory encounters (Konkle et al. 2009). It is proved that the way something feels is influenced by how it looks, and vice versa.

1. Difficulties faced by people with ASD

Tactile impairment is the prevalent sensory characteristic observed by children with sensory dysfunction (Freed et al. 1998). Autistic people may experience difficulty with processing tactile information and fail to get a ‘feel’ on daily stuff. Hypo-sensitive autistic people usually can’t feel things by touching while hyper-sensitive group refuses to tactile experiences. Following TableX.XX shows the common symptoms that hyposensitive and hypersensitive autistic people exhibit when facing various touch stimuli.

Table 6.5 Tactile stimuli
Hyper-tactile
• Does not like to be touched or hugged, even the slightest touch can send them into a panic attack; • Dislikes to have anything on hands or feet; • Avoids tasks with strong tactile element (glue, clay, water, paint, sand and etc.); • Only likes certain types of clothing or textures.
Hypo-tactile
• Does not seem to notice touch of others; • Tends to seek out tactile experience to stimuli themselves (e.g., physical touch and different textures); • Holds others tightly for pressure sensations and enjoys heavy objects (e.g., weighted blankets) on top of them; • Has high pain threshold, unaware of danger because of low response to pain.

Hyper-tactile individuals may resist being touched or hugged, wearing certain types of clothing, and complain about having their hair or face washed. This may cause the brain to be overly stimulated and lead to excessive brain activity, making it difficult to concentrate or organize behaviours, leading to developmental delays, learning problems, and other sensory problems.

Hypo-tactile individuals with autism often seek deep pressure sensations. Based on the theory of Temple Grandin, deep pressure is defined as "the type of surface pressure that is exerted in most type of firm touching, holding, stroking, petting of animals or swaddling." Firm massages, weighted vests, and weighted blankets are other ways to apply deep pressure.

2. Tactile aids for people with ASD

According to Jan Cline, coordinator of training at Bittersweet Farms Inc. in Ohio, when people with ASD interact "hands on" with materials in an art class, for example, they connect with what they are creating and develop communication skills through their works of art. The intimate connection with materials such as clay, paint, paper, and textiles enable them to engage their sense of touch and develop deeper meaning of what's happening in the environment around them. In hospital, tactile information can provide people with ASD positive sensory feedback, to tell them what hospital is like subconsciously.

2.1 Soft textures

Sensitivity to scratchy textiles create additional tactile issues for individuals on the spectrum. Shin and Gaines determined that organic bamboo and organic cotton were the two most preferred textiles by individuals with autism. The soft touch and moisture wicking properties were found to be the most positive features. Although this study looked at textiles for apparel, the same principles are relevant for designing interior spaces.

Observations of young adult residents in research conducted by Dr. Angela Bourne also revealed tha the majority of people collected numerous soft, furry, stuffed animal toys and surrounded themselves with clothing and bedding that was soft. This supports Childers and Peck, who revealed soft textures/surfaces are generally seen as more pleasant and preferred to hard ones.

Figure 6.43 Soft furniture (Source: google)

Individuals that are sensitive to touch may be particular about certain textures and fabrics, avoid using their hands in play, and find human touch uncomfortable. A soft environment is of particular importance to this population and will protect them from injury and promote a feeling of security. A soft environment serves a variety of spectrum symptoms, including symptoms that result in weak mobility and balance, and helps to reduce injuries from “stimming.” Creating a soft environment would be a safe choice for a child with hyper-sensitive tactile tendencies, who often appear to have a very low pain threshold. A soft environment would also benefit children with ASD who have proprioceptive and vestibular problems, as they will often misperceive distances and have trouble with balance. A softer environment with upholstered furniture, carpet, rounded edges, etc. would make the entrance more protective.

Figure 6.44 Furniture of Seattle Children's Hospital (Source: archdaily)

Figure 6.45 Hall of Southmead hospital (Source:archdaily)

2.2 Metal surfaces

According to the theory of soft textures we just talked, autistic patients should have been unwelcomed to metal material as it is hard surface. The reality is different from what we suppose. Zuo, Hope, Jones, and Castle(2004)_studied human responses to metal surfaces: "Smooth metallic surfaces evoke positive emotional responses such as lively/cheerful, modern, elegant, and comfortable. In contrast, rough metallic surfaces evoke negative emotional responses such as dull/depressing, traditional, ugly, and uncomfortable." Results were obtained after blindfolded touching. In Bourne's interviews(2013) with adults with ASD, several of the men commented on liking images of residential interiors that had smooth, shiny surfaces. Comments were made about how they liked the shiny floors, counter tops, and lighting in the images they were. These individuals further explained that the shiny features looked "rich" and clean.

2.3 Natural textures

Mostafa also discusses the autism-friendly tactile environment in the housing space (2010). She mentions, with the hyper-textural user, smooth, soft materials should be used while the hypo-textural user needs stimulation through rough textures. Again, natural materials provide a positive balance, with areas created customized to each user within the building.

The use of natural building materials, such as wood, in the indoor environment, can make it possible to introduce natural elements in hospitals or institutions where there are limitations to the use of indoor plants. Research has demonstrated that using nature-inspired design in this way can positively impact perceptual and physiological stress responses (Salingaros el at. 2006). Natural materials are also regarded as a tool of Biophilic Design, which has been universally recognized its benefit to everyone, they can really be harnessed to address issues symptomatic of students on the spectrum.

Figure 6.46 Entrance of Zaans Medical Centre (Source: archdaily)


Figure 6.47 Hall of ZGF's Randall Children's Hospital (Source: archdaily)

2.4 Multiple textures

In the interior design of the hospital's entrance hall, materials are more flexible and easy tools to create atmosphere suitable for ASD patient. It is proved that the use of multiple materials has a positive effect on the ASD. Juhani Pallasmaa (2005) stated, "Vision reveals what the touch already knows." People almost always know how something will feel just by seeing it, and this is followed by the feelings that accompany that sensory experience. Therefore, a variety of textures and patterns that reflect a hand-crafted quality and are seamlessly integrated in the interior and exterior spaces allow the person with ASD to touch and feel and gain knowledge from their surroundings and become more self-reliant.

Figure 6.48 Hall of Oakville Trafalgar Memorial Hospital (Source: archdaily)

2.5 Tactile walls

Children with tactile hypo-sensitivity sometimes enjoy rough and messy play and often are not bothered by physical injury. For these reasons, they always need adequate supervision. Therefore, providing a separate space where the child is free to feel objects and play roughly is highly encouraged. In the school design for ASD, tactile surfaces with varying materials on the wall can be beneficial for mobility training. （BB102） Similarly, in the hospital, appropriate sensory integration activities for tactile hypo-sensitivity including a tactile all with varying textures, clay, skin brushing, a sandbox are recommended.

Figure 6.49 Different tactile walls (Source: pinterest)

3. Design considerations of ASD-friendly tactile design in reception hall

- Bamboo and organic cotton were mostly preferred by individuals with autism.
- Soft, furry, stuffed animal toys can be put on the seating to surround autistic individuals
- Upholstered furniture, carpet, rounded edges are generally recommended.
- Smooth metallic surfaces evoke positive emotional responses on autistic individuals.
- Natural materials provide a positive balance between hypo-sensitive and hyper-sensitive patients
- A variety of textures and patterns that reflect a hand-crafted quality and are seamlessly integrated in spaces allow the person with ASD to gain knowledge from their surroundings and become more self-reliant.
- Tactile walls with varying textures, clay, skin brushing, a sandbox can be provided to children with tactile hypo-sensitivity.
- Air flow caused by the use of fans can have a positive effect on people with autism, as well as good ventilation.
- Adequate heat and humidity avoid tactile defensiveness.

08. Safety

All building elements in the reception hall must be carefully assessed for safety – standard details might not be enough to protect individuals with ASD, who may be particularly vulnerable. In general, the layout and organization of the facilities and the intent of the design should be to allow the greatest possible freedom and independence for all users while minimizing hazards, security risks or behavioural triggers for those with ASD.

1. Safety issue faced by autism

The first challenge facing some people with autism, especially the hypo-sensitive group and children, is lack of awareness to realize that they are or will be in danger. Less fear may explain why children with autism often run into traffic or deep bodies of water. Besides, they would have self-injury (hitting head, pulling hair, pica, biting, pinching), aggression (hitting, pinching, scratching), and destructive behaviours (personal property, others' property, small items, furniture, fixtures, and fittings). (Lowe 2007) Here we list a set of behaviours that may lead them more susceptible and exposed to danger.

Table 6.6 Some symptoms and behaviours with potential risks
Hyper-sensitive autistic people may:
• Easily overreacts to various sensory input. • Has poor balance ability.
Hypo-sensitive autistic people may:
•· Does not react to sounds indicating potential danger. • Frequently puts things into mouth; • Chews on inedible and non-food items (e.g., soil, grass); • May licks things to get a better sense of what they are. • Has high pain threshold and unaware of danger, even may tend to self-harm; • Does not response to pain after being hurt or touch extreme temperatures. • Tends to move around unnecessarily and enjoys spinning in circles.

2. Safety aids for people with autism

2.1 Material

(1) Durable material

The material in the reception hall should be durable in case of the destructive behaviours. Because some hypo-sensitivity are frequently puts things into mouth and unaware of danger because of low response to pain. And often, children prone to sensory-seeking behaviourss enjoy rough play or lean on objects in an attempt to find stability in their environment.17A large amount of study agree that materials and finishes should be selected to maximize durability and be compatible with their intended function. One reason for that is the repetitive behaviourss of autistic, closing the same door over and over, walking the same path repeatedly. Beaver claimed that carpets, wall surfaces and ceilings have to be durable and easily cleaned. Shiny vinyl floors are to be avoided. Also, Richer and Nicoll (1971) suggests that use of elements and materials that are durable. As the case study of Sweetwater Spectrum Community (2013) in USA, a new national model for supportive housing for adult with autism, suggest the use of durable materials, such as impact-resistant drywall, commercial grade doors, and cement board exterior cladding.

(2) Harmless material

Compared to the typical developing individuals, autistic users have more intense reactions to dirt, bacteria and toxins, so materials used in the environment must be carefully selected, with less potential for allergic reactions. Beware of chemicals, odours and off-gassing in surfaces such as foam and carpeting. In the view of Ahrenten and Steele (2009), it needs to pay particular attention to specifying products and materials that reduce exposure to toxic chemicals. As the case study of Sweetwater Spectrum Community (2013) in USA, a new national model for supportive housing for adult with autism, highlight the use of harmless materials, such as no VOC paints, adhesives and sealers, formaldehyde-free insulation and wood products, and non-toxic, vinyl-free flooring.

(3) Non-slip and easy cleaned material

Flooring should be seamless and smooth, slip-resistant, easily cleaned and appropriately wear-resistant. For soft flooring to reduce the movement noise, it could choose linoleum, rubber the false flooring, PVC or Vinyl flooring.

2.2 Furniture

(1) Well fixture

Well-fixed furniture and structures are essential. Due to autistic often have the tendency of destructiveness, furniture and decorative objects should be well fixed and unmovable. Falling furniture is actually a risk to all people, but because of the way autistic interact with the world around them, it can be a great risk to them. Chairs, tables, cabinets and fittings should be fixed to the floor or to each other to ensure furniture cannot be used as potential weapons or footholds for climb (Beaver 2003). Structures and fixtures were robust and firmly anchored, so that there was no need to interrupt the children's games with safety warnings or instruction (Richer & Nicoll 1971). Beaver (2006) state that fittings must be firmly fixed, otherwise they could be pulled out of their place. For example, carpets should be taken under the skirtings so that they can't be ripped up.

(2) Soft edge or corner protection

It is suggested that all objects in the reception hall, including furniture, have softened edges. Because it would add protection when an autistic is experiencing violent movements during a meltdown. Mostafa (2014) states that an avoidance of sharp edges and corners. Vogel (2008) also stated that soft surface can reduce the potential for injury. For example, a fabric chair is better than a metal one in the view of potential danger. If there is a sharp edge, protector is needed to prevent patient from hurt. The good effect of soft material is multi-dimensional. Soft material is not only used to cover the edge of the corner to prevent patient with ASD from hurting, but also help to noise reduction and a comfortable tactile.

Figure 6.50 Soft edge of furniture and structure

(Source: ZGF's Randall Children's Hospital)

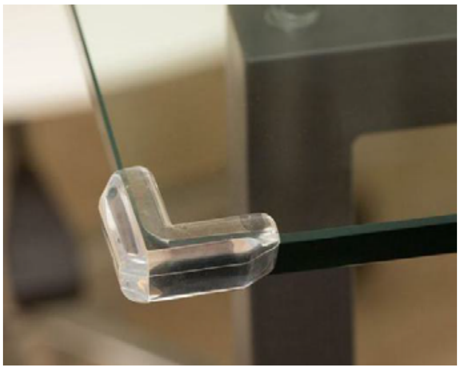

Figure 6.51 Corner protection

(Source: pinterest)

2.3 Structure

(1) Windows and doors

Windows can be opened to building exterior and restrict locked from the interior. Glazing should be made out of safety glass-both on the exterior and the interior sides. Blinds could be inside double glazing (Beaver 2003). There should be no support in front of the window that can be climbed or used as footholds to prevent ASD users from looking through the window and falling. High level windows which provide additional day lighting and ventilation help to prevent the children from climbing out the window and reduce stress. As for the floor-to-ceiling windows, visual contrast can be used as warning in case the autistic users collide with windows.

Generally, doors should open away from areas with high traffic flow towards areas with a lower traffic flow. On doors that are designed to remain open, such as fire doors, the edges should be recessed when open in order to avoid creating an obstruction.

(2) Staircase

Often, the staircase can be seen in the reception hall. Some are open staircases, and some are enclosed ones. Besides some basic guidelines in the hospital environment, concern should also be given to the users with special need. For the open stairway, staircases that jut out, should be avoided. It can be seen as overhead obstruction, which can hit the head of some users with ASD. Helical and spiral steps, the treads of which are often too narrow, should be avoided. It will lead to dizziness to some vulnerable users. Single steps may be difficult to negotiate, are not visually obvious and should be avoided.

Changes of level may pose risks for some children, so suitable safeguards should be provided in case of falling. Stair finishes should not have patterns that may cause step edges to be indistinguishable or cause visual confusion of any kind. Stairs should be lit well to provide a contrast between the treads and risers. Coloured, contrasting nosing or illuminated or luminous nosing (tread edges) can help safety. The stairway should be clearly defined through contrasting accent materials adhered to the front edge of the tread. The visual cues remind the patients where a step begins and ends. Handrails should be rigid, securely fixed and able to support the weight of a person leaning on them. There is a successful case of staircase (Figure 6.52).Tread edges with the color of gray define each step clearly and handrail with different heights ensure the safety of children(left picture).Under the staircase, there is a planting area where people can sit on the border, so that it prevent the users with ASD playing beneath the staircase. Therefore, it can reduce the possibility of hitting heads. (right picture)

Figure 6.52 Staircase in the Akron Children's Hospital (Source: pinterest)

(3) Other protruding obstacles

Sharp angles and overhead obstructions should be avoided. Compared to the typical developing individuals, people with autism are more vulnerable to these potential hazards. If these exist, and cannot be removed, they should be emphasized by painting them in a bright, contrasting colour or, preferably by erecting a physical barrier.

Safety considerations of staircase:

- Staircases that jut out, should be avoided.
- Helical and spiral steps, the treads of which are often too narrow, should be avoided.
- Single steps which are not visually obvious and should be avoided.
- Stair finishes should not have patterns.
- Contrast between the treads and risers should be provided.
- Handrails should be rigid.

2.4 Warming signal

Clear warning signals or physical barriers should be provided to inform risks of protruding obstacles, slippery area, untouched objects, unclimbable area and etc. Use dividers, tape boundaries, and signs for setting expectations and limits. (Figure 6.53)

Figure 6.53 Warning signage (Source: google image)

3. Design considerations of ASD-friendly safety in reception hall

- Use durable material for furniture, wall, flooring.
- Materials should be harmless, nontoxic, zero-or low-VOC.
- Flooring should be seamless and smooth, slip-resistant, easily cleaned and appropriately wear-resistant.
- Chairs, tables, cabinets, fittings and art furnishings are fixed to the floor/wall or each other.
- Soft surface of furniture, flooring, ceiling and wall.
- Furniture with soft edge are recommended.
- If there are sharp edges and corners, it should be protected.
- Windows can be restrict locked from the interior and open to exterior. Use of safety glazing both on the exterior and interior.
- There should be no support in front of the window that can be climbed or used as footholds.
- Doors open to the high flow area should be recessed.
- Treads and risers of staircase should be defined clearly, using color or material contrast.
- Sharp angles and overhead obstructions should be avoided.
- Clear warning signals or physical barriers should be provided to inform risks of protruding obstacles, slippery area, untouched objects, unclimbable area and etc.
- The staffs in the reception hall should have good sight lines for passive supervision.

09. Hospital Equipment

In hospital individuals with autism may display an abnormal sensitivity to specific sensory stimuli from the hospital equipment. In order to have a pleasure hospital visit for autism, the influence of medical equipment should be taken into consideration.

1. Difficulties faced by people with ASD

Due to the function complexity of in the reception hall, the multiple equipment contained is one of factors may affect the experience of ASD users in hospital. Unthoughtful design may lead to sensory disturbance. For example, the noise some equipment generates will be regarded as white noise for the typical developing individuals, while the autistic users couldn't bear. That is because autism often involves difficulties in distinguishing and processing sound. Furthermore, in medical environment, chances are high that people exposed to the sounds of alarms beeping and buzzing all day long. Not only auditory noises, stimulation related to the tactile and sight is similar.

2. Method of reducing equipment's adverse effects

2.1 Alarms

In the reception hall, alarms are set to ensure the safety of all the users, such as fire alarm (Figure XXX). However, sharp and high-pitched sound may lead to violent behaviourss when ASD users hear the fire alarm activate. The location of alarm should not near the waiting area which has relatively quieter environment. The volume should be controlled. There are many ways to lower the volume of alarm on condition that the safety is ensured, for example, designers can try to make alarms quieter, combining audible alarms with visual cues like interactive screens.

Figure 6.54 Fire alarm (Source: google)

Meanwhile, there are many clinical alarms which are used to remind nursing staffs transferring through corridor to the reception hall. There is also some proposed advice on clinical alerting, Today, it is possible for different alarms to be routed directly to the appropriate person. By bypassing the nursing station and sending alerts to the right on-duty clinician's preferred mobile device (smartphone, Wi-Fi phone, tablet, or page), hospitals can reduce the number of calls or overhead announcements that have to be made. This reduces the amount of noise and promotes a quieter environment for resting and healing.

Nurses and physicians can get help triaging alarms with the help of intelligent software. Clinical alerting software can act as the first stage of triage by "incorporating the facility' s preset priority levels and using built-in logic to pass along the highest levels of alerts first."

This makes the job of the nurse more efficient through enhanced meaningful communication: They only receive alerts to their mobile device that require immediate attention and are actionable. Further, hospitals can use the software to build escalation paths that help ensure critical alarms always receive a timely response from a caregiver, even if the clinician is assigned to the patient is unable to respond to the alert. Yoko Kamitani Sen, founder of Sen Sound, proposes that in the future nurses might use wearable devices to alert them to a patient in need rather than an alarm. Although it hasn't fully came into practice yet, this kind of technology is one of the strategies.

2.2 Electronic screens

Modern hospitals foster a highly computerized clinical environment, resulting in nearly everything being hooked to a monitor that can make audible noises. The selection of monitor screen should be careful. A rotated monitor computer and printer should be placed on the reception desk. As mentioned before, the computer screen would be possible to cause glare which is a visual overload for patient. It should consider the brightness level of the monitor for people with visual sensitive. Additionally, the sound of printer and of computer keyboard would disturb patient with autism during treatment.

Proper placement of reception desk can avoid glare on the screen. It suggests that select matte screen monitor and have a dimmer to adjust the brightness. For individual with autism, the colour contract and brightness is softer so it is less painful to look at. Although elimination of all noise is not feasible, it is best to use quiet keyboard and well quality printer. The printer could be placed away from the patients and visitors.

Electronic screen (Figure 6.55) can also be used to inform, instruct and assist with queuing. The luminance should not be too high. Study has pegged that more than half of autistic adolescents have visual processing deficits, including sensitivity to light, as we discussed before. For some electronic screens in the waiting area, it can be switched off or keep mute in case of visual distraction. Since the reflective surface on screen, the direction of electronic screen should be considered, avoiding glare. The non-patients-necessary electronic device such as TV can be removed out of sight.

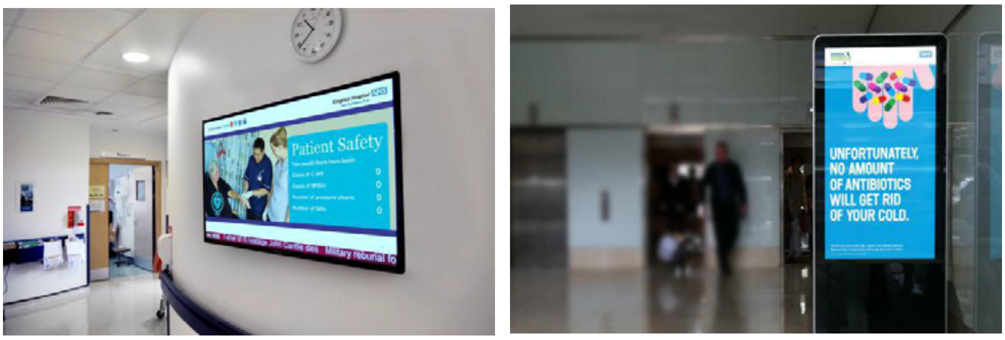

Figure 6.55 Electronic screen (Source: google)

3. Design considerations of ASD-friendly equipment in reception hall

- The location of alarm should not near the waiting area which has relatively quieter environment.

- Designers can make alarms quieter, combining audible alarms with visual cues like interactive screens.

- It is possible for different alarms to be routed directly to the appropriate person, reducing the number of calls or overhead announcements.

- Intelligent software can be used to incorporating the facility's preset priority levels to pass along the highest levels of alerts first.

- Machines should be arrayed in order to limit the visual distractions.

- Some unnecessary equipment should be stored in another area, beyond the sight of patients.

- Low-noise monitor is the priority.

- The luminance of electronic screen should not be too high.

- Electronic screen in the waiting area, it can be switched off or keep mute in case of visual distraction.

10. Assistive technologies

A growing number of studies have investigated diverse applications of technology-based interventions with people with ASD. There is a need to provide appropriate technology assistant to help children with autism to integrate their senses and have more pleasurable interactions with people and their environment. Firstly, we made a review on how technologies function as support tools for persons with Autistic Spectrum Disorder. And then we purpose some ideas on how technology can be used in the reception hall.

1. The role of technologies in autism-friendly design

Technology can be used in the hospital. Though it doesn't belong to environmental factor, it also plays an important role on wayfinding and reducing the anxiety of the ASD users. Parents and clinicians regularly report that children with autism are drawn to technological devices and researchers have noted the importance of devising treatments that take advantage of this fascination (Colby, 1973). A growing number of studies have investigated diverse applications of technology-based interventions with children with autism. When technology used in the building environment, less manpower is required to result in positive change which is a critical benefit.

2. Assistive technologies applications

2.1 Multimedia intervention

Multimedia intervention is based on the Sensory Integration Theory (Ayres,1972) which is the process that refers to the detection, integration, organization, and use of the sensory information that helps a person interact with his or her environment. Multimedia interactive intervention focus on teaching children how to integrate their senses, gain body-awareness, and adapt to the environment. Usually it provides "sensory diets" for the sensory-seeking users. One therapeutic approach to sensory processing disorders is to combine sensory integration and body-awareness therapies in Multi-Sensory Environments (MSE), also known as a multimodal environment. These are physical environments saturated with visual and audible stimuli. MSE also house specialized equipment for sensory stimulation, where children with sensory processing disorders use a variety of tools, including objects with various textures, mirrors, and tactile sensations (Schaaf, Miller, 2005). Besides, some goal-oriented tasks in the MSE can maintain users' attention and increase engagement. Multimedia intervention gives children a sense of control over the stimulation and a sense of purpose when interacting with stimuli. It can help children to turn their attention towards their bodies. There are some studies among those successful multimedia interventions. SensoryPaint and Snoezelen room are two typical examples.

SensoryPaint (Ringland et al. 2014) allows persons with autism to paint on a large display using physical objects, movements, and midair gestures, and to receive visual-aural stimuli. A field study showed that use of the system enables children to balance attention between their own body and sensory stimuli and promotes socialization. Snoezelen room (Fava, Strauss, 2010) offer stimuli such as lights, soap bubbles, and aromas stimuli such as lights, soap bubbles, and aromas. It is a relaxing space that helps to reduce agitation and anxiety, but they can also engage and delight the user, stimulate reactions and encourage communication. It is proved the atmosphere and the equipment of the multi-sensory intervention have an activating effect. (Leonardo Fava et al. 2010).

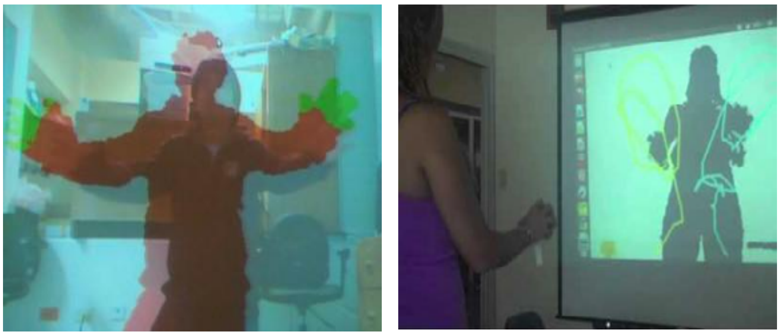

Figure 6.56 SensoryPaint (Source: semanticscholar.org and youtube)

Figure 6.57 Snoezelen room (Source: atctoscana.it)

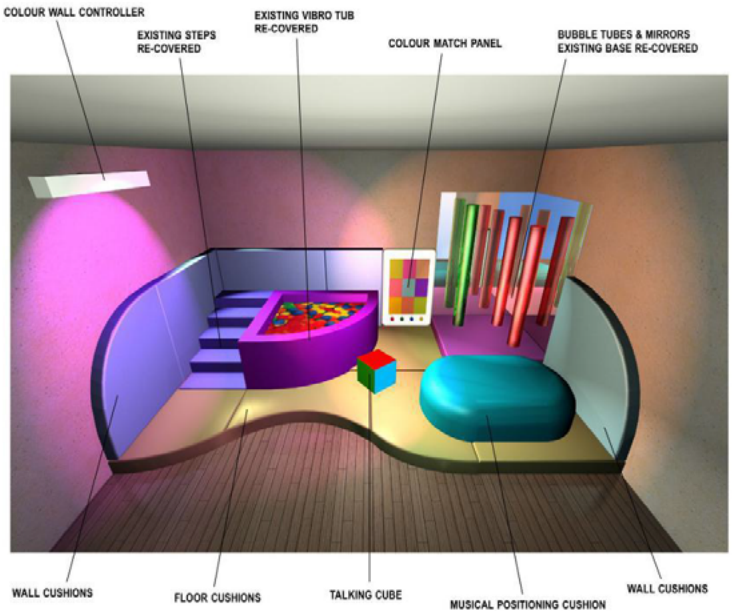

Figure 6.58 Construction of Snoezelen room (Source: pinterest)

In the hospital environment, dedicated multi-sensory room can be located near the entrance and some interactive installation can be displayed in the hall, to provide sensory engagement to all users, including the individuals with ASD.

2.2 Interactive robotics

Ideally, the robot will be viewed as a companion and a friend of both the child and the caregiver. Robots have interesting characteristics that make them useful as tools to treat ASD (Robins, et al.;2005). Robots show predictable behaviours, produce controlled social situations and interact with persons in a simple manner. This makes people with ASD feel less anxious by making social situations less complex. Jordan et al. (2013) studied the use of robots to work on attention, communication and social skills in adolescents with ASD. They recorded parameters while the participants played the card game called Face Match in different environments: with a humanoid robot, a Smart Board and the cards. the researchers found that although there were individual behaviours patterns during the three game modes, repetitive behaviours was reduced when the adolescents played with the robot or the Smart Board. Thus, social robots may become very useful tools in therapy with ASD children. In the reception hall, interactive robotics can be used in the playing area. They can communicate and play games with users with special need. Robotics can also aid in wayfinding. The system consists of a mobile robotic guide and small passive RFID(Radio-frequency identification) sensors embedded in the environment (Kulyukin,2006). However, if the path to the destination is blocked and not all critical tags are in place, the robot may have no way to reach the destination.

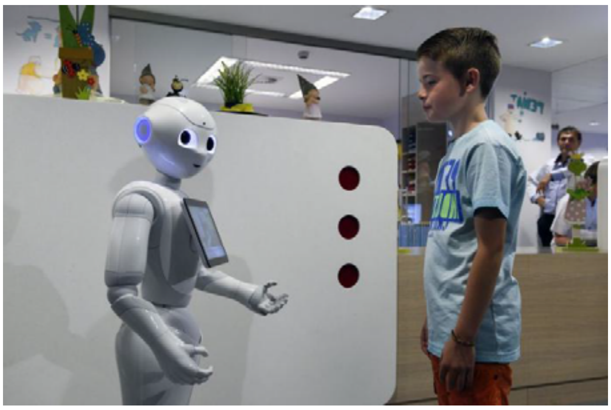

Figure 6.59 Wayfinding robotics (Source: lifestyle.sapo.pt)

2.3 Virtual reality application

Due to the advantages of using "Virtual reality" technology to create controlled and real environments, it can be a useful efficient support tool. Virtual reality application can be used in the waiting area of entrance hall as a positive distraction. It can relieve the anxiety and fear in the mind of ASD users. It also has some other positive effects on autistic users. Many researches demonstrate the improved skills on learning, playing and communicating.

Figure 6.60 Virtual reality application (Source: msensory.com)

The following research shows how social learning and imitation skills can be improved through virtual application. Researchers Josman et al. (2011) developed a safe environment using virtual reality technology which enabled persons with ASD to learn how to cross the street. Six children with ASD formed the experimental group and six children with neurotypical development formed the control group. The researchers concluded that persons with ASD learned the skills needed to make the right decisions when crossing the street in a virtual environment and thus, the knowledge acquired could be applied to real situations. It proves virtual reality facilitates learning in a safe environment enabling a gradual increase in the complexity of tasks approaching the conditions of real life. The skills learned in the virtual reality can transfer to real life.

Virtual environments have also been studied to help learn skills such as playing. Herrera et al. (2008) conducted two case studies on children with autism in which they evaluated this skill with virtual environments. The findings showed improvement in play skills following the intervention.

Some virtual reality applications can also promote the communicating skills. In 2006, Parson et al. (2006) studied the behaviours of two adolescents with ASD in two virtual environments, a café and a bus. In this study, the authors proved that the adolescents significantly interpreted the scenes and appreciated the opportunities to maintain a dialogue and respond correctly although they continued to show repetitive behaviours and interpret the situations literally. Mitchell et al. (2007) followed this same line of research created a virtual coffee shop. The researchers found that there were cases of significant improvement, directly related to the time spent in the virtual world when deciding and explaining where they chose to sit.

Though these various virtual reality applications are mostly used in the school or healing room to address the problems of social, communication, behavioursal, and adaptive skills in those with ASD. Public space, like entrance hall are merely used. As an autism-friendly entrance hall, an area of virtual reality interaction can be explored to gain recognition and skills under the supervision of professional staffs. Virtual reality application can also be used to show the general map and key routes. It can help the wayfinding effectively and give them a controllable sense. It can help the wayfinding effectively and give them a controllable sense. The requirement of virtual scene should also keep the least details for hyper-sensitive users. And for the hypo-sensitive or sensory-seeking users, stimulation should be provided for engagement. What we need to concern is the secure problems, such as falling, caused by virtual reality application. And if autistic users are not adjustable to the scene in the virtual reality application, such as darkness, the staffs need to help to take off the head-mounted display in time.

Besides, scenes in the virtual reality application can act as "escape space". When they experience sensory overload, virtual reality application can provide a safe and private space to let them calm down.

2.4 Mobile equipment

Modern auditory prompts such as smart phone and MP4 players are relatively small and unobtrusive so that it is easy to carry. When ASD users wear earphones, preferred music can block part of noises and sooth the negative emotion. The use of mobile equipment can also aid wayfinding. Torrado et al. (2016) developed a mobile tool (Assis T-In), which consists of an Android smartphone application supported by QR codes, to help people with cognitive disabilities address indoor navigation tasks. Through the orientation systems, not only wayfinding can be easier, the safety of ASD users with sensory-seeking behaviourss can also be better guaranteed.

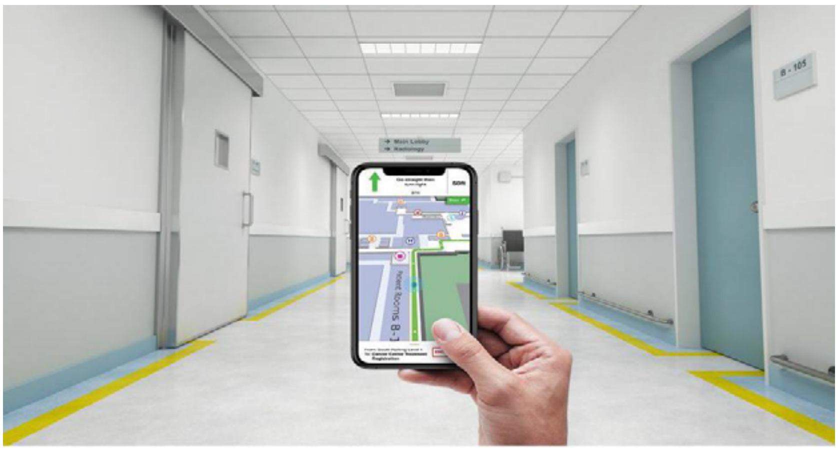

Figure 6.61 Wayfinding mobile phone (Source: prnewswire.com)

3. Design considerations of ASD-friendly assistive technologies in the reception hall

- Multimedia intervention can be applied in the sensory room near the reception hall.
- Multimedia intervention can be displayed inside the reception hall to gain sensory engagement.
- Robotics can be a guide for wayfinding.
- Interacting with robotics are easier and more controllable for the autistic users.
- Virtual reality application can be applied as an educational tool in the waiting area.
- Virtual reality application can aid in reading maps and getting knowledge of general hospitals.
- Modern auditory prompts such as smart phone and MP4 players can create a pleasant auditory environment.
- Mobile equipment can ensure both safety and wayfinding.

11. Escape space

Escape space is an aid to hyper-sensitive autistic individuals. Because of the heavy density of people in the hospital, many triggers, such as, the unexpected incidents can make ASD users overly anxious. Children with hyper-sensitive symptoms can be easily overwhelmed when too much stimulation is present in the environment or simply because they are tired or in a bad mood. At that time, an escape space to expel energy is needed. Retreat spaces or escape spaces were created specifically for ASD users prone to sensory overload. And People diagnosed with ASD may resist being close to other people or having other people close to them. Quite frequently they choose to stand or sit in locations where they can hug the wall to attain privacy. To help a person with ASD to feel more comfortable in public spaces, escape space needs to be implemented. It can provide opportunities for a person with ASD to ease into a space and acclimatize to their surroundings.

1. Characteristics of escape space

In the entrance hall of the hospital, the concept of "escape space" has not been introduced. Thus, we search for some examples in the classroom and home to find the characteristic in common. Research (Mostafa, 2008) has found escape spaces in the classroom have been very successful and are especially helpful to children that tend to be hyper-sensitive, as the environment is particularly stressful for them. Attention span, learning performance, and focus improved while negative behaviourss decreased. A study by Mostafa implemented an escape space in a classroom, the space is divided from the rest of the classroom using screens, bookcases and other pieces of furniture. She observed that over time the space was used less frequently, and the children spent decreasingly less time inside. The following describes a study by Mostafa in which an escape space was implemented in a classroom:

Before implementation, the student with ASD often removed herself from the group to sit in a corner and after several minutes would rejoin the group. After the escape space was added to the classroom, the student initially retreated to the space quite frequently. Over time, the student used the space less and less. The teachers did note that the student would look over her shoulder at the space but could stay focused on the task at hand as if knowing the escape space was there if needed was sufficient for her to continue.58

She summarized such spaces may include a small partitioned area or crawl space in a quiet section of a room, or throughout a building in the form of quiet corners. These spaces should provide a neutral sensory environment with minimal stimulation. If necessary, it can be customized by the user to provide the necessary sensory input.

In the other research, the research was conducted at a special-needs school in Tokyo, the small escape spaces were placed in three classes, elementary school, junior high school, senior high school. The author also calls such spaces, "calming space". Three small escape spaces were created and set up in accordance with the physical size of the children. After installation, an observation survey was conducted. By referring to the interview on ASD person A who is in elementary school and the observation and interview survey conducted for the three use cases, the conditions required for the installation of the small calming space can be assumed below.

1) *Sound environment:* external sounds need to be blocked. In addition, it is possible that loud noises/sounds may be made inside the space by the student occupying it. Thus, the small calming space proposed in this study should be able to provide an environment that allows the child to calm himself/herself and reset his or her emotional status.

2) *Visual environment:* to create an independent, calming space that is dark and invisible from the outside environment is preferred.

3) *Size:* the size should be determined according to the physical size of the user. The size should not be too large for a user sitting alone inside the space.

4) *Structure/material:* it is desirable that the structure be solid and difficult to break. In some cases, it is preferable that it be portable.

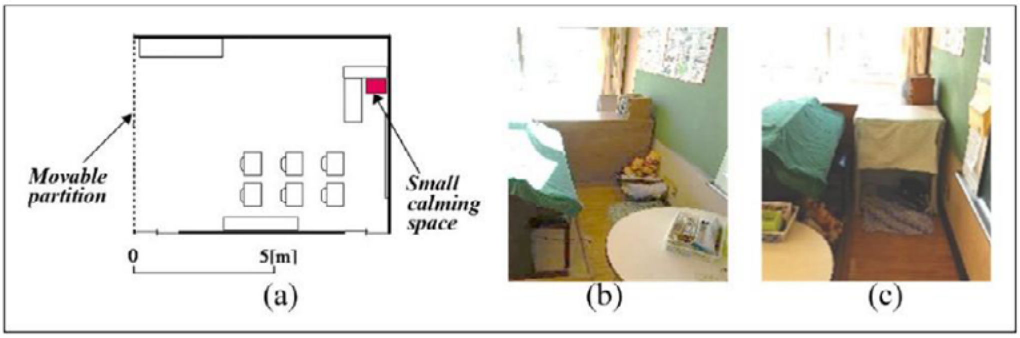

Figure 6.62 Setting the small calming space in the classroom: (a) position of the small calming space, (b) before setting, and (c) after setting (Source: Kanako Ueno)

Figure 6.63. The escape space is being used (Source: Kanako Ueno)

An escape space in the home can have equal benefits for a child on the spectrum. The design is simple: A few bean bags chairs or other seating components and, if necessary, a few outside items for sensory integration can be brought in like a stereo or an item with a pleasing texture. The escape space is meant to be an area of solitude where the child can retreat to relax and regain control. In homes where space is not a luxury, an escape space can be just a spare closet that has been emptied of its contents or a screened-off corner of a quiet room. Installing an "escape space" could be very beneficial in reducing disruptive behaviourss and tantrums. From the literature review, cardboard escape space and tent-like space are mostly used in home.

Figure 6.64 The cardboard escape space (Source: pinterest)


Figure 6.65. The tent-like escape space (Source: pinterest)

Highlights:

- A neutral sensory environment with minimal stimulation.
- External sounds need to be blocked.
- View connection should be blocked.
- The structure is solid and difficult to break.
- Soft texture can be introduced.

Sensory-soothing fixtures

- Bean bag chair
- Soft pillows or stuffed animals
- Dimming lighting
- Music

Case study 1*. Calming Room in the Dollywood*

This calming space is in the Dollywood theme park in Pigeon Forge, specific to the autistic users. As we know, quite normal voices echo in the brains of ASD users, causing great annoyance. The theme parks are often noisy and can make autistic children feel trapped. As a result, Dollywood has created a calm and relaxed space where children with autism can avoid unpleasant situations in order to let them enjoy the experience like other children. The room features low lighting, a tepee for privacy, cushy 6-foot bean bag chairs, a TV, stuffed animals and even items used in treatment, such as fiberoptic light strands. It has the dimmer switch for the lighting, which are cool colors, blues, and greens. Families can spend up to a half hour in the room to let their children recover from sensory overload.

Figure 6.66 Calming Room in the Dollywood theme park（Source: Pinterest）

Case study 2. *Escape space in the Miami International Airport*

The room is designed to be a quiet area for young passengers with cognitive or developmental disabilities such as autism. It provides a relaxing environment during the travel experience. The long waiting time at the airport will make them anxious and annoyed. Thus, the calming room is established to soothe their emotions. The room includes sensory-soothing fixtures such as an aquatic bubble tube, wall puzzles, cushioned seats and a light projector, all within a dimly lit space.

Figure 6.67 Escape space in Miami International Airport (Source: Pinterest)

Case study 3. *Escape space in the Newfoundland hotel*

Newfoundland hotel is the first autism-friendly hotel in Canada. The hotel features a special lounge with a brightly painted mural, a swing, a climbing wall and a sensory boat to help engage children with autism in a comfortable environment. There's also a kids' menu available with pictures of the food items, which can help foster independence for children who may have trouble speaking.

Figure 6.68 Escape space in the Newfoundland hotel (Source: Pinterest)

Case study 4. *Sensory Room 101 in the Meriden Public Schools in Connecticut*

This sensory room in the school is not complicated, but it turns out successful. The team at Meriden Public school don't spend a lot of money to get started. Instead, just begin with a carpet, painting walls with calming color and light fabric over the lights. But different items are introduced to meet the need of all kinds of autistic users.

Figure 6.69 Escape space in Meriden Public Schools (Source: Pinterest)

Lego walls are equipped since building things is a great way to organize an autistic child and provides a calming activity. Bouncing balls can be used by hypo-sensitive users. This provides full-body input, but can easily overstimulate some students, so this activity should be closely supervised. Bubble tube which is a glass tube that is lit from within and has bubbles that create shifting patterns of light shows many benefits to the ASD users. It is located in a quiet area and adds to the relaxing environment with calming visuals and sounds. The staffs observe students may bring a book or quiet activity into this area, lie in a beanbag chair, and just relax as they organize themselves and prepare to go back to class. Body socks also work well with autism users. They are full-size suits that provide students with deep joint input that is calming to most children. When using the socks, students can see out but cannot be seen from outside. This is great for those students who require quiet time, prefer being in small spaces.

In the hospital environment, escape space is a place for autistic individuals to retire, for example, when they are experiencing sensory overload and feel stressed in the complicated hall. In the escape space they can calm down, regain control and be away from a specific appointment or therapy temporarily. The user with ASD will have solitude in order to collect his or her thoughts and calm down. This designated place for relaxation can help individuals on the spectrum feel a sense of control and release. In the design of the escape space in hospital, the space should not feel like therapy or school but be intriguing and engaging.

2. Forms of escape space in reception hall

2.1 Furniture as escape space

To incorporate escape or break-out spaces into the interior environment can have some ways. One way is to provide a dedicated escape space inside. According to cases in classroom or home. We suggest, the escape space in hospital entrance should have minimal sensory disturbance and fewer textures and materials that the child dislikes. Creating a soft environment would be a safe choice for a child with hyper-sensitive tactile tendencies, who often appear to have a very low pain threshold. In addition, soft materials will absorb sound, benefiting those with sensitive hearing. This space can be equipped with minimal furnishings, soft lighting, soothing music, and soft pillows to sit on. A few outside items can be provided in the space for sensory stimulation, if they are not overwhelming to the child and will be a source of comfort. Items should be small, like a piece of fabric or sandpaper. Escape spaces can be stress-reducing interventions for individuals with ASD. And it is good not to be standout in order to avoid obtaining attention from others.

The escape space inside should not be breakable. It is to ensure the safety of the ASD users. Again, since different preferences between autistic users are different for each child, space can be different for each child. Caregivers or himself/herself can choose the escape space according to the preference and need. The location of escape space should also be considered. It is recommended in the quiet zones, reduce the interference from the surroundings.

The design of tent-like escape space is crucial to incorporate into the entrance hall. It should be harmonious with the surrounding of the hall. Bad design may make the escape itself "stick out" so that it fails to reduce the disturbance. Cardboard is not a durable material and will be damaged after few usages. We also recommend the escape for autism can also be

used by typical developing individuals. ASD users can ask for assistance in the reception desk if it is occupied by others. The staffs in the reception desk can aid them to select the suitable escape space. We search some neoteric design which can possibly be adopted inside the entrance hall. HUSH cocoon-like pod from Freyja Sewell is an excellent SCS (Sensory Concentration Space) installation, where ASD users relax in the 100% wool felt structure, sounds drown out from the exterior, leaving a comfortable place to lay back. Hidden in the top part of the structure are LEDs that can change color and the mood. The autistic users can even button it up and peek out of the slit if they want to view the outside world. It can also be open it up and fold to a seat if the ASD users want to socialize. Typical developing individuals can also retreat and have a rest when using it.

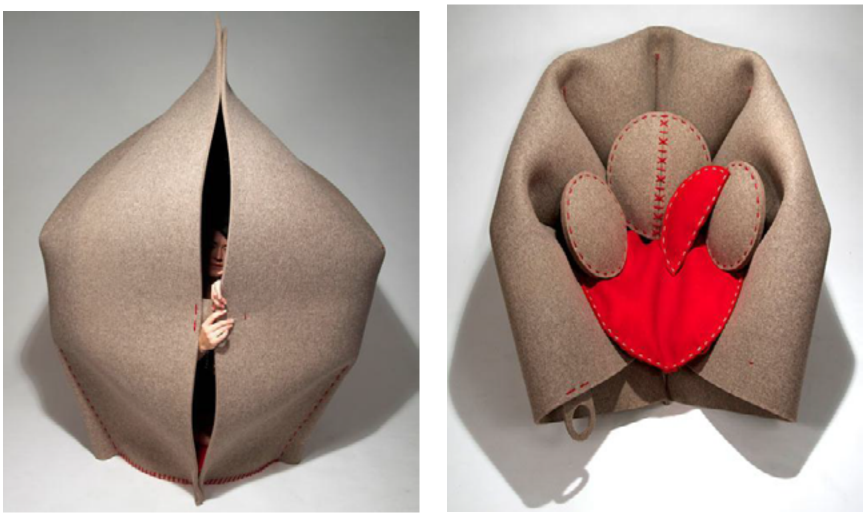

Figure 6.70 HUSH（Source: Freyja Sewell）

Broadly speaking, area that can create a relatively private space in such a public hall can serve as an escape space, since one of the biggest factors in the discomfort of ASD users is a lack of privacy, personal space, and a feeling of infringement on one's territory. Escaping to semi-public space can also help enable an individual with ASD to choose their level of privacy and control the amount of interaction they have with others. Furniture can be a tool to achieve it. Someone may argue it is not an enclosure structure and it is visible from the outside. However, cocooning makes the vulnerable person feel more protected, hence more likely to feel less stress in crowded situations.

Special seating with soft furnishings can be used, such as bean bag chairs, cocoon-like space, which may be created with a swing that tightly embraces them, or a hammock. It not only provides a low-sensory environment, blocking the view which bothers, but also contributes some playful elements. Cave-like spaces are recommended as well, as they soothe to people with ASD and help reduce sensory input and allow them to relax. We list some other cocooning spaces. Most of them are design for the

public space while provide the home-like atmosphere. Below are examples (Figure 6.71).

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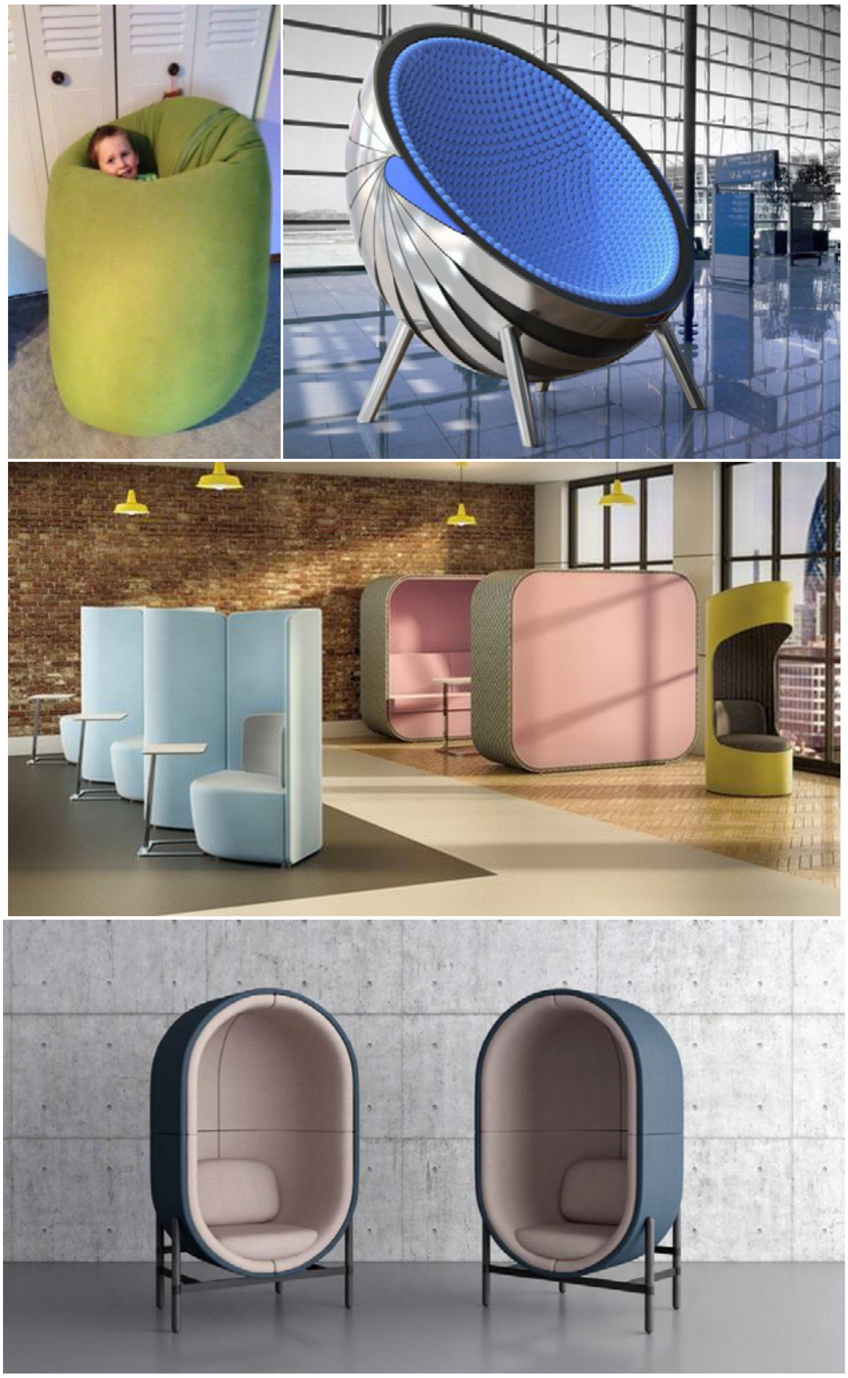


Figure 6.71 Various cocooning seats (Source: pinterest)

2.2 Structure as escape space

Many escape places are provided in structure. The flexibility of the space provides the opportunities to keep private and quiet. It is the most common way for escape space integrated with the hospital environment.

Nationwide children's hospital in Columbus, Ohio, U.S.A (Figure 6.72) has an attractive design in the hall. Designers create a forest including two-story fabricated trees, woodland "creatures" and vibrant wall graphics. The aim is to motivate all the patients to have a good journey of adventure in the hospital. The arched hole under the tree is a successful escape space, providing a quiet shelter to the people with ASD. The Caboolture Super Clinic (Figure 6.73) is not a hospital for autism, but the seats outlined by the structure can be seen as a reference of escape space. It is a neutral sensory environment with minimal stimulation. Soft pillows and stuffed-animals can be laid on the "cave". The autistic users can choose the shape of space according to their needs. Calming space in the Bønsmoen Primary School (Figure 6.74) is also a good reference. The Children can choose the color zones they want to sit. The space is large enough, they can sit or lie on the soft furnishing.

Figure 6.72 Nationwide children's hospital (Source: pinterest)

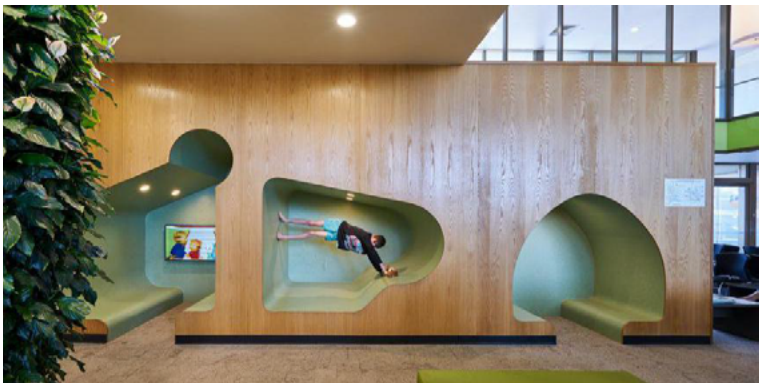


Figure 6.73 Escape space in Caboolture Super Clinic (Source: Pinterest)

Figure 6.74 Escape space in the Bønsmoen Primary School (Norway) (Source: Pinterest)

2.3 Dedicated room

The other way is providing a separate home-like room. It should be close to the hall, letting hyper-sensitive individuals retreat to quiet space when feeling overwhelmed with sensory overload from the environment as soon as possible. To provide minimal sensory integration are throw blankets, throw pillows, lambskin rugs, and other decorative items which can help relieve stress in ASD users.

For children who are hypo-sensitive or sensory-seeking to play and engage their senses, this room also generates safe sensory experiences compared to other indoor play areas. As for what items and activities can take place in a sensory integration space, the ideas are endless. Many rooms have a tactile wall with three-dimensional objects with different textures and sizes to engage tactile senses. Projectors can be used to impose bright colors and patterns on a wall for visual stimulation. Some technology can be adopted in the sensory room (Figure 6.75). Equipment for multi-sensory spaces does not need to cost a fortune as long as it safely engages the child and the child has an interest in using the space. Activities for sensory integration can be as simple as a kiddie pool or box filled with balls (Figure 6.76).

Figure 6.75. Sensory room （Source: Pinterest）

Figure 6.76 Sensory integration can be simple (Source: Pinterest）

3. Design considerations of ASD-friendly escape space in reception hall

- A neutral sensory environment with minimal stimulation is pleasing to the ASD users.
- Sound-absorbing material can be used to block external sounds in the escape space.
- Space with enclosure can embrace the users with special need and block the view bothers.
- The material of the escape space should be breakable and durable.
- Sensory-soothing fixtures, such as pillows, stuffed animals, beanbags, music, dimming lighting can be introduced in the escape space.
- Cocooning furniture can serve as escape space in the hospital reception hall, such as HUSH (designed by Freyja Sewell).
- Escape space can be integrated with the structure in the reception hall.
- Sensory room can be established close to the entrance hall to make them calm down when they are over-stimulated.

12. Transition area

Transition space is an area which helps ensure the seamlessness required when circulating from one zone to the next, allowing sensory transition while moving from one sensory zone to the other. Entrance space itself act as a transition space in the hospital, linking the outside and clinical room.

1. Difficulties faced by people with ASD

When people start from entering the hospital, which certainly belongs to public area. The first space when entering hospital is the reception hall, whose function is of great importance. Specifically, it is very important to provide a space that will slowly introduce the user to the environment that lies ahead, as individuals on the spectrum may exhibit resistance to entry into the unknown.

A lot of literature state that individual with ASD would difficult to move from one place to another or one activity to another. They may have greater difficulty in shifting attention from one task to another or in changes of routine. This may be due to a greater need for predictability (Flannery & Horner,1994), challenges in understanding what activity will be coming next, or difficulty when a pattern of behaviours is disrupted. Known from the literature review, the autistic individuals feel more comfortable and in control when they have a transition zone between private and public spaces (Vogel 2008). Mostafa (2008) states in the classroom design, transition space, is an criterion allows for the sensory shift from one activity to another, or one sensory level to another, and helps avoid abrupt changes in function and stimulation. It is also reasonable under the context of healthcare design. The presence of transition zones helps the user recalibrate their senses as they move from one level of stimulus to the next.

2. Transition area applications

2.1 Visual transparency

When people begin to know what to expect in each space, transitions become more predictable and less stressful. The visual transparency from space to space allows the ASD users to scan the environment and establish their bearings as they adjust to a new setting. Being able to see into the hospital environment before making a commitment to enter it can satisfy this need for control. Regnier and Denton label this as “previewing”. The concept of previewing can be accomplished by sidelights, windows in doors, and subdividing spaces so one has a view from a distance (Regnier et al. 2008). Accordingly, glazing can be used in the facade of main entrance so that the autistic users can preview the hospital environment which enable them to adapt in advance.

View connection should also be considered when they enter from large open areas with high ceiling to smaller closed-in rooms with lower ceilings. When glass is used as the division of space, the frame or corner should be marked with visual contrast in case the autistic users have collisions with it.

The feature of transparency is fitting into the environment of entrance hall. Umeda hospital designed by Kengo Kuma presents the good use of the visual transparency. The view through the glass can transfer the information inside to the ASD users. The time they are closing to the entrance provides the opportunity of transition. The glazing in the entrance of Assuta medical center also provides the interaction between the outside and inside. Previewing and adapting take place imperceptibly.

As entrance hall is a multi-functional area, not only glazing can be applied in the facade, the partition can also be put into use. In Nationwide children hospital, glazing is used to separate the public area and clinical area, which allow the autistic users to observe the space before arriving there.

Figure 6.78 Umeda Hospital (Source: archdaily)

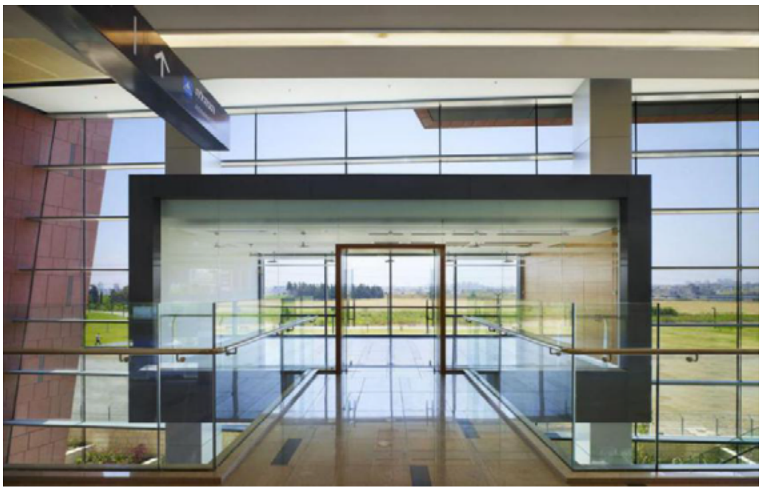


Figure 6.79 Entrance of Assuta medical center (Source: archdaily)

Figure 6.80 Glazing in Nationwide children hospital (Source: archdaily)

2.2 Curved wall

Curved wall can be used in the large area as a transition space. In some narrow corridors, it may lead to problems of wayfinding. In the entrance hall, this problem is not prone to appear. Curved surfaces are liked by autistic children as they can flowing them around a corner and create a better transition than a sharp angle (Beaver, 2006). A study by Bourne (2013) noted that individuals with ASD were affected most when they transitioned from space to space and when the number of people in a space changed. This was observed in clinging to the wall and walking rigidly along the perimeter of the room to avoid touching and getting close to people. They appeared to avoid areas where there were groups of people actively talking. Curved walls provide tactile surfaces to transition through the environment without touching other people and lead the children naturally from one space the other, avoiding sharp angles, obstructive corners, and hidden doorways. Thus, curved walls facilitate movement into the next sensory zone. Curved walls are designed from the phase of plan. Although circular walls and walls with splines are not fitting in certain design, walls with fillets can also be a compromised way. (Figure 6.82)

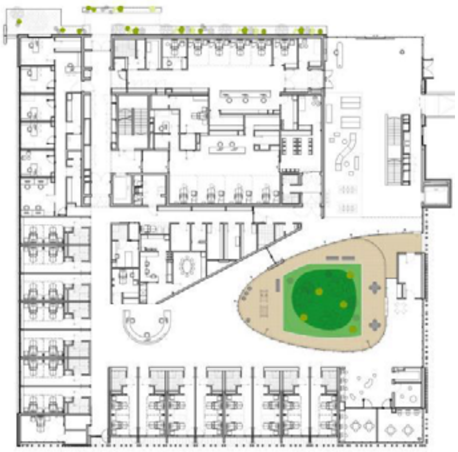
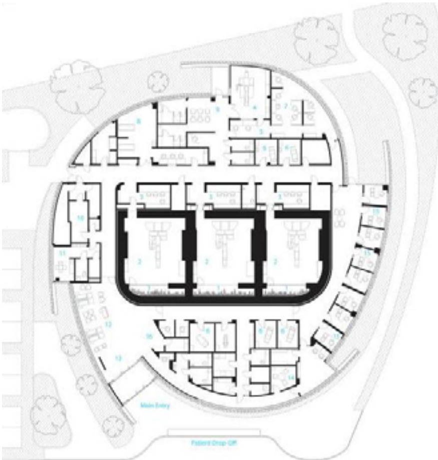


Figure 6.81 Shiv hospital (Source:archdaily)



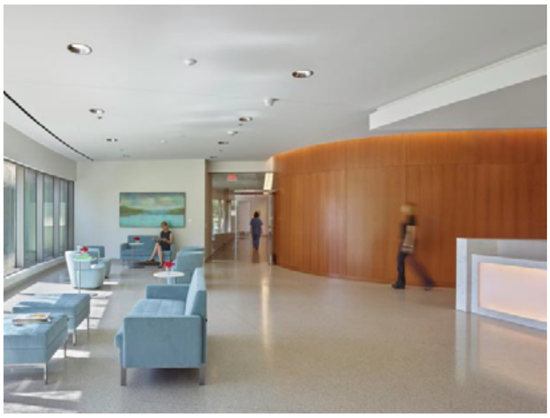


Figure 6.82 Kraemer Radiation Oncology Center (Source: archdaily)

2.3 Sensory garden

Sensory garden has been promoted by designers and architects who focus on designing healthy spaces as way of designing transition space. Sensory garden, nature-inspired artwork, or a water element can be incorporated in the entrance hall as a buffer zone between inside and outside surrounded by natural spaces.

Sensory garden as a multi-sensory environment can be created for leisure, recreation, therapy and educational use. Sensory garden can be healing through aesthetics, design elements, and through active participation in maintaining the plant material and creating the space (Cooper-Marcus, Barnes, 1999). The lush greenness, the sounds of water and birds, and the variety of textures and colors offer the mind a restful place. This leads to the idea of gardens healing by simply being a place to be in. It provides both a stimulating space for hypo reactive children and a calming space for children that are hyper reactive.

The design of sensory garden can be seen as Biophilia design. Passive activities brought in Biophilic design can provide tranquility, peace, and spirituality and relieve the anxiety of sensory change. Biophilia is a term coined by Harvard University professor E. O.Wilson. He postulates that humans are naturally attracted to nature-like forms and emphasizes that biophilia is the innately emotional affiliation of human beings to other living organisms. Studies indicate that contact with nature is critical to ASD users and that nature itself can make buildings: more enjoyable and pleasing (therapeutic), relate to the sensory sensitivities and neurological needs, and promote new skill sets and experiences for individuals with autism. Kellert(2005) argues that visual representations of nature, symbols of nature, views to nature, and indoor plants and other natural design elements appeal to one's innate affinity and can evoke positive experiences in the built environment. Many people with ASD have differentiated or delayed cognitive processing. Kahn and Kellert (2002) determined that the direct experience of nature greatly enhances cognitive processing. In their view, the natural world affords numerous opportunities for stimulation and engagement. Various elements of nature, such as trees, bushes, plants, flowers, birds, and landscapes, can be incorporated into interior environments to mimic this type of stimulation and engagement. Incorporating these elements can be accomplished through sensory garden and artwork inside the entrance hall.

Sensory garden can be implemented to support the principles of sensory integration therapy. Halls of Children's Hospital of Philadelphia and Zaans Medical Centre introduce the nature inside. Plants and grass allow visitors to create mental cues by relating the scenes to pleasant experience. This may allow patients to have a better understanding of their environment and enjoy a restorative moment.

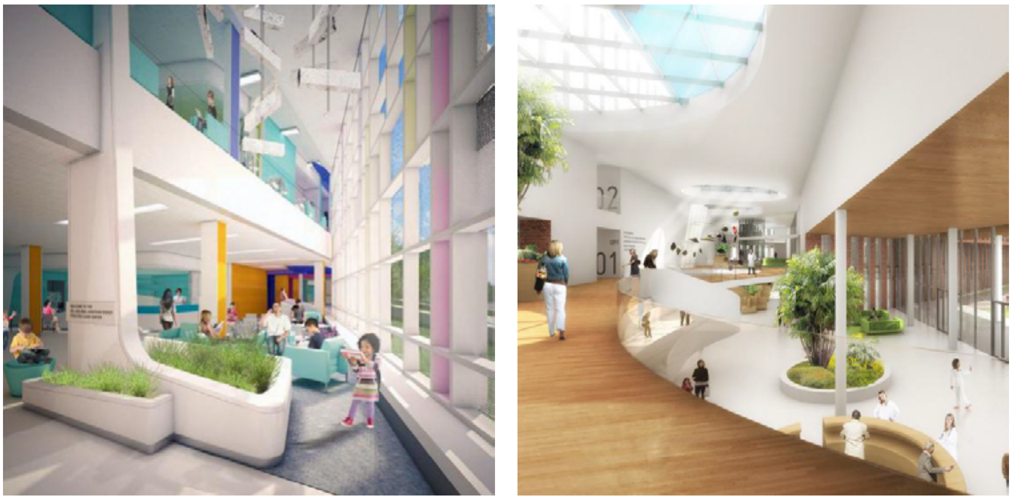


Figure 6.83 Halls of Children's Hospital of Philadelphia and Zaans Medical Centre (Source: archdaily)

Figure 6.84: Fundacion Santa Fe de Bogota hospital (Source: archdaily)

Figure 6.85 Artificial sky in the hospital (Source: archdaily)

In the Fundacion Santa Fe de Bogota hospital (Figure 6.84), there is a sensory garden between two layer of facades. It acts as a buffer zones when users enter the entrance. The outermost facade uses the brick in extension and not in compression as used to. It uses metallic parts and cables that support the brick as a fabric. This allows brick to have different patterns and textures giving the opportunity to have different natural lighting depending on the needs of garden. In this way, the outdoor sensory garden is introduced inside totally. The sound of leaves and the texture of soil can be a comfort for all the autistic users.

Designers can also utilize the transitional ceiling to reduce stress and anxiety. Hospital ceiling healing art can fit into standard suspended ceiling. As Figure 6.85 demonstrates, blue sky with clouds can create a virtual outdoor scene. It can effectively reduce reflected sound in large and open environments as well as to delineate space. Artificial Sky healing art is specifically designed to help improve patient outcomes and the healing art has some of the highest acoustical ratings in the industry. Positive effect has been proven, including reducing muscle tension and redirecting negative thoughts.

2.4 Amusement area

Amusement area in the entrance hall can let the autistic users continue the behaviour of playing and gaming. Hence, playing area can attract the attention of users with ASD. We can also call it "positive attraction". Playing have serious therapeutic benefits for kids on the autism spectrum from motor skills and coordination to communication, listening and social skills. The installation can be a good tool for interacting with others in a cooperative and competitive way, communicating needs and wants. In the Shiv hospital (Figure 6.86), seats with different shapes can attract them once they enter the hospital. Thus, the autistic users will ignore the negative emotions resulting from the previous painful experience in the hospital.

Figure 6.86 Shiv hospital (Source: archdaily)

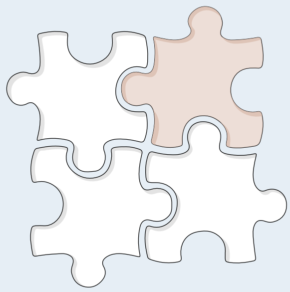
2.5 Node

In a long corridor, node can be an aid tool for transition as well as wayfinding. Nodes are clearly defined transition. Nodes frequently include special places along a pathway that invite social connections and communication. Often, there are in-between places used as a place of rest or conversation. For individuals with ASD, nodes can be helpful for them to pause, gather their thoughts, and make decisions about which way to go. Sometimes nodes denote an intersection where pathways lead off to clinical area. Seating in the corner can be a relaxing node as follows. (Figure 6.87)

Figure 6.87 Seating in Manhattan Star Academy (Source: pinterest)

3. Design considerations of ASD-friendly transition area in reception hall

- The visual transparency from space to space allows autistic users to scan the environment.
- Curved surfaces can create a better transition than a sharp angle.
- Sensory garden can be introduced in the reception hall as a buffer zone between inside and outside
- Biophilic design can provide tranquility, peace, and spirituality and relieve the anxiety of sensory change.
- Amusement area in the entrance hall can be a positive attraction.
- Nodes are clearly defined transition.



6.5 Evaluation tool construction: Evaluation of hospital environments for ASD users

1. Autism-friendly tool: 3STI for Hospital

Introduction
Based on previous research, we develop an evaluation tool to measure the accessibility and comfort of the hospital environment to ASD visitors when they are using the different functional areas of the hospital. The tool is divided into two parts, Part A is used to measure the general environment, and Part B is about 12 important autism-friendly built environment criteria we have proposed.

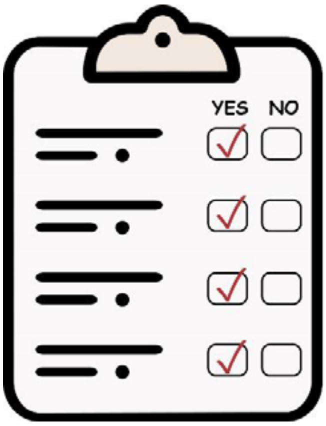
Scoring system
According to the symptoms and common behaviours of autistic users, we propose the requirements and audit checklist of each criterion, the performance of the built environment is measured by a ranked score. The audit checklist consists of a series of needs of the autism-friendly environment, was designed to assist rate the score. At this stage, we suppose that every evaluation criterion is the same importance and score equally. Inside each criterion would have a different number of indicators depend on the complexity of the criterion but not the weight. If the indicator is implemented in the space, select the “Yes” box next to the indicator, otherwise, select the “No” box. All the indicators of the same criteria are divided equally and the score of the criterion depends on how much indicators the space implemented. In order to calculate easily, each criterion would multiply by 10 that means the maximum of each criterion is 10 points. For example, if there are 4 indicators in the “03 sound” criterion, each indicator would be deserved 0.25 points. When all the 4 indicators are implemented in the space, it would get 10 points which means the optimal performance for the criterion. If there are only 3 indicators are implemented the score would be 7.5 points (o.25*3*10 = 7.5). In general, the score of the criterion could be formulated as “Score of each criterion=x/n * 10” (“x” means the number of indicators the space implemented, “n” means the number of indicators inside the criterion).

It is common that the number of indicators inside the criterion can not be capable of being divided by 1 exactly. In this case, the score would be rounding-off to one decimal. For example, there are 3 indicators of one criterion but just two of them are implemented in the space, the score of the criterion should be 2/3 * 10= 6.7 according to the formula.

Score of each criterion = x/n * 10

“X” means the number of indicators answer “Yes”
“n” means the number of indicators inside the criterion
the result is rounding-off to one decimal

For example, there are 4 indicators inside the criterion and on the left, all the indicators are met while on the right, 3 of them are met. Therefore, the score would be 10 and 7.5 respectively.



Score : 4/4 * 10 = 10

Score : 3/4 * 10 = 7.5

Final score and evaluation standard

The maximum score of the evaluation tool is 130 points, including 10 points for the general environment and 120 points of 12 criteria (10 points of each). According to our research on the autism-friendly hospital environment, we give the following evaluation standard:

Each criterion is rated from 0 to 10 points and is divided into 5 ranks. When it is rated from 7.5 to 10 points, this indicator represents the top quality of the autism-friendly environment. Similarly, rated from 5 to 7.4 represents medium-high quality, 2.5 to 4.9 represents medium-low quality, 0 to 2.4 points represents low quality. There are 13 criteria in the 3STI tool, thereby the hospital environment with an overall score between 97.5 and 130 has a high level of friendliness to autism users , corresponding to 65 to 97.4 points is medium-high, 32.5 to 64.9 points is medium-low, below 32.5 points is a low level of autism friendliness, the evaluation standard is shown in the table below.

Rank		**Score of each criterion**	**Total score**
A	Top quality	7.5-10	97.5-130
B	Medium-high quality	5-7.4	65-97.4
C	Medium-low quality	2.5-4.9	32.5-64.9
D	Low quality	0-2.4	<32.5

2. Evaluation tool for Hospital's reception hall

PART A: General Environment

Requirements:

Reception hall is the first space after entering the hospital. The overall design needs to give a non-institutional and welcoming impression on the visitors and users. It is also the most public space in the whole hospital, where prone to be sensory overload for the autistic users. Minimized but effective details should embody in many aspects, such as wayfinding equipment, decoration.

Auditing checklist:

(1) There are enough storage areas to put medical equipment, daily necessaries and non-patient stuff to keep the general environment clean and in order. Yes ▢ No ▢

(2) The indoor space doesn't have a peculiar odour, especially the toilet, storage room and public trash Yes ▢ No ▢

(3) By the use of warm lighting, cosy colour scheme and furniture, the overall indoor atmosphere is homey, welcoming and informal. Yes ▢ No ▢

(4) The indoor environment is pleasant and comfortable, with stable and uniform temperature and humidity, there are not heating radiators with high temperature exposed to the air. Yes ▢ No ▢

Score of general evironment: __/4 * 10 =_____

Example:

✓ Homy and welcoming atmosphere

✗ Institutional atmosphere

PART B: 12 Criteria of Autism-friendly Built Environment

01. Space hierarchy

Requirements:

The space of entrance hall should be straightforward and easy to navigate. This is because individuals with autism have difficulties forming mental maps of spaces they travel through, especially the complex space like entrance hall. It should be organized with a clear physical structure that defines different area for different activities. Visual cues can indicate each function.

Auditing checklist:

(1) Layout is optimized as simple as possible. Yes ▢ No ▢

(2) Space zoning means to divide reception hall into different zones, with each zone having only one function or activity. Yes ▢ No ▢

(3) Each functional area is with clear signposts or visual cues to explain its function
(e.g., the text, symbol can indicate the function and boundaries, furniture placement, flooring, finishes serve as a means of communicating information) Yes ▢ No ▢

(4) Space continuity should be enhanced.
(e.g., the repetition of the architectural forms) Yes ▢ No ▢

Score of space hierarchy:__/4 * 10 =_____

Example:

Point (3)
✓ Boundaries show functions

Point (4)
✓ "Circles" enhance contintity

02. Wayfinding

Requirements:

Due to their sensitivity to colour, colour coding will affect their act of moving. ASD-friendly signage design should be clearer and understood easily. Simple symbols can be combined with letters. Landmarks help individuals with ASD orient themselves in each space.

Auditing checklist:

(1) The use of colour coding is applied in wayfinding system. (e.g. colour coding means doors, different departments or functional area are represented by different colour)	Yes ▢	No ▢
(2) There are landmarks to help ASD users remember space. (e.g., distinguish coloured wall, different floor materials, artworks, sculpture, murals, special decoration, etc. can be used as landmarks)	Yes ▢	No ▢
(3) There are easy-understandable symbols in wayfinding signposts.	Yes ▢	No ▢

Score of wayfinding:__/3 * 10 =_____

Example:

Point (1)

✓ Colour-coding path

Point (2)

✓ Landmarks aid wayfinding

03. Sound

Requirements:

The reception hall is filled with a mix of noise, including the sounds of conversation, the hum of equipment, and the outside traffic noise. For autistic users, the problem of acoustics must be seriously addressed. The level of noise can be reduced in many aspects. The noise of various mechanical equipment should be lowered to reduce the source of the noise. Sound-absorbing materials should be considered from the ceiling to floor, from walls to furniture.

Auditing checklist:

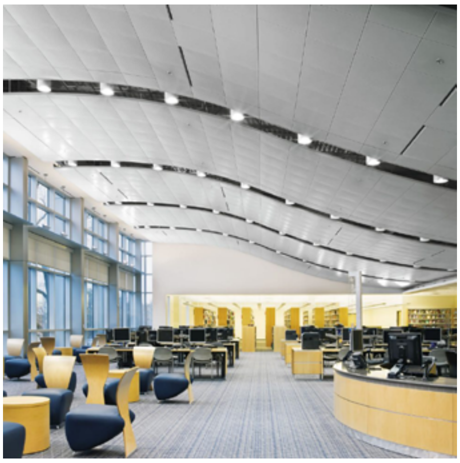
(1) The walls and windows of reception hall are sound insulated.	Yes ▢	No ▢
(2) The ceiling is with sound-absorbing materials or structure.	Yes ▢	No ▢
(3) The surface of floor materials is made by less noise impact materials or carpeted.	Yes ▢	No ▢
(4) Soft furnishings or furniture with sound protection is used in reception hall.	Yes ▢	No ▢
(5) The background music or natural sound (e.g., water or fountain) is provided for covering various noises	Yes ▢	No ▢
(6) The machinery of the HVAC system doesn't produce noisy sounds.	Yes ▢	No ▢
(7) The sound of hospital communication devices, such as loudspeakers, is gentle, and the voice does not occur suddenly and harshly.	Yes ▢	No ▢

Score of sound: __/7 * 10 =_____

Example:

Point (2)

✓ Sound absorbing ceiling



Point (4)

✓ Soft furnishing

04. Colour

Requirements:

The ASD users have different preferences on colour selection. Subdued and colours mixed with grey were favoured by the children with autism. The suitable use of colour and harmonious colour scheme can help them make sense of their surroundings to enhance the sense of spatial hierarchy, assist space navigation, and create a relaxing indoor environment.

Auditing checklist:

(1) The indoor space is decorated by neutral and nature colour scheme.	Yes ▢	No ▢
(2) There are not overnumbered colours in interior environment.	Yes ▢	No ▢
(3) The handrails, doors, fittings and other furniture are coloured in contrast colour with its background so that they can be clearly noticed.	Yes ▢	No ▢
(4) The bright colours are avoided in interior environment. (e.g., bright red, bright yellow and etc.)	Yes ▢	No ▢

Score of colour:__/4 * 10 =_____

Example:

Point (1)

✓ Neutral and nature colour scheme

Point (2) & (4)

✗ Overnumbered and bright colours

05. Lighting

Requirements:

All forms of light in the hospital can be categorized as either natural or artificial light. Natural lighting is favored in the medical building. Meanwhile, measures should be taken to avoid overwhelmed sunlight. Artificial lighting should be warm, controllable and non-distracting. Glare which may distract the autistic users and blur their sights can be avoided by a good selection of materials.

Auditing checklist:

(1) The natural lighting is provided wherever possible.	Yes ☐	No ☐
(2) Windows have glare protections to control the shining sunlight. (e.g., curtain, window blinds or frosted glass, external screen, etc.)	Yes ☐	No ☐
(3) All artificial lightings are soft, warm and uniform with diffuser and without flicker.	Yes ☐	No ☐
(4) There are no glaring and reflection from various materials.	Yes ☐	No ☐
(5) The intensity of lighting can be adjusted according to the time of day.	Yes ☐	No ☐
(6) The reception area has a higher level of vertical illuminance and the waiting areas have a calming illuminance.	Yes ☐	No ☐

Score of lighting:__/6 * 10 =_____

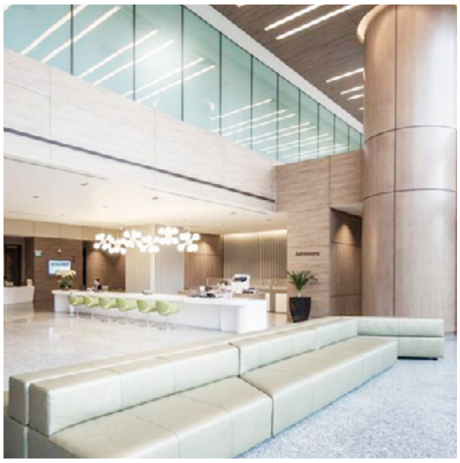
Example:

Point(1)& (2)

✓ Top lighting and curtains

Point (4)

✗ Glare from the reflection of glass



06. Smell

Requirements:

The layout of the entrance hall should ensure that there is no olfactory stimulation. For example, the cafe/dining area and toilet should keep a distance from the reception and waiting area. Good ventilation keeps the indoor air fresh. An autism-friendly hospital should use materials that have low or no VOC finish and all the products should be fragrance-free.

Auditing checklist:

(1) There are no strong odours near toilets, washrooms, coffee machines, vending machines, public trash can and other frequently used public facilities.	Yes ▢	No ▢
(2) The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through good ventilation, both natural and mechanical.	Yes ▢	No ▢
(3) Low or no VOC finish products and coating are selected.	Yes ▢	No ▢
(4) Products such as cleaning supplies and air purifiers used in hospitals are fragrance-free.	Yes ▢	No ▢

Score of smell:__/4 * 10 =_____

Example:

Point (5)

✓ Smell of plants

Point (4)

✗ Smell of disinfectant

07.Tactile

Requirements:

For people with ASD, engagement of the tactile sense is especially important, as they learn by engaging physically with materials. Smooth surfaces can evoke cheerful emotions and soft materials evoke a feeling of comfort, warmth, and safety. The concept of personal space is also associated with a sense of touch so that space should be enough.

Auditing checklist:

(1) There is enough space for people to go in and out or seat individually without touching other people.	Yes ▢	No ▢
(2) The surfaces of building structure, fittings and furniture have a smooth and clean surface, without the existence of dust, water stain or other dirt.(e.g., walls, floors, tables, chairs, handrails and etc.)	Yes ▢	No ▢
(3) There are no objects with a rough surface that have the potential risk of scratching the skins.	Yes ▢	No ▢
(4) There are some positive tactile interventions. (e.g., offer a soft touch toy or a pillow in the seating area, or tactile walls)	Yes ▢	No ▢

Score of tactile: __/4 * 10 =_____

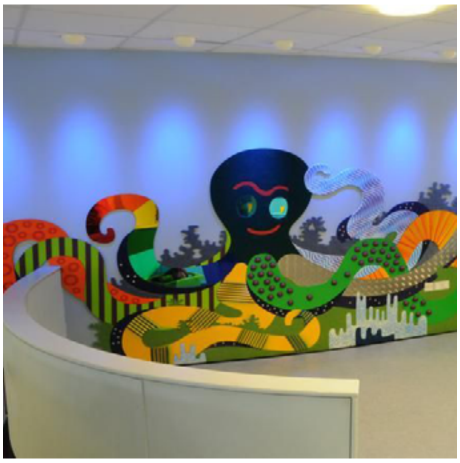
Example:

Point (2)

✓ Smooth and clean surfaces

Point (4)

✓ Positive tactile intervention



08. Safety

Requirements:

All building elements in the reception hall must be carefully assessed for safety – standard details might not be enough to protect individuals with ASD, who may be particularly vulnerable. Attention should be paid to materials, furniture, structure.

Auditing checklist:

(1) The building materials are durable, harmless and easy-cleanable and the floor materials are anti-slippery. Yes ▢ No ▢

(2) There are clear warning signals or physical barriers or visual contrast to inform risks of protruding obstacles, slippery area, untouched objects, unclimbed area, steps and etc. Yes ▢ No ▢

(3) The opening of windows is with restricted locker and doors are open inwards with restricted locker. Yes ▢ No ▢

(4) The furniture is unmovable, chairs can be fixed to each other or fixed on the floor. Yes ▢ No ▢

(5) The corners of structure, furniture and equipment are rounded or with corner protections. Yes ▢ No ▢

Score of safety: __/5 * 10 =_____

Example:

Point (2)

✓ Warning signals

Point (5)

✓ Rounded furniture

09. Hospital equipment

Requirements:

People are exposed to the sounds of alarms beeping and buzzing all day long, And visual stimulation and acoustic stimulation can be generated by multiple equipment, such as electronic screens, illuminance signposts in the reception hall. Thus, all the equipment should help to create non-distracting built environment.

Auditing checklist:

(1) The non-patients-necessary electronic device such as TV screens can be removed out of sight (e.g., these devices can be put in cabinet with sliding door or recessed space)	Yes ▢	No ▢
(2) There are not too many electronic screens for notifying information.	Yes ▢	No ▢
(3) The emergency alarm is away from reception desk and waiting chairs.	Yes ▢	No ▢

Score of hospital equipment:__/3 * 10 =_____

Example:

Point (4)

✓ Signposts with suitable brightness

Point (2)

✗ Too much electronic screens

10. Assistive technologies

Requirements:

When technologies used in the building environment, less manpower is required to result in positive change in the behaviours of ASD. It can be easier to relieve the tension on wayfinding and have a better auditory environment.

Auditing checklist:

(1) There is a navigation application to assist wayfinding.	Yes ▢	No ▢
(2) There is an interactive game device, or interactive robotics, or virtual reality application for distracting ASD patient's attention away from sensory stimuli.	Yes ▢	No ▢
(3) Modern auditory equipment such as smart phone and MP4 players is provided which can create a pleasant auditory environment.	Yes ▢	No ▢
(4) A sensory room is placed near the entrance,such as Snoezelen room.	Yes ▢	No ▢
(5) The interactive device does not cause sensory stimuli to ASD users.	Yes ▢	No ▢

Score of assistive technologies: __/5 * 10 =_____

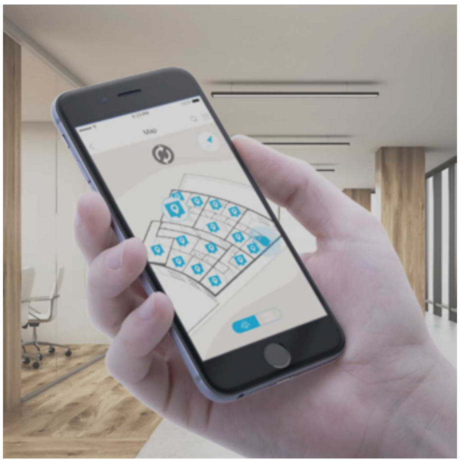
Example:

Point (2)

✓ Interactive display

Point (1)

✓ Mobile equipment for wayfinding



11. Escape space

Requirements:

Escape space is an aid to hyper-sensitive autistic individuals. Because of the heavy density of people in the hospital, many triggers, such as unexpected incidents can make ASD users overly anxious. Providing opportunities for a person with ASD to ease into a space, escape space needs to be implemented. Tent-like enclosed space, cocooning furniture can act as escape space in the reception hall. Escape space can be also whin a certain structure.

Auditing checklist:

(1) There is a quiet and safe space that can help ASD users escape away from sensory overload and hide themselves for relaxing or calming down.	Yes ▢	No ▢

Score of escape space: ___/1 * 10 =_____

Example:

Point

✓ Escape space within structure

Point

✓ Tent-like enclosed space

12. Transition area

Requirements:

Transition space is an area that helps ensure the seamlessness required when circulating from one zone to the next, allowing sensory transition while moving from one sensory zone to the other. Transparent glasses can provide a view connection to gain predictability. Curved walls also lead the children naturally from one space to the other, avoiding sharp angles.

Auditing checklist:

(1) There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance.
(e.g. the transition area of the corridor can be a recessed threshold in the entrance for temporary staying and previewing) — Yes ▢ No ▢

(2) There are sensory gardens, playing areas incorporated in the entrance hall as a buffer zone between inside and outside. — Yes ▢ No ▢

Score of transition area: ___/2 * 10 =_____

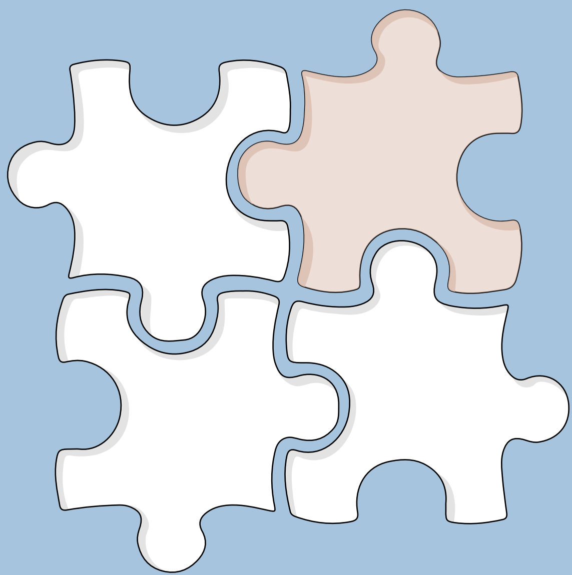
Example:

Point (1)
✓ Transparency

Point(2)
✓ Sensory garden

Score statistics

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: Hospital Reception Hall		Score (0-10)
PART A: **General Environment**		
PART B: **12 criteria of Autism-friendly Built Environment**	01. Space hierarchy	
	02. Wayfinding	
	03. Sound	
	04. Colour	
	05. Lighting	
	06. Smell	
	07. Tactile	
	08. Safety	
	09. Hospital equipment	
	10. Assistive technologies	
	11. Escape space	
	12. Transition area	
Final Evaluation Score *(total score 130)*		
Rank		



7. Research on Hospital's Circulation Space

Author: Luo Xi

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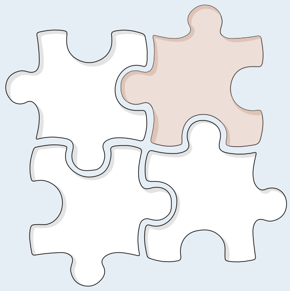


7.1 Official design guidelines for hospital spaces

1. Design requirements of circulation space --- Corridors

Space description

Corridors in a hospital serve a more important function than in many other buildings because they act as transitional areas between patients and medical service. The hospital is a big place and people can often feel overwhelmed trying to locate a particular service or department, especially people are easily become anxious if they are hurry to visit patient room or attend an important appointment. Therefore corridor must be simple and safe to negotiate, and aid navigation around the building. The most important function of the corridor is the circulation function, it is necessary to ensure that various users and medical equipment can pass through the space without obstacles. Especially notice that large-scale equipment, such as wheelchair, trolley and bed, should be allowed for two-direction traffic, 180-degress turns and corner turns without obstacles. While meeting the requirements of medical service, the design of the built environment of the corridor is also important. Due to its functionality, corridors are easily designed to be long. Especially in this case, with an unwell design of light and colour makes the corridor look like a tunnel. The windows at the end of the corridor may also form a huge light spot, which greatly affects people's sight. Therefore, the design of the corridor should not only meet the basic needs of medical services, but also the design of built environment should be patient friendly. The simple and comfortable space and easy-understanding navigation can effectively reduce the anxiety of patients in circulation space of hospital.

Summary of corridor built environment requirements:

1. Corridor width
2. Doors
3. Handrails
4. Wayfinding
5. Lighting
6. Windows and ventilation
7. Visual and colour contrast
8. Hospital technologies
9. Materials and finishes
10. Accessibility and security

Source:

Health Building Note 00-01 General design guidance for healthcare buildings
Health Building Note 00-03 Clinical and clinical support spaces
Health Building Note 00-04 Circulation and communication spaces
Health Building Note 12 Out-patients department/3.16)
National Health Service Lighting and colour for hospital design

Health Building Note is abbreviated as HBN below;
National Health Service is abbreviated as NHS below.

1.1 Corridor width

(1) Corridor width for general traffic

Corridors should be wide enough to allow two users to pass each other and negotiate doorways. The recommended minimum clear corridor width for general traffic, where there is a low volume of traffic and passing spaces are provided, should be 1500 mm. This width allows for varying users to pass in between the defined passing spaces and for the approximate positioning of a 1000 mm door across the corridor. Varying users include independent wheelchair user; visually impaired person with stick; semi-ambulant person with frame and assistance). Where there is a higher volume of traffic, a constant clear corridor width of 1800–2100 mm will allow most users to pass comfortably. This width allows two independent wheelchair users to pass; allows independent wheelchair user and semi-ambulant person with walking frame to pass; allows wheelchair user and semi-ambulant user with crutches to pass.

(Source: HBN 00-04 Circulation and communication spaces/3.3, 3.7, 3.8)

(2) Corridor width for bed/patient trolley traffic

The recommended minimum clear corridor width for circulation of beds/trolleys is 2150 mm if passing spaces are provided. This width allows bed straight movement and passing. Where two beds need to pass regularly, the recommended minimum clear corridor width should be 2960 mm. Consideration should be given to providing passing spaces where beds can be turned through 180 degrees particularly along long stretches of corridor and/or outside primary entrance doors or lifts.

(Source: HBN 00-04 Circulation and communication spaces/3.9, 3.10, 3.11)

1.2 Doors

(3) Size of doors

The recommended minimum size of door for general traffic, including users turn into and out of a corridor is 1000mm, for one bed movement and turning into and out of a corridor is 1200mm.

(Source: HBN 00-04 Circulation and communication spaces/3.15)

(4) Safety issue of door

Where doors are located within circulation routes, to help prevent partially-sighted users colliding with the door edge when the door is open or being opened, consideration should be given to stopping the handrail before it reaches the door swing area and making the last 500 mm knurled or patterned to indicate the approach of a potential hazard.

(Source: HBN 00-04 Circulation and communication spaces/3.16)

Outward-opening doors into main circulation routes and corridors are not recommended. Where it cannot be avoided that a door opens into the corridor, the door should be recessed so that when fully open it does not restrict the clear corridor width.

(Source: HBN 00-04 Circulation and communication spaces/3.17)

1.3 Handrails

(5) Handrails should be fitted in main communication routes (that is, main corridors between departments) and in departmental corridors as required. See specific departmental guidance for further information.

(Source: HBN 00-04 Circulation and communication spaces/3.29)

(6) All corridors should have a clear width that allows for the fitting of handrails without reducing the required clear space for access.

(Source: HBN 00-04 Circulation and communication spaces/3.30)

(7) Appearance/finishes of Handrails

Handrails should be:

- easily visible, that is, contrast visually with the surface to which they are fixed;
- smooth and free of any abrasive elements;
- neither too cold nor too hot to the touch.

(Source: HBN 00-04 Circulation and communication spaces/7.22)

(8) Handrails may have raised indicators built in to convey information such as floor level.

(Source: HBN 00-04 Circulation and communication spaces/7.23)

1.4 Wayfinding

(9) Directional signs should be provided identifying all routes that patients and escorts may need to follow both within the department and to other departments.

(Source: HBN 12 Out-patients department/3.16)

(10) All signposting should be clear, as simple as possible, easily understood and self-explanatory. Most patients should be able to find their way without having to ask for directions.

(Source: HBN 12 Out-patients department/3.17)

(11) The use of colour and art to identify particular routes and rooms can help to reduce the number of signs required. Certain doors, for example fire-exit doors, will require specific labelling.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.51)

The document “Wayfinding: effective wayfinding and signing systems guidance for healthcare facilities” states detailed information on wayfinding signage, see in “3.1 Hospital wayfinding considerations”

1.5 Lighting

(12) Natural lighting

Scientific evidence indicates that daylight has beneficial effects on patients (Rubin et al (1998), visitors and staff. It has been shown to reduce psychological problems and improve patient outcomes and increase morale and reduce sickness levels among staff. Therefore, natural light should be provided where possible. Steps should be taken to prevent solar heat gain.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.44)

(Source: HBN 00-03 Clinical and clinical support spaces/7.26)

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

(13) Artificial lighting
Natural lighting is variable in quality and quantity, a comprehensive artificial lighting installation is essential. Artificial lighting should be capable of providing the required levels of illumination at all times. It also has an important contribution to make to the aesthetic appeal of the interior. The good combination of lighting can give an informal atmosphere. Lighting should be well and evenly lit, with low-contrast and glare-free background illumination.

(Source: HBN 12 Out-patients department/3.34)

(Source: HBN 00-04 Circulation and communication spaces/3.21)

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

(14) Where specified, tubular fluorescent lamps and fittings should always be fitted with diffusers to minimize glare and reflection. Tubes should be positioned longitudinally down corridors to aid orientation.

(Source: HBN 00-04 Circulation and communication spaces/3.27)

(15) Provide offset or indirect lighting to give a light airy feel to the corridor, avoiding glare for patients on trolleys.

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

(16) At night, avoid spill-light to bedded areas. Consider dimming or step-switching to reduce corridor lighting at night.

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

The document “Lighting and colour for hospital design”, which is a report based on an NHS Estates Funded Research Project states detailed information on the use of lighting, see in “3.3 Hospital lighting considerations”

1.6 Windows and ventilation

(17) Windows can not only bring natural lighting into interior space, but also provide a visual link with the outside. The position, size and shape of windows should maximize the use of natural light. An external view, even if limited, has also been proved to be beneficial.

(Source: HBN 12 Out-patients department/3.39)

(Source: HBN 00-04 Circulation and communication spaces/3.22)

(Source: HBN 00-01 General design guidance for healthcare buildings/5.45)

(18) Sunlight glare should be minimized and may be controlled by using light-coloured walls, solar shading or fitting blinds or curtains. Solar gain can be mitigated by external screens or by architectural detailing of the shape of windows and depth of reveals.

(Source: HBN 12 Out-patients department/3.33)

(Source: HBN 00-04 Circulation and communication spaces/3.25)

(19) Use of natural ventilation is encouraged wherever possible. Mechanical ventilation should be provided in the treatment facility, the chiropody room, the plaster room, and all internal space in hospitals.

(Source: HBN 12 Out-patients department/5.99)

(Source: HBN 00-01 General design guidance for healthcare buildings/5.46)

(20) Windows should have restricted openings. Tilt-and-turn windows that protrude into interior space should be avoided.

(Source: HBN 00-04 Circulation and communication spaces/3.26)

(21) Windows should not be situated at the ends of corridors as this may produce glare.

(Source: HBN 00-04 Circulation and communication spaces/3.23)

(22) Low windows can aid lighting of floor areas but should not cause glare or disorientation and should be designed to prevent people falling against or through them.

(Source: HBN 00-04 Circulation and communication spaces/3.24)

1.7 Visual and colour contrast

(23) Visual contrast is as important as colour contrast, as some people with visual impairments confuse different colours of similar tone. Monochromatic colour schemes should be avoided.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.39)

(Source: HBN 00-04 Circulation and communication spaces/2.5)

(24) Use more than one colour in long corridors to provide variety. Floor colours should contrast visually with wall colours.

(Source: HBN 00-04 Circulation and communication spaces/2.7)

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

(25) Visual contrast may also be used to highlight specific features, for example lifts, stairs, doors, light switches and litter bins. Contrasting handrails/crash rails may be fitted to act as navigation tools.

(Source: HBN 00-04 Circulation and communication spaces/2.8)

(Source: HBN 00-04 Circulation and communication spaces/2.9)

The document “Lighting and colour for hospital design”, which is a report based on an NHS Estates Funded Research Project states detailed information on the use of colour, see in “3.2 Hospital colour scheme considerations”

1.8 Hospital technologies

(26) Emergency escape lighting is required in primary escape routes.

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

(27) View of a clock and being able to keep track of time helps people feel in control.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

1.9 Materials and finishes

(28) Highly-patterned walls and floors should be avoided.

(Source: HBN 00-04 Circulation and communication spaces/2.11)

(29) Floor and wall surfaces should minimize light reflection.

(Source: HBN 00-04 Circulation and communication spaces/2.12)

(30) Floor surfaces should be slip-resistant (whether wet or dry).

(Source: HBN 00-04 Circulation and communication spaces/2.13)

(31) For ease of mobility, floors and floor finishes should be firm. The use of soft coverings, such as thick carpet, should be avoided.

(Source: HBN 00-04 Circulation and communication spaces/2.14)

(32) Junctions between different flooring materials should be carefully detailed so that they do not constitute an obstacle or tripping hazard.

(Source: HBN 00-04 Circulation and communication spaces/2.15)

(33) All finishes and junctions between finishes (for example between walls and floors) should be easily cleanable and not support the propagation of bacteria etc.

(Source: HBN 00-04 Circulation and communication spaces/2.16)

1.10 Accessibility and security

(34) Access controls should be installed to all non-public areas.

(Source: HBN 00-04 Circulation and communication spaces/2.19)

(35) Corridors should be as straight as possible with limited recesses and chamfered corners to aid surveillance and security.

(Source: HBN 00-04 Circulation and communication spaces/3.28)

(36) Sharp angles and overhead obstructions, such as staircases that jut out, should be avoided. If these exist, and cannot be removed, they should be emphasized by painting them in a bright, contrasting colour or, preferably by erecting a physical barrier.

(Source: HBN 00-04 Circulation and communication spaces/3.12)

(37) Corners should be carefully detailed. Splayed or rounded angles are helpful, as wall surfaces are likely to be touched by people who require a tactile knowledge of the building or use handrails for support.

(Source: HBN 00-04 Circulation and communication spaces/3.13)

(38) Corridor widths should be unobstructed by projections. However, where obstructions are unavoidable (for example in existing buildings), a local reduction in clear width to 1200 mm is acceptable for general traffic corridors provided that hazard protection is installed.

(Source: HBN 00-04 Circulation and communication spaces/3.14

2. Design requirements of circulation space --- Waiting areas

Space description

People do not normally choose to wait. Waiting area, should, as much as possible, be combined with other activities. Establish a good and orderly environment through the architectural environment is the first challenge for architects. Anxiety of patients and their escorts when having to wait can be reduced if the built environment design achieves a quiet and restful atmosphere. The waiting space should be simple, comfortable and safe, providing auxiliary functions such as rest, socializing, storage, etc., A direct visual connection with the reception of the clinic is necessary to feel in touch with hospital staff when people are waiting. Waiting area should have a simple access to service area such as toilets and refreshment areas. Some entertainment facilities like reading materials can be helpful to distract because patients are easily anxious in the medical space. Below we will discuss the universal requirements of the waiting area of each clinic suit.

Summary of waiting area built environment requirements

1. Size of waiting area
2. Location
3. Privacy
4. Seating arrangement
5. Lighting
6. Windows and ventilation
7. Visual and colour contrast
8. Sound
9. Hospital communication technologies
10. Entertainment and technologies
11. Materials and finishes
12. Accessibility and security

Source:

Health Building Note 00-01 General design guidance for healthcare buildings
Health Building Note 00-03 Clinical and clinical support spaces
Health Building Note 00-04 Circulation and communication spaces
Health Building Note 12 Out-patients department
National Health Service Lighting and colour for hospital design

Health Building Note is abbreviated as HBN below;
National Health Service is abbreviated as NHS below.

2.1 Size of waiting area

(1) An efficient appointments system in should be assumed when planning the size of the waiting area. Size of waiting area are determined by the following 3 aspects:

a) the number of patients attending the clinics.

b) the number of escorts and where they wait.

c) the number of patients in wheelchairs.

(Source: HBN 12 Out-patients department/4.13)

Waiting areas may be sized at 1.85–2.25 m² per place (see following table).

This allows for:

a) 90% of common places for patients

b) 10% of waiting places to be suitable for people in wheelchairs.

c) a children's play area based on 10% of the number of main waiting places and sized at 2 m² per child (with a minimum space for three children.

(Source: HBN 00-03 Clinical and clinical support spaces/7.30)

Table 7.1 Waiting area size

Waiting area: 10 places					
Component spaces	**% of users**	**Quantity**	**Unit area allowance (m²)**	**Total area (m²)**	**Waiting area allowance (m²)**
Common places	90%	9	1.5	13.5	
Wheelchair places	10%	1	3	3	
Children's play area (no. of children)	10%	3	2	6	
Net allowance				**22.5**	**2.25 per place**

Waiting area: 20 places					
Component spaces	**% of users**	**Quantity**	**Unit area allowance (m²)**	**Total area (m²)**	**Waiting area allowance (m²)**
Common places	90%	18	1.5	27	
Wheelchair places	10%	2	3	6	
Children's play area (no. of children)	10%	3	2	6	
Net allowance				**39**	**1.95 per place**

Waiting area: 30 places					
Component spaces	**% of users**	**Quantity**	**Unit area allowance (m²)**	**Total area (m²)**	**Waiting area allowance (m²)**
Common places	90%	27	1.5	40.5	
Wheelchair places	10%	3	3	9	
Children's play area (no. of children)	10%	3	2	6	
Net allowance				**55.5**	**1.85 per place**

Waiting area: 40 places					
Component spaces	**% of users**	**Quantity**	**Unit area allowance (m²)**	**Total area (m²)**	**Waiting area allowance (m²)**
Common places	90%	36	1.5	54	
Wheelchair places	10%	4	3	12	
Children's play area (no. of children)	10%	4	2	8	
Net allowance				**74**	**1.85 per place**

(Source: Health Building Note 00-03 Clinical, clinical support and specialist spaces)

2.2 Location

(2) Connection with reception desk

It is crucial that people can see the reception/staff area. The clinic waiting area should be close to the clinic reception desk, be within easy distance of the consulting and examination rooms.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(Source: HBN 12 Out-patients department/4.12)

(Source: HBN 00-03 Clinical and clinical support spaces/7.23)

(3) Connection with auxiliary facilities

The location of toilets and other auxiliary facilities should be within convenient reach. Entrances to toilets should be discrete and not in view of the waiting area.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

2.3 Privacy

(4) Waiting areas must provide as much privacy as possible, especially as people may be injured or distraught.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(5) A clinic waiting area should not be oversized merely to cope with the occasional build-up of patients. Locating two clinic waiting areas adjacent to each other may facilitate overspill arrangements by allowing shared use. A large space may be broken down into small units by the skillful arrangement of seating and by indoor planting.

(Source: HBN 12 Out-patients department/4.14)

(Source: HBN 00-03 Clinical and clinical support spaces/7.24)

2.4 Seating arrangement

(6) Comfortable seating is a prerequisite if people are waiting a long time. The seating layout should be considered carefully for patients with accompanying person and individual patients.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(7) Group seating

Seating arrangements should allow for relatives and friends to sit together but keep other parties separate. Seats directly opposite each other should be avoided.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(8) Individual seating

Seating arrangements that cause people to sit next to strangers can exacerbate stress, anxiety and irritation. Seating should allow for people with small groups as well as for personal space.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(9) Seating should not be located immediately outside clinical rooms.

(Source: HBN 00-03 Clinical and clinical support spaces/7.25)

(10) Adequate space is needed for wheelchair patients.

- 1.5 m² per ambulant place (that is, in a general chair);
- 3 m² per wheelchair place.

(Source: HBN 12 Out-patients department/4.12)

(Source: HBN 00-03 Clinical and clinical support spaces/7.29)

2.5 Lighting

(11) Natural lighting

Scientific evidence indicates that daylight has beneficial effects on patients (Rubin et al (1998), visitors and staff. It has been shown to reduce psychological problems and improve patient outcomes, and increase morale and reduce sickness levels among staff. Therefore, natural light should be provided where possible. Steps should be taken to prevent solar heat gain.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.44)

(Source: HBN 00-03 Clinical and clinical support spaces/7.26)

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

(12) Artificial lighting

Natural lighting is variable in quality and quantity, a comprehensive artificial lighting installation is essential. Artificial lighting should be capable of providing the required levels of illumination at all times. It also has an important contribution to make to the aesthetic appeal of the interior. The good combination of lighting can give an informal atmosphere. Lighting should be well and evenly lit, with low-contrast glare-free background illumination.

(Source: HBN 12 Out-patients department/3.34)

(Source: HBN 00-04 Circulation and communication spaces/3.21)

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

(13) Ensure lighting is glare-free for people looking in typical viewing directions (towards a central desk, or at TVs or illuminated displays).

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

The document "Lighting and colour for hospital design", which is a report based on an NHS Estates Funded Research Project states detailed information on the use of lighting, see in "3.3 Hospital lighting considerations"

2.6 Windows and ventilation

(14) Windows can not only bring natural lighting into interior space, but also provide a visual link with the outside. The position, size and shape of windows should

maximize the use of natural light. An external view, even if limited, has also been proved to be beneficial.

(Source: HBN 12 Out-patients department/3.39)

(Source: HBN 00-04 Circulation and communication spaces/3.22)

(Source: HBN 00-01 General design guidance for healthcare buildings/5.45)

(15) Sunlight glare should be minimized and may be controlled by using light-coloured walls, solar shading or fitting blinds or curtains. Solar gain can be mitigated by external screens or by architectural detailing of the shape of windows and depth of reveals.

(Source: HBN 12 Out-patients department/3.33)

(Source: HBN 00-04 Circulation and communication spaces/3.25)

(16) Use of natural ventilation is encouraged wherever possible. Mechanical ventilation should be provided in the treatment facility, the chiropody room, the plaster room, and all internal space in hospitals.

(Source: HBN 12 Out-patients department/5.99)

(Source: HBN 00-01 General design guidance for healthcare buildings/5.46)

(17) Windows should have restricted openings. Tilt-and-turn windows that protrude into interior space should be avoided.

(Source: HBN 00-04 Circulation and communication spaces/3.26)

2.7 Visual and colour contrast

(18) Visual contrast is as important as colour contrast, as some people with visual impairments confuse different colours of similar tone. Monochromatic colour schemes should be avoided.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.39)

(19) Floor colours should contrast visually with wall colours.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.40)

(20) Fittings should contrast visually with the surface to which they are fixed and the surface against which they may be viewed.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.42)

(21) Use light, warm colours for flooring and subtle greyed tones for walls as a backdrop to stronger colours for chair upholstery.

(Source: NHS Lighting and colour for hospital design/Chapter4 Hospital environment)

The document "Lighting and colour for hospital design", which is a report based on an NHS Estates Funded Research Project states detailed information on the use of colour, see in "3.2 Hospital colour scheme considerations"

2.8 Sound

(22) Any unwanted sound is a noise. Rooms where consultations, diagnostic and clinical procedures take place should be sited so that they are not unduly affected by external or internal noise. This will apply particularly to consulting, examination and treatment rooms, interview rooms and offices. Being able to sit quietly is important for keeping calm and distracted.

(Source: HBN 12 Out-patients department/3.35)

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(23) Noise reduction in a space can be assisted by the use of soft floor coverings, curtains and acoustic treatment of walls and ceilings, where this is hygienically acceptable.

(Source: HBN 12 Out-patients department/3.38)

2.9 Hospital communication technologies

(24) Notification of medical information

To ensure that medical information is easily accessible to users, electronic screens and notice boards can be used to show the latest medical information while waiting. Being able to see these messages will make the hospital visitors feel less anxious and more comfortable.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(25) Next patient call systems

Patients in the clinic waiting area should preferably be called by name by the nurse, receptionist or consultant. If there are issues around patient confidentiality, alternative systems may include numbering and patient paging. However, impersonal systems should generally be avoided. Special consideration needs to be given to calling patients with an auditory or visual impairment. Patients should be called personally, but in order to assist patients who are deaf or have some auditory impediment, a simple and unobtrusive “next-patient” call system will be required. This should comprise an illuminated indicator panel and warning buzzer of subdued tone located at the clinic reception desk.

(Source: HBN 12 Out-patients department/3.28)

2.10 Entertainment and technologies

(26) Background music and other entertainment facilities(television/video) and enclosed notice boards may be provided. A low-level background music or a video system may help patients to relax, and mask confidential discussions.

(Source: HBN 00-03 Clinical and clinical support spaces/7.28)

(Source: HBN 12 Out-patients department/4.17, 5.59)

(27) View of a clock and being able to keep track of time helps people feel in control.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(28) Access to communications (telephone, internet etc.) helps people feel in control and connected.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(29) Vending machine should be readily available and close to the waiting area.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(30) A variety of reading material should be available, interesting and up to date.

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(31) There is sufficient evidence to demonstrate that appropriate art and decor reduces the physical and emotional stress of patients and staff. It can also be used to assist wayfinding and should be always integrated within the whole design. Plants can contribute to a homely and non-institutional atmosphere.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.53)

2.11 Materials and finishes

(32) Materials and finishes should be selected to minimize maintenance and be compatible with their intended function. Building elements that require frequent redecoration or are difficult to service or clean should be avoided. A high standard of finish can inspire confidence and give a positive image of the organization

(Source: HBN 00-01 General design guidance for healthcare buildings/5.34, 5.37)

(Source: HBN 00-01 General design guidance for healthcare buildings/Waiting area)

(33) The choice of finishes should form an integral part of the design process and be coordinated within the overall design scheme. The selection of colours and reflectance can have a significant impact on the lighting within the room and will need to be coordinated with the lighting design.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.36)

2.12 Accessibility and security

(34) It is essential to ensure that suitable access and facilities are provided for all users regardless of physical ability. This includes people who use a wheelchair, those who have difficulty in walking, and those with a visual or hearing impairment.

(Source: HBN 12 Out-patients department/3.31)

(35) Doors from waiting areas into non-public access areas should be fitted with access control systems.

(Source: HBN 00-03 Clinical and clinical support spaces/7.27)

(36) Steps should be taken to ensure chairs cannot be used as potential weapons either by fixing chairs to the floor or to each other.

(Source: HBN 00-03 Clinical and clinical support spaces/7.23)

(37) A patient falling is the most common patient safety incident. A risk assessment of the internal environment should be carried out to determine whether patients are at risk.

(Source: HBN 00-01 General design guidance for healthcare buildings/5.30)

(38) Sufficient protection should be provided to prevent them from accessing balconies or climbing over the balcony edge protection. This should take into account furniture or features with footholds which may allow access over the barrier (for example, chairs, tables, plant pots, walls etc.).

(Source: HBN 00-01 General design guidance for healthcare buildings/5.33)

3. Detailed requirements of some criteria from NHS documents

3.1 Hospital wayfinding considerations

"Wayfinding: effective wayfinding and signing systems guidance for healthcare facilities", published by NHS Estates described general considerations of developing effective signs of wayfinding, they can be summary as following:

(1) Key factors of wayfinding signs

- Text

A "clear and uncomplicated" typeface, with a consistent thickness of stem, using upper-case for the first letter then lower-case for the rest of the word. The size of text is depending on positioning of the sign and viewing distance. Information should always be grouped using a logical method and be easy to understand. Signs can be ordered and grouped by alphabet, by function, by direction on directional signs or by floor. The important information should be emphasised to make it eye-catching.

- Symbols

Symbols have the potential to be a universal language, a symbol or pictogram can often be recognised and understood more quickly than words, but only if the meaning of the symbol is clear.

- Colour of signs

The colours used for text and sign background should contrast with each other and also with the predominant colours of the environment. The contrast between the text and the background colour affects the visibility, noticeability and legibility of the sign. Never use yellow with white for signs because it has a very low colour contrast, black text on dark colours for signs have the same problem.

Using a large number of colours (more than five) may make it difficult to differentiate between them, especially for colour-blind people, or when lighting conditions are poor.

- Key information

Key information emphasised using bold type, separated using lines or different colour to make it can be easy-catched by eyes.

- Positioning of signs

Careful consideration needs to be given to the positioning of signs, as it can greatly influence the noticeability, visibility, and legibility of the text on the sign, and the effectiveness of the wayfinding system as a whole. Far above eye-level sign are not comfortable to read, so low-down signs are easily obscured.

- Illumination of signs

Artificial light can be provided around your site to ensure signs are noticeable and legible at all times of the day.

(2) Wayfinding and colour-coding

"Lighting and colour for hospital design", which is a report based on an NHS Estates Funded Research Project, described general considerations of wayfinding and colour-coding, they can be summary as following:

Signs can be presented in different colours for different parts of the hospital, although the colours should be chosen so that the signs are readable. Small areas of colour (for example, in skirtings and cornices) can highlight different areas. Finally, large areas (walls and floors) could be in different colours in different parts of the hospital.

Consistency is vital in the design and implementation of all elements of wayfinding. Large areas of strong colour should be used cautiously, and colour blindness should always be taken into account when planning schemes.

Different tones or shades of the same colour should be avoided in coding, for example light blue and dark blue. People can become confused if the same words are used blue.

Identify why, and for whom, the colour-coding will be of use. Colour-coding for patients and visitors should be easy to comprehend with only a few colours. Colour-coding for the benefit of hospital staff can be slightly more complicated; staff should preferably be briefed on the issue.

Colour-coding should not dominate the visual environment. Try to limit the use of colour in a space (for example, on one wall of a corridor, instead of the whole corridor) or to specific features such as signage.

Contrast is vital for legibility for all in signage. Clear spaces around or near signage optimises recognition.

3.2 Hospital colour scheme considerations

Lighting and colour for hospital design, which is a report based on an NHS Estates Funded Research Project, described general considerations of the use of colour, they can be summary as following:

(1) The use of colour scheme

Limit the colour palette: a lot of differing colours may lead to visual confusion and a feeling of unease.

Coordinate colours of all finishing materials (floors, walls, textiles and even noticeboards) for colour harmony.

Do not overuse one particular colour. Blue and white tend to be preferred colours, but their overuse can lead to monotonous depressing environments.

Colour controls light and reflected illuminance, so maximise this by using light colours wherever possible including exterior surfaces.

(2) Colour contrast

Help visually impaired and elderly patients by visually marking the changes in floor grade or slope, limiting usage of extreme patterns, and using pale, matt floor finishes.

Use contrasting colours for doors, their leading edges, door furniture and frames. Colour contrast need not be yellow and black.

Consider coloured handrails attached to a wall at waist height, colour contrast at dado-rail height and use colour-coding on floors.

Provide colour distinction between adjacent surfaces for enhanced visibility.

Improve the visibility of architraves, door frames, skirting and doors by colouring them differently. This will especially help visually impaired and elderly patients.

3.3 Hospital lighting considerations

Lighting and colour for hospital design, which is a report based on an NHS Estates Funded Research Project, described general considerations of the use of light, they can be summary as following:

(1) Task illuminance

For the overall hospital environment, artificial lighting should be capable of providing the required levels of illumination at all times, well even and lit. Different illumination for different tasks is equally important. For example, if the task is critical in terms of accuracy and perhaps the detail is small, such as when applying stitches to an open wound, then lighting will need to be at a higher level, or illuminance, than for a less visually critical task such as moving equipment around the ward. Also if lighting is to enable patients to read and the patients are elderly with perhaps poor sight, then a higher level of illuminance will usually be necessary than if the patients are teenagers.

The following table indicates typical illuminance level for different tasks.

Tasks	**Illuminance (lux)**
Circulation areas (corridors from night to daytime)	50–150
Reading (from casual to critical)	200-500
Examination/treatment (from minor to critical)	500-750

(2) Lighting appearance

Lighting appearance is concerned with the colour appearance of the light. Electric lamps, particularly fluorescent lamps, come in a range of different colours, ranging from those that give a cool to those that give a warm appearance – this is described by a lamp's "correlated
colour temperature" (CCT) and is measured in degrees Kelvin (K).

On balance, since most areas of hospitals have daylight at some time, it is preferable to use a lamp colour that blends reasonably well with daylight but does not appear too cool at night. For this, a light with a CCT of 4000 K is recommended.

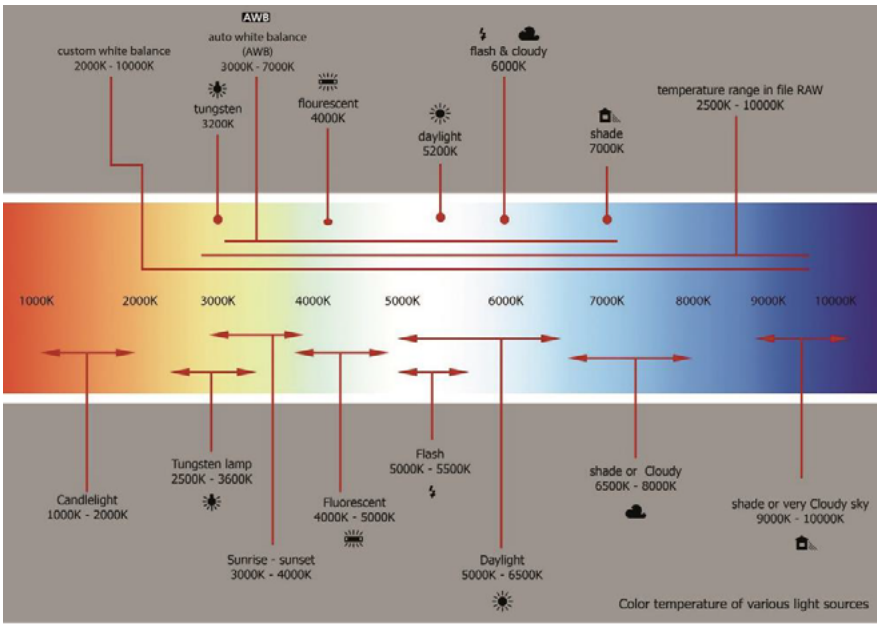
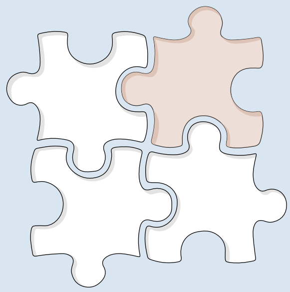


Figure 7.1 Colour temperature chart

(Source: Designing for autism spectrum disorders, Gaines et al. 2017)



7.2 Discussion

1. Discussion for hospital built environment : Corridor

Corridors serve as circulation spaces connecting different areas in the medical space. The space is designed to meet the needs of various users, including disabled people, people with visual impairments etc. Although the design of the hospital is already trying to meet all kinds of accessibility needs, but due to the ASD group are especially sensitive to the environment, some built environment elements still cause different sensory stimuli to them.

Sound

Due to the need for efficient movement, the floor of the corridor needs to use firm materials, which will make the sound of movement of people, bed, trolley, objects hitting and falling obviously (1.9 Materials and finishes (31)). Moving of beds and trolley with high speed, falling of objects on hard ground, etc., will create sudden and sharp noise sounds, which are an acoustics stimulus that people with autism can't bear. There is no doubt that the convenience of medical services is the first consideration in architectural design, but at the same time, some strategies should be considered to reduce the negative impact of these noises on ASD users.

Colour

A clear, as simple as possible, easily understood and self-explanatory wayfinding system is required. Different colours, icons, text and number can be used for the design of signpost to explain location, direction and function information (1.4 Wayfinding). The NHS publication introduced that the contrast colour should be used to make the text and symbol noticeable with the background of signpost and surroundings. Use signs with artificial light in order to make the wayfinding information noticeable at all times of the day (3.1 (1) Key factors of wayfinding signs). Then the problem occur is that, firstly there will be various types of signposts that may have potential visual stimuli to ASD users. Bright colours such as red and yellow maybe used to increase the colour contrast, but these colours are too bright to them. The improper choice of lighting for signpost can cause flicker, which is an unacceptable visual stimulation to people with autism. Secondly since ASD users usually with limited communication and understanding skills, they have to find out the effective information they need while dealing with the sensory stimuli around them in hospital. The excessive wayfinding instructions may distract autistic users and cause confusion of space layout, eventually lead to getting lost in large hospital space. Therefore a legible wayfinding system with low sensory stimuli is vital for autistic people to use hospital space.

As introduced in HBN requirements (1.7 Visual and colour contrast), the use of contrast colours is not only very important to make the wayfinding information noticeable, but also highlight fittings on surface, architectural elements, and some danger signs, make these elements be easy viewed by users. But the choice of colour and the number of colours should be carefully considered for ASD users. Bright colour and too much colour for signposts, fitting and furniture, wall and floor paints as well, can cause unbearable visual stress to ASD users.

Nature lighting

HBN suggest to providing natural lighting, natural ventilation and an outside view (1.6 Windows and ventilation) wherever possible. However, natural elements are very uncontrollable. Natural light may sometimes be too dazzling and cause glare, outdoor view may be too noisy, including traffic noise, crowded people, and noise from weeding machine. Connection with nature can contribute to the creation of a comfortable and healthy indoor environment, but windows also connect ASD users with the outside chaotic view, overload sunlight and noise, which are intolerable sensory stimuli to ASD users.

Artificial lighting

HBN requires a good, evenly and glare-free lighting system for the interior space (1.5 Lighting (13)), and there is no specific requirement for the choice of lighting. It should be noticed that people with autism are very sensitive to the visual stimuli of light. Many research results have proved that they can detect the flicker of lights that ordinary people don't feel, so the choice of artificial lighting in the corridor is very important.

Spatial pressure

The function of corridor is connecting different spaces, for the requiring of simple layout and safety issue, it is usually straight and long with limited recesses (1.10 Accessibility and security (35)), This requirement will make corridors, especially long corridor form a "tunnel effect", which will cause visual stimulation and spatial pressure to ASD users. Besides, without any other function use make corridor a boring atmosphere.

Confusion of information

The requirements of HBN mentioned the size and safety issue of door (1.2 Door). Adding a warning patterned at the end of handrail before doors and avoiding outward-opening doors can certainly make the space safer. The problem faced by ASD user is that there are many doors with similar size and appearance in the corridor. For ASD users, they may have difficulty to distinguish the function of each space, and the number of doors may cause them pressure of visual and understanding information.

Hospital technologies

Emergency lightings are essential hospital technologies in the corridor, which is used to point escape routes for people who escape in danger. Clock is also very common, because being able to keep track of time helps people feel in control (1.8 Hospital technologies). But these electronic products may threaten the senses of ASD users, flickering electronic screens, excessively bright lights, or the ticking sound produced by rotation of second-hand of clock, these all create visual and acoustics stimulus to people with autism in this space.

Change of environment

From a noisy outdoor to a relatively quiet hospital environment, from a large reception hall to a long corridor, and from the circulation space where people come and go to the ambulatory room where the interior environment is unknown, This visiting flow is not difficult for ordinary users, and they can quickly adapt to different building environments in different spaces. However, people with autism are afraid to face differences and changes, changes of built environment also included.

Each hospital space has different building structure and environment. Take corridor and waiting area as example, people with autism have to face two completely different environments. First of all, the size and shape of the space are different, the interior decoration is different, and the state of people is different. People in waiting area are waiting or reading quietly, and people in corridor are moving slowly or quickly. When ASD users enter the waiting area from the corridor space, or from the waiting area to corridor or other spaces of hospital, they may not be able to adapt sudden changes of the surrounding environment. Some strategies should be introduced to help them adapt these changes of space.

Keep calm
Hospitals is a large public building, in such a complex environment, there are many unavoidable sensory stimuli that people with autism cannot bear, such as sudden alarm sounds, crowds of people and sounds of all kinds of medical equipment. ASD users are likely to occur stereotype behaviours and become irritable and anxious when they cannot cope with such sensory overload environments. A protective strategy needs to be proposed to help them distract from sensory stimuli and keep them calm when they are sensory overload. **Keep calm**
Hospitals is a large public building, in such a complex environment, there are many unavoidable sensory stimuli that people with autism cannot bear, such as sudden alarm sounds, crowds of people and sounds of all kinds of medical equipment. ASD users are likely to occur stereotype behaviours and become irritable and anxious when they cannot cope with such sensory overload environments. A protective strategy needs to be proposed to help them distract from sensory stimuli and keep them calm when they are sensory overload.

Following questions raised from discussion of corridor:

1. How to reduce the sensory stimuli in hospital space for ASD user?
2. How to help them keep calm when they are sensory overload?
3. How to provide a harmonious colour scheme for ASD users?
4. How to correctly use contrast colour.
5. How to avoid sensory stimuli from outside chaotic view, overload sunlight and noise?
6. How to provide them with a comfortable lighting environment?
7. How to avoid "tunnel effect" of corridor?
8. How to provide a clear and legible wayfinding?
9. How to help ASD users distinguish the function of each room when doors with similar size and appearance.
10. How to reduce the sensory stimuli from hospital technologies.
11. How to help them adapt sudden changes of surrounding environment?

2. Discussion for hospital built environment : Waiting area

Waiting area serve as space where patient and escorts stay there for a while before meeting the doctors. The space is designed to meet the needs of various users, including disabled people, people with visual impairments etc. Although the design of the hospital is already trying to meet all kinds of accessibility needs, but due to the ASD group are especially sensitive to the environment, some built environment elements still cause different sensory stimuli to them.

Sound

Waiting area is different with corridor where bed, trolley and other hospital equipment need to fast pass through. As HBN suggest that soft floor coverings, curtains and acoustic treatment of walls and ceilings can be used to reduce indoor movement noise and isolate corridor noise (2.8 Sound (3)). Then the choice of these insulation coverings should be carefully considered for ASD users, materials with bright colour or high pattern can cause visual stimuli to them.

Colour

Every functional space in the hospital should have a clear sign to indicate arriving. Different colours, icons, text and number can be used for the design of signpost to explain location, direction and function information (1.4 Wayfinding). The NHS publication introduced that the contrast colour should be used to make the text and symbol noticeable with the background of signpost and surroundings. HBN suggested using contrast colours to highlight fittings on surface, architectural elements, and some danger signs, colour make these elements be easy viewed (2.7 Visual and colour contrast). The use of different colour, especially in waiting area, includes different or contrast colour for floor and wall finishes, for furniture and background, for fitting and its surface for sign and its background. This will especially help visually impaired and elderly patients. But there may be potential risk to ASD users. The choice of colour and the number of colours should be carefully considered for ASD users. Bright colour such as red and yellow maybe used to increase the colour contrast, but these colours are too bright to ASD patients. Excessive number of colours may cause unbearable visual stress to them and make autistic people unable to distinguish valid information

Nature lighting

HBN suggest to providing natural lighting, natural ventilation and an outside view (2.6 Windows and ventilation) wherever possible. However, natural elements are very uncontrollable. Natural light may sometimes be too dazzling and cause glare, outdoor view may be too noisy, including traffic noise, crowded people, and noise from weeding machine. Connection with nature can contribute to the creation of a comfortable and healthy indoor environment, but windows also connect ASD users with the outside chaotic view, overload sunlight and noise, which are intolerable sensory stimuli to ASD users.

Artificial lighting

HBN requires a good, evenly and glare-free lighting system for the interior space (2.5 Lighting (12)), and there is no specific requirement for the choice of lighting. It should be noticed that people with autism are very sensitive to the visual stimuli of light. Many research results have proved that they can detect the flicker of lights that ordinary people don't feel, so the choice of artificial lighting in the corridor is very important.

Confusion of space function

In addition to seats, there are some other functional areas, HBN requires some auxiliary services in the waiting area, such as refreshment area, reading area and artwork area (2.10 Entertainment and technologies). Ordinary users can easily distinguish the functions of each area, but autistic users may be troubled. Due to the limited understanding and communication ability of ASD users, without a clear function description or visual cue of each area, they may fail to distinguish where they can sit, where they can buy food and water, where they can relax. Strategies need to be introduced to help them understand the space, confusion about functions of each area may lead ASD users become crashing and frustrating.

Safety

Arts and plants can be used to decorate the interior environment, contribute to a non-institutional atmosphere, be used as landmarks to help patients to remember this space (2.10 Entertainment and technologies (31)). But these objects may have potential safety issue for people with autism, if these art decorations can be easily obtained and are likely to be used as weapons to hurt others and themselves. In addition, there are no clear requirements for protective measures on hard edges, the hard edges of furniture, end of walls and corners maybe dangerous for ASD users because they may run to these sharp corners and hurt themselves.

High sensory stimuli area

As required in HBN, waiting area should be adjacent to toilets and other auxiliary facilities (2.2 Location (3)), and vending machine should be readily available and close to the waiting area (2.10 Entertainment and technologies (29)). People may come to these places frequently or gather in front of them which result that these spaces are always with a chaotic environment. These chaotic environments with various sensory input and can cause sensory stimuli to ASD users. Make to location of auxiliary facilities away from waiting area will contribute to reduce the sensory stimuli, then a clear visual cue for wayfinding is needed.

Hospital technologies

Sometimes the waiting room is quiet enough for ordinary patients, but it is still a place full of sensory stimuli for autistic patients. Because some sensory inputs that normal people don’t notice can have negative influence on them. Noise from machines is a major threat for patient with ASD while waiting. Illuminated displays is necessary to convey the medical message to patient in waiting area, and sometimes televisions and videos will be provided to spend waiting time. Clock is also very common, being able to keep track of time helps people feel in control (2.10 Entertainment and technologies). But these electronic products threaten the senses of ASD users, flickering electronic screens, excessively bright lights, or the ticking sound produced by rotation of second-hand of clock, these all create visual and acoustics stimulus to people with autism in this space.

Change of environment

From a noisy outdoor to a relatively quiet hospital environment, from a large reception hall to a long corridor, and from the circulation space where people come and go to the ambulatory room where the interior environment is unknown, This visiting flow is not difficult for ordinary users, and they can quickly adapt to different building environments in different spaces. However, people with autism are afraid to face differences and changes, changes of built environment also included.

Each hospital space has different building structure and environment. Take corridor and waiting area as example, people with autism have to face two completely different environments. First of all, the size and shape of the space are different, the interior decoration is different, and the state of people is different. People in waiting area are waiting or reading quietly, and people in corridor are moving slowly or quickly. When ASD users enter the waiting area from the corridor space, or from the waiting area to corridor or other spaces of hospital, they may not be able to adapt sudden changes of the surrounding environment. Some strategies should be introduced to help them adapt these changes of space.

Keep calm

Hospitals is a large public building, in such a complex environment, there are many unavoidable sensory stimuli that people with autism cannot bear, such as sudden alarm sounds, crowds of people and sounds of all kinds of medical equipment. ASD users are likely to occur stereotype behaviours and become irritable and anxious when they cannot cope with such sensory overload environments. A protective strategy needs to be proposed to help them distract from sensory stimuli and keep them calm when they are sensory overload.

Following questions raised from discussion of waiting area:

1. How to reduce the sensory stimuli in hospital space for ASD user?
2. How to help them keep calm when they are sensory overload?
3. How to provide a harmonious colour scheme for ASD users?
4. How to avoid sensory stimuli from outside chaotic view, overload sunlight and noise?
5. How to provide them with a comfortable lighting environment?
6. How can help them quickly and easily find the waiting area?
7. How can help them understand space hierarchy of waiting area?
8. How to avoid multi-sensory overload from adjacent auxiliary facilities (toilets and vending machines) that should be closed to waiting area?
9. How to keep them safe from potential risk of furniture, especially arts and plants in waiting area?
10. How to avoid multi-sensory stimuli from equipment (illuminated displays, paging system, televisions, videos and clocks).
11. How to help them adapt sudden changes of surrounding environment?

7.3 3STI principles in hospital environments

The general environment of hospitals

Patient-friendly hospital environment

From the research of design codes from NHS documents we learned that the building of hospitals should provide a patient-friendly setting up to allow individuals to overcome medical issues. Patients in a healthcare facility are often fearful and uncertain about their health, their safety, and isolation from normal social relationships. The large, complex environment of a typical hospital further contributes to the stressful situation. Stress can dampen a person's emotional and spiritual resources, impeding recovery and healing. The architecture design for therapeutic environment play a very effective role in reducing patients stress in therapeutic environment where is potentially full of stress and the patient is stress-prone mentally. Healthcare architects and researchers have identified four key factors which, which can measurably improve patient outcomes:

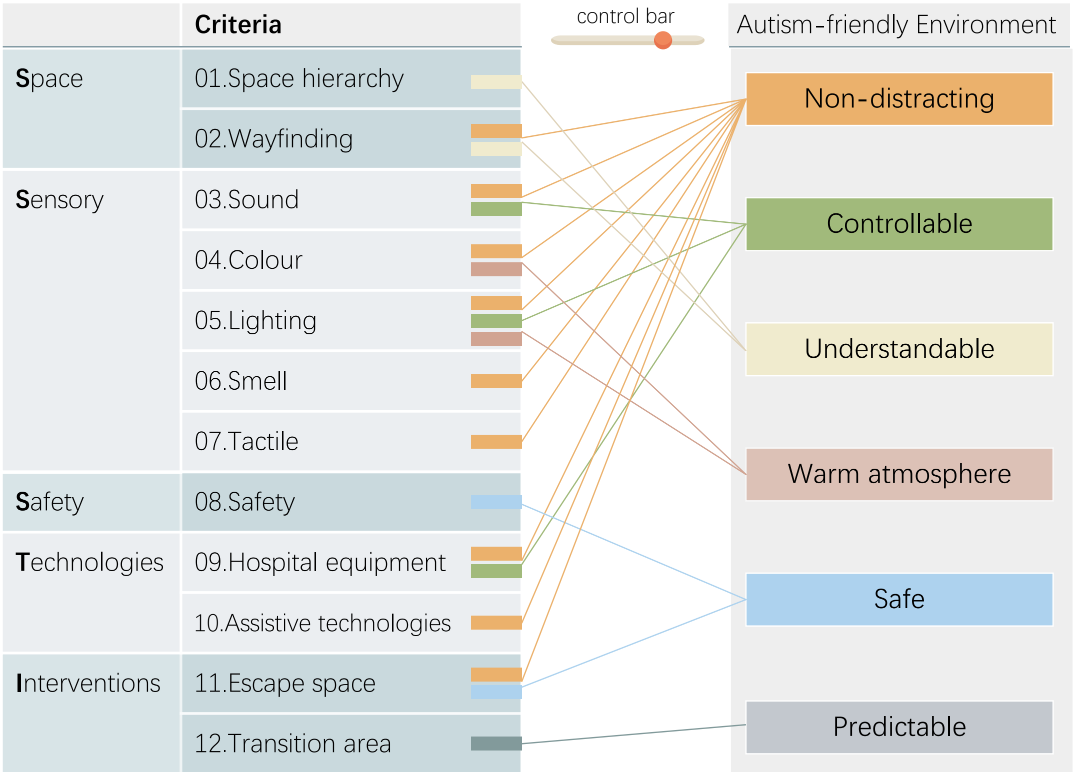
- Reduce or eliminate environmental stressors
- Provide positive distractions
- Enable social support
- Give a sense of control

The requirements of ASD users

These key points of a patient-friendly medical environment can be achieved by architectural design solutions. But this is not enough for ASD visitors. The hospital should be designed with inclusiveness as much as possible to meet the special needs of various groups for the built environment. More strategies should be taken into consideration about their sensitivity to architectural elements, the limited ability to understanding and adapting to space and poor physical control of balance. In the following, we describe the characteristic of the hospital environment needed by ASD users according to the 3STI prototype.

The application of 3STI in hospitals

The research focuses on the built environment of hospitals, “09. Equipment” is transferred to “09. Hospital equipment”.



The characteristic of autism-friendly environments

- **Non- distracting**

This aspect mainly considers sensory stimuli of space. Sensory distractions have negative impacts on them and may make autism users unable to use the hospital environment and hospital services. The sensory interference, including sound, colour, light, smell, and tactile need to be reduced. As the toilet and vending machine are needed near where people are waiting, but the air freshener used in the toilet, the noise sounds and blinking lights of the machine, and the crowds of people can easily cause sensory overload to them. These sensory issued need to be reduced by appropriate architectural design.

Moreover, the orderless environment is also a kind of visual disturbance. The untidy space where medical equipment and daily necessities are randomly placed and exposed to the public is not friendly to the ASD visitors. This disturbance can be eliminated or reduced by offering enough storage area. The overnumbered advertisement papers on the wall may make patients confused about wayfinding signposts. Instead of attached to the wall or everywhere, leaflets can be put together in the notification board.

Finding a balance in temperature may be challenging for individuals with ASD, the unstable and uncomfortable temperature and humidity (e.g., too warm or cold) can be alarming and painful. The overheated environment might direct increase indoor odours that make the environment unpleasant for smell sensitive people. It is necessary to offering visitors an indoor space with a comfortable and uniform temperature.

There are potential possibilities that people may touch each other when sitting adjunctly in waiting area, but hyper-sensitive autistic people usually dislike being touched by others, The offering of flexible chairs is a kind of solution, people can move the chair to a private area or put the chairs together and wait with the escort. However flexible chairs have the risk of safety, it may be used as a weapon or as a foothold to climb. People may fall down from high, and even fall out of windows and balconies, especially for autistic children with limited physical balance. Therefore we suggest, also as suggested in NHS documents, seating arrangements should allow individuals space for waiting alone, and group seating for relatives and friends to sit together and keep other parties separate. All the seating should be fixed on the floor or each other to make it uneasily movable.

Highlights:

√ Low-sensory stimuli (sound, colour, light, smell, and tactile)
√ The providing of enough storage space to avoid untidy and orderless environment
√ Comfortable and uniform indoor temperature
√ The providing of both individual seating and group seating

- **Controllable**

The challenge for ASD users is the uncertainty in the space, architectural elements can be affected by many uncontrollable natural factors and it is important to make the built environment under control. Take lighting system as an example, season, weather, and time of a day can affect the indoor light level and temperature. By the use of adjustable intensity lighting system can balance the change of natural lighting. It can be used to increase the lighting level and keep the room bright on cloudy days, to reduce the brightness appropriately at night to create a suitable environment for rest. The audio system is the same, the level of broadcast and loudspeaker can be appropriately reduced when the general environment is quiet and the sound in the middle level can be heard clearly. The gentle and slow-in voice can reduce the frighten of ASD users within building. When a TV screen is provided where people are waiting, instead of shutting it down, it is better to put this equipment in a cabinet with a sliding door, so that it can be removed out of sight when necessary.

On the other hand, more important, the design solution is not “one size fits all”, personal needs and preferences are important considerations when designing for sensory elements of the built environment. Especially the ability of hyper-sensitive and hypo-sensitive groups of autistic people to accept architectural elements is different, so they have different needs of the interior environment. In this case, the brightness and colour adjustable lights can adapt to the needs of individuals. It can be used in some private space to make the lighting greatly bright or keep a dim lighting environment. The controllable building elements not only increase the flexibility of environments, is also a way to reduce the uncomfortable sensory experience and help to control the emotional stability of ASD visitors. It makes hospital environments better adapted to the needs of different group of people, also provide ASD users with a better spatial experience.

Highlights:

√ The control of audio system
√ The control of lighting system
√ The control of hospital equipment

- **Understandable**

The medical environment contains a lot of information such as various text and symbol signs, colour coding departments, visual information from electronic screens, sound information from loudspeakers. Common visitor can understand the information cloud and find the target message they need quickly or ask the hospital staff for help, but this is not easy for people with autism. When ASD users enter the hospital, they have to extract effective information from various information while bearing the sensory stimuli from the built environment and the crowd of people. Their limited ability to understand and communicate skills makes them prone to collapse when they cannot handle the simultaneous input of senses and information. Therefore, a legible space hierarchy and wayfinding system are particularly important to help them quickly understand the space and navigating to the services they need. Not only ASD users, everyone prefers a building that is easy to navigate but, ASD users usually need clearer, detailed and easily understandable information.

Highlights:
√ Legible space hierarchy
√ Easy-understandable wayfinding

- **Warm atmosphere**

The home feeling atmosphere can allow people to relax and retain more information. But generally speaking, the atmosphere of the hospital is usually boring and institutional due to its functions, which may frighten the visitor with autism and make them nerves when searching for medical service. The change in interior design can offset this feeling. Warm colour scheme and lighting, cosy furniture, materials with interesting textures, thoughtfully placed works of art, and plants and decorations can help to convert a conventional hospital into a cosy and informal gathering place.

- **Safety**

People with autism tend to have unnecessary movements, weak physical balance, chew on non-food items and frequently put the hand into mouth, all these common behaviours make them have an urgent need of safe environments. Especially hypo-sensitive users, they cannot feel the sensory input and lack of awareness to realize that they are or will be in danger. Safety issues include the safety of building structures, materials, and furniture. Any place with potential risk should be avoided, such as the sharp corner and hard edge of wall and furniture, the slipping floors and unstable decoration objects. The clear and easy-understandable safety signs are needed when some obstruct cannot be removed.

In addition, for people with autism, the challenge for the hospital is not only to provide a safe built environment but also to ensure the emotional safety of them. Although the sensory stimuli can be reduced through architecture design, there are still many unavoidable sources of stimulus in hospital, sudden crowds of people and noise, sudden alarm, outside noisy traffic, etc., which can cause them to fall into anxiety and aggression, even hurt themselves or others.

Helping them to keep ASD users calm, an escape space can be implemented in the hospital environments, where is a relatively quiet and personal space can provide them with a sense of safety that can help them to calm down as soon as possible.

Highlights:
√ Safety of building structures, materials, and furniture
√ Emotional safety

- **Predictable**

Many autistic people have a fear of "difference", including spatial or environmental difference. There are various functional spaces in the hospital, and each space has its own unique built environment. When people visit hospital, they inevitably cross between different spaces. Ordinary users can easily and quickly adapt to changes in the surrounding environment, but ASD users are different. Changes of built environment, especially sudden and obvious one, may cause them anxiety and fear. Making the space predictable, offering them an opportunity to preview the unknow space can help ASD users adapt to change of space in advance, which can be achieved by providing a transition area between two different space or adding a visual connection of next space.

Discussion about hyper- and hypo-sensitivity

Based on the previous study, it is known that people with autism can be majorly divided into 2 categories being either hyper-sensitive or being hypo-sensitive to sensory stimuli. The senses of hyper-sensitive people are too acute, they can be over-responsive to sensory stimuli. Conversely, hypo-sensitive people appear to be under-responsive, as if certain sensory information goes unnoticed or certain senses are impaired.

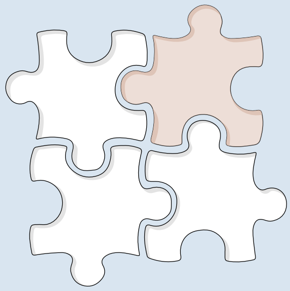
Because they have two distinct needs for the built environment, the requirements cannot be met in the same space. The healthcare environment should be an inclusive, easy-to-use, and comfortable building environment for all users. So we consider reducing the sensory stimuli in the space for hyper-sensitive people and enhancing the safety level of the space for hypo-sensitive people. The reasons are as follows:

- **About sensory environment**

Loud noise, bright light, wet materials, strong odour, flicker screen and movement can make hyper-sensitive users feel distressed, uncomfortable, and even painful, these sensory inputs may cause their meltdown. It is like a computer that freezes because too many processes are ongoing at once. While hypo-sensitive users don't respond to sensory information and they usually need or seek for strong sensory inputs to stimuli themselves. Sensory therapy is often used in autism medical centres to enhance sensory input and help hypo-sensitive autistic children to feel the world. But for general hospitals, it is important to reduce such stimuli barriers to help hyper-sensitive autistic people use medical services easily and comfortably.

- **About environment safety**

Considering that hypo-sensitive users can't feel the sensory input, which makes the safety issue of the environment especially important. For example, they probably don't feel pain after a hard fall, hurt by sharp corners of furniture and wall, don't scream out when touching extreme hot water, like unnecessary movements which may lead to slip down or fall down the stairs. Therefore, the selection of materials and safety of building structure and furniture (e.g., tables, chairs, doors, and windows) need to be carefully decided.



7.4 3STI principles in hospital environments : 12 criteria proposal

Introduction

01. Space hierarchy

We already know from previous literature review and case study that a clear and legible space is important for autistic people. This criterion includes the macro space layout of the building, as well as the micro space hierarchy of each sub area in the building.

1 The design of space for people with autism

1.1 Macro space layout

From a macro view, the simple layout is undoubtedly friendly to people with autism, the use of a single visiting circulation is certainly recommended. It can effectively avoid people traveling on the same route, intersection of visiting flow and functional area.

When designing a school for children with autism, Mostafa divided the space area into high sensory stimuli zones and low sensory stimuli zones Classrooms and therapy rooms were placed in low-stimuli zones. The cafeteria, swimming pool and playrooms all belong to high-stimuli zones. A sensory garden was introduced between the two zones to help ASD children adapt to changes in the surrounding environment in advance (Figure 7.2, see projects details in Case study chapter).

Figure 7.2 Master plan of Advance School for Developing Skills of Special Needs Children (Source: diagram by author)

Figure 7.3 show the plan of Special Needs Schools, St. Coletta School, design by Michael Graves. With a simple layout, a long main corridor connecting all functional areas, student in school can easily find the place they need. The gymnasium is located as possible as far away from the teaching area. (See detailed introduction of project in Case study)

Figure 7.4 show the plan of Sweetwater Spectrum Housing, which is specially designed for autism people, by LMS Architects. Indoor functional spaces are distributed on both sides of the C-Type corridor, the autistic users' bedroom are located far away from the public area such the kitchen and bathroom, living room and dining terrace in the corner. This can effectively control the negative impacts of sensory stimuli on people with autism in the space environment. (See detailed information of project in Case study)

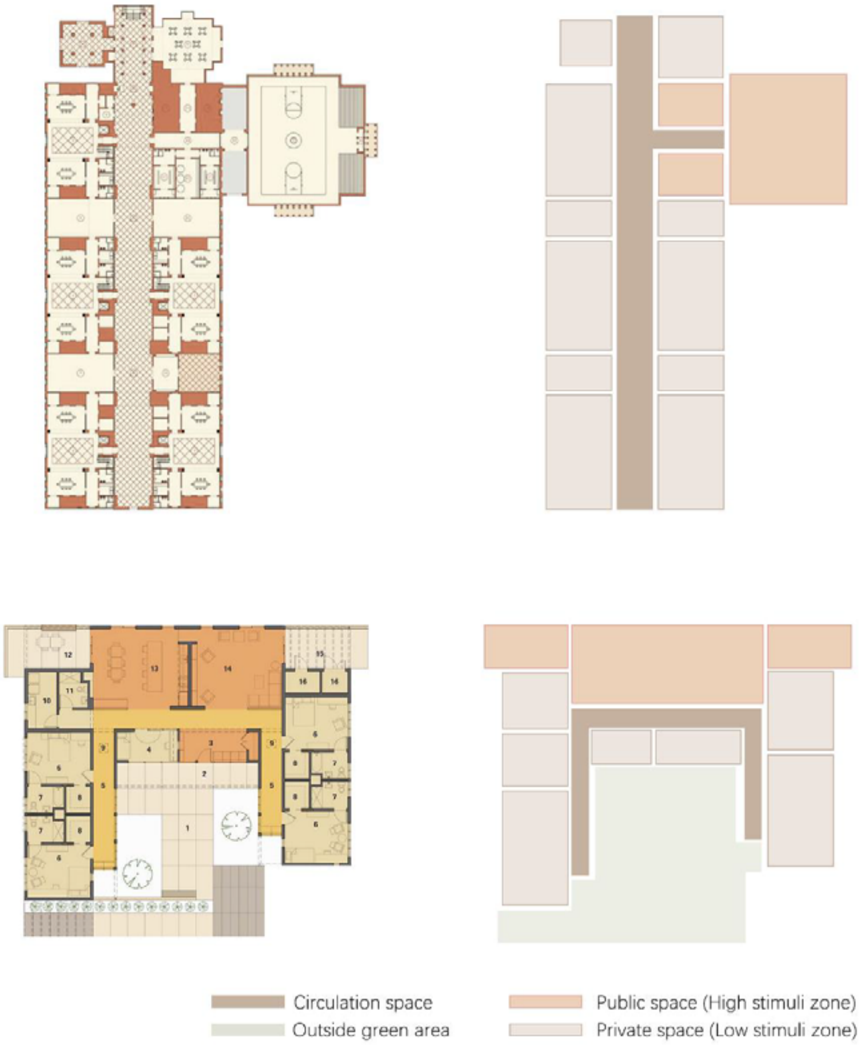


Figure 7.3 Plan layout of Advance St. Coletta School (up)
Figure 7.4 Plan layout of Advance Sweetwater Spectrum Housing (down)
Source: diagram by author

However, the functions of healthcare buildings are completely different from schools and homes. A general hospital has departments with outpatient, surgery, injection, and various examination spaces. We cannot require hospital to change the spatial layout through the level of sensory stimulation. We can only recommend that, on the basis of meeting the requirements of medical design, simplify the visiting circulation of the space as much as possible, provide a clear and understandable wayfinding system to help ASD users understand the space.

1.2 Micro space hierarchy

(1) Separate high stimuli facilities away from quiet area

From a micro view, considering the circulation space of corridors and waiting areas, sensory stimulation areas in these spaces can be kept away from places that need to be quiet. Use walls, furniture and plants to separate vending machines and illuminated screen away from the quiet waiting area, which can reduce the sensory stimulus for waiting ASD people.

Application in waiting area

The noise space such as the toilet can be placed away from the waiting area, but also need to meet the requirements in HBN "People in the waiting area can easily find auxiliary spaces such as toilets", in this case a clearer signpost is necessary to help people finding the location of toilet.

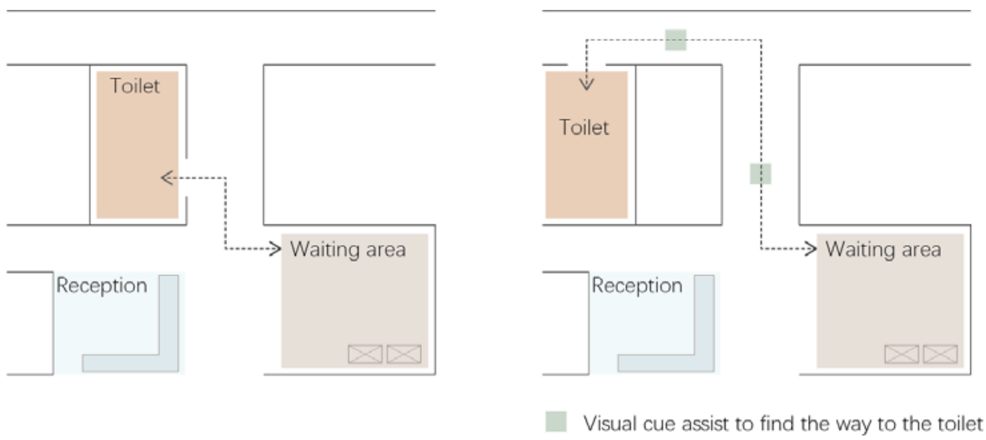


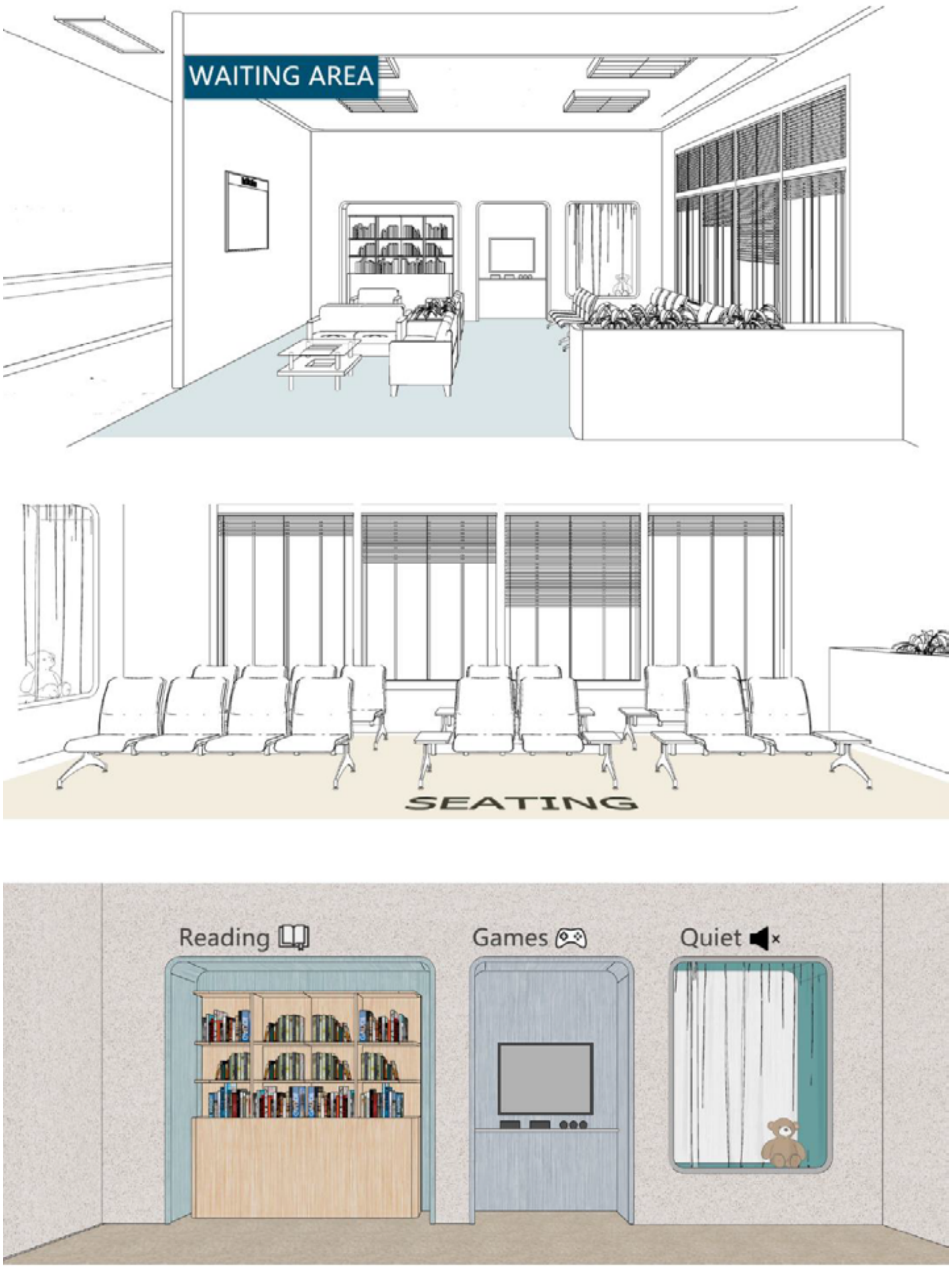
Figure 7.5 Rearrange the location of toilet for a quiet waiting area (Source: by author)

(2) Clear visual cues for each functional area

Space hierarchy will affect the ASD people. Khare and Mullick (2008) suggested organizing visual environment through concrete visual cues and visual importance by incorporating colour coding, numbers, symbols, labelling, illuminated signboards, highlighters etc. The presence of these visual cues to explain the definition and function of different space help autism users to understand the spatial structure and use its service.

In hospital, there must be a clear signpost for large functional space to tell people arriving, such as waiting room and clinical reception desk. But for ASD users, function of small also need to be explained by signs. Ordinary users, when they see a chair, they know that it is a waiting area. When they see a book, they know that they can take a book to read. When they see a vending machine, they know that they can buy food and water here. For ASD users, they need a clearer expressing to tell them the use and function of an area. The signs, visual cues about the functional area can be implemented by text and symbol descriptions, colour, different floor materials, etc. (See in Figure 7.6).

The space hierarchy is not a completely independent criterion. In fact, each criterion does not exist independently. The criteria interact and complement each other in order to provide a better built environment. Iran Scott (2009) said that it is thus important that all visual cues, colour schemes, different qualities of light, texture changes are used to support the spatial hierarchy rather than confuse it. As mentioned above, if the function space is rearranged in circulation space, signposts are needed to assist wayfinding, besides visual cues can be used to make the definition of space clearer



As images showing, clear text, easy symbols, colours, different floor materials, special landmarks and etc. can be used as visual cues to identify the boundary and function.

Figure 7.6 Some examples of visual cues (Source: by author)

1.3 The multi-functional use of space

Waiting area

In addition, considering about architectural space, the multi-functional use of space should also be considered. As HBN's required for the waiting area, some entertainment, like background music, reading material, and refreshment need to be provided in the waiting area to enrich the space functions. These strategies can help with people distraction and reduce people's anxiety while waiting. HBN does not have such requirements for corridors, and studies have shown that making corridors multi-functional can provide a better spatial experience for ASD users.

Corridor

Beaver, a designer from GA Architect stated that we have banished the corridor from our buildings and even the word is now outlawed. Of course, there has to be a means of getting from A to B, but we prefer to call that the circulation space. It has to be an interesting space, not just a box shape, and should be multi-functional. He broke up the corridor space with bench seats or other interesting space for rest or interaction activities, so the institutional corridor has been turned into a social and activity space. This theory has been applied to architectural design, as shown in the Figure 7.7 below, it is a house specially designed for children with autism, by GA architects. As can be seen from the plan, conventional straight and long corridor has been changed it into a diverse environment where children can rest and play, feeling comfortable, relaxed and interested in.

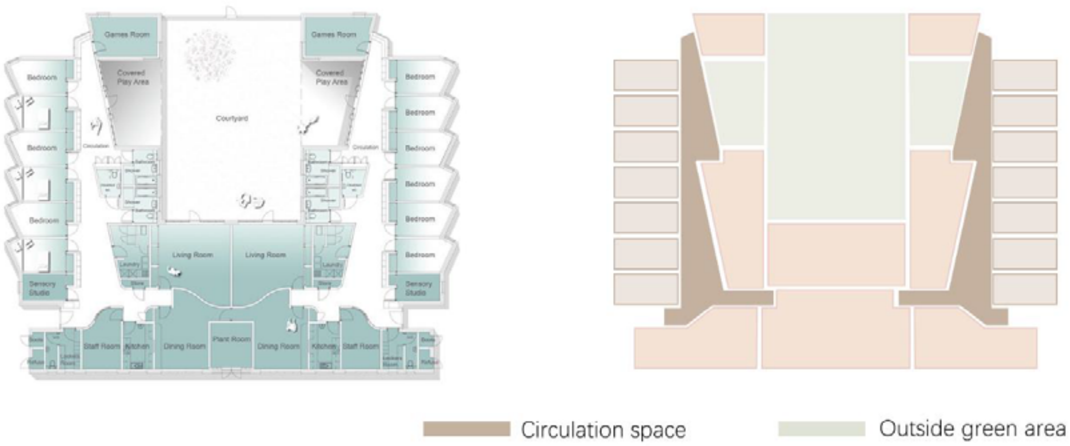


Figure 7.7 Plan of Sunfield's Rowan and Oak House, by GA Architects (Source: by author)

For the corridor space of a hospital, there is no doubt that the effective movement for patients and medical equipment is the most important. In wherever possible, adding some extra interesting space in the corridor space where conditions permit, to break the corridor "tunnel effect" and the boring atmosphere is recommended. Recessed space can be used to break the corridor space into compartments, where seats, art works and entertainment can be places for distraction and reducing pressure. At the same time, these functional areas should be clearly identified to help ASD users understand their function definition.

Case study: Mitford Hospital Autism Inpatient Unit

The strategy about how to make the corridor multi-functional is various, here we think that the corridor space of Mitford Hospital Autism Inpatient Unit can be considered as a design reference. In order to avoid the existence of long corridors in the building, the architects used curved walls with some recessed space, tables and chairs and interactive applications were provided in these recessed spaces. Neutral colour was used to indicate the space function. For detailed information and photos of this project, please refer to the "Case study".

Figure 7.8 Corridor of Mitford Hospital Autism Inpatient Unit
(Source: https://medicalarchitecture.com/projects/adult-autism-unit/)

2 Summary of space aid for ASD users

In the above we explained the application of the results of existing autism friendly studies to hospital space and their feasibility and limitations. The key concept is to reduce sensory stimuli in space and also make the space hierarchy clear, legible and understandable.

Space aid for ASD users can be achieved by following points:

√ Easy-understandable space layout and non-crossing visiting flows.
√ Separate high sensory stimuli area away from quiet areas.
√ Use visual cues to indicate the function and boundary of each area.
✗ Avoid making interior space like a building box with a boring atmosphere.

3 Design considerations of ASD-friendly hospital environment

Corridor

- Corridors should be as straight as possible with limited recesses for the movement of bed and trolley.
- The width of the corridor should meet the two-direction traffic and turns of various users and medical equipment.
- In the corridors where don't affect the movement of patients and medical equipment, corridors can be not only for traffic function, but also multifunctional. The recessed space can be designed as a place to stay temporarily, tables and chairs or artwork can be provided in it. This will weaken the "tunnel effect" of corridor, break the boring atmosphere and rigid architectural forms, also make the entire circulation space more interesting and welcoming. Text, icon, number and colour can be used to tell ASD people the function of these additional area.

Waiting area

- The clinic waiting area should be close to the clinic reception desk, within a direct visual connection.
- Auxiliary facilities, such as toilets and vending machine, can be considered as high stimuli zone. These spaces can be moved away from the quiet waiting area but within convenient distance, besides providing a detailed signpost to help ASD users to find them
- It's better to break the boring atmosphere with the multi-functional use of space. As HBN recommended in requirements, soft background music, read materials and be provided for passing the waiting time, we also recommend the use of interactive technologies for the same purpose while waiting.
- Considering that there are several different functional areas in waiting area, the function of each area should be clearly declared with text, icon or colour to help ASD users know what they can do in this area. The functional area in waiting area including seating area, reading area, entertainment area, artwork area and etc

02. Wayfinding

All hospitals are complex environments, and for patients, staff and visitors the ability to get from one part of the facility to another quickly, efficiently and without worry is an important one. The term “wayfinding” covers everything to do with how people find their way round environments. A legible space contains distinct features that aid in wayfinding, making it easy both to find a desired location and to return to the point of origin.

1 Difficult faced by people with ASD in wayfinding

HBN and NHS documents state that wayfinding systems in healthcare facilities should be available for all users. Some key considerations were listed to help people with visual impairments and people who are deaf or hearing impaired to find their way in hospital space. ASD people is also vulnerable group people who need special help, the inclusive design of wayfinding system for autism people should be came up with.

Many people with autism spectrum disorder (ASD) have a hard time figuring out how to get from one place to another. This navigational challenge can be difficult, especially when a person goes somewhere for the first time. People with ASD often have a great feeling of anxiety when they are in a large and complex building like a hospital. They worry about what they will do if they get separated from parents, cares or escorts and have to find their way alone.

There are also data that shows a number of navigational impairments in ASD: autistic groups were slower at learning spatial regularities, less efficient in their foraging behaviour, less able to learn locations based on allocentric representations, less likely to sufficiently explore an environment, and more likely to revisit locations that they have already explored. In the study by Morag et al. (2016), they mentioned individuals with learning disorders and autism raised the need for maintaining a similarity in the interior spaces across multiple floors.

2 The design of wayfinding for people with autism

2.1 Memorable space

(1) The use of colour coding

Some research pointed that children having sensitivity to colour. Ludlow et al. (2006) conducted an experiment to test the effect of using coloured overlays on a reading exercise with children with ASD. They found that children with ASD were significantly more able to read faster with a coloured overlay than a white page (Ludlow et al. 2006), suggested that this could have implications for the design of signage.

Sánchez et al. (2011), and Vázquez and Torres (2013) all advocate for the use of colour coding to help people with ASD. Also, Irish (2013), in a case study approach describing a new school for children with ASD and other disabilities, used colour coded doors to help children with ASD to navigate the school environment.

Colour coding can be applied in wayfinding system of a hospital, means each department or functional area can be represented by a different colour. Beside the use of colour must maintain a similarity and consistent. For example, blue is used in the corridor wayfinding signs to represent waiting areas, then the signs of waiting areas should also be blue.

Case study: a. Colour solution in Boston Children's Hospital
Set of alliterative and color-coded symbols designed to distinguish department of hospital and buildings aiding visitors and staff in navigating a complex arrangement of linked corridors and spaces. Functional and appealing to adults, the symbols are an immense delight to children as well. Set of alliterative and color-coded symbols designed to distinguish department of hospital and buildings aiding visitors and staff in navigating a complex arrangement of linked corridors and spaces. Functional and appealing to adults, the symbols are an immense delight to children as well.

Figure 7.9 The use of colour in wayfinding
(Source: Boston Children's Hospital)

(2) Artworks, materials or natural elements as landmarks
Vogel (2008) research data gathered from parents, teachers, and therapists of children with ASD, as well as adults with ASD, to create a set of interior design standards for schools. She uses examples such as making evident "paths" with coloured tape or printed footprints, creating bold and memorable "edges" using murals, and using sculpture or a water feature as a "landmark" (Vogel, 2008).

Signage is sometimes overused in healthcare, when there are overnumbered text, symbol and colour information in space landmarks may play a role in "attention grabbing" assisting as a wayfinding cue to reinforce the identity of space. In the medical environment, sculptures, artworks, murals and other decorative objects with obvious characteristics can be used as landmarks to make the space memorable in order to empower visitors to navigate the facility more independently. In addition, decorating interion environment with natural elements and special materials, it's another alterative and good choice.

Case study: b. Wayfinding Solution in Oxleas Children's Development Centre

With a 'nature' colour palette and organic shapes inspired by nature, designs included custom seating in infection-safe fabric, timber pillars to echo tree boughs, leaves graphics are printed from floor to ceiling on the wall. The flooring also contains similar graphic motifs, helping to define areas and making visitor remember this space easily. (See in Figure 7.10 and 7.11)

Figure 7.10 Natural decoration as a landmark in corridor
Oxleas Children's Development Centre
(Source: https://www.boex.co.uk/portfolio/oxleas-childrens-development-centre/)

Figure 7.11 Natural decoration as a landmark in waiting room
Oxleas Children's Development Centre
(Source: https://www.boex.co.uk/portfolio/oxleas-childrens-development-centre/)

c. Wayfinding Solution in Royal Children's Hospital Melbourne

The wayfinding solution at the new Royal Children's Hospital focuses on the integration of landmarks at key navigational decision points, the primary objective being to create journeys that are easily describable, in a simple sentence, using basic English. The Buro North team collaborated with illustrator Jane Reiseger to develop the wayfinding strategy. Together they have created a fun and lyrical pictorial signage system that likens the RCH to the natural world. As patients move through different floors in the hospital their journey takes them from 'underground' at the lower ground levels through to 'sky' on the top floor.

Specific areas within each level are described in relation to an appropriate animal, for example, the central waiting area on the lower floor is represented by "Underwater world" and many marine elements are used to decorate the interior; "forest world" exist in middle level, cartoons of "forests and animals" are painted on the wall at the end of the corridor leading to the wards.

We thought this strategy can help autistic users, especially children with autism, to find a place they've been to before. Children may remember like this:" I live on the tree with that koala! ".

The thing needs to be noticed is that when using art works, murals and cartoons drawing as landmarks, it can greatly help ASD users remember space and its location, but the existence of bright colours and too many colours must be avoided, which will cause them visual pressure and make wayfinding solution counterproductive.

Figure 7.12 Central waiting area are represented by "Underwater world"
(Source: https://www.dexigner.com/news/24905)

Figure 7.13 Ward rooms in the "forest level", with trees and animals drawing on the wall of corridor (Source: https://www.dexigner.com/news/24905)

2.2 Easy-understandable symbols

Using signs with symbols and text instead of text-only signs helps ASD users understand the information. Sánchez, Vázquez, and Serrano (2010) conducted a literature review of previous studies to find the design criteria that were cited as supporting adults with ASD in the built environment, noting that pictograms or photographs used as signpost could be useful in wayfinding.

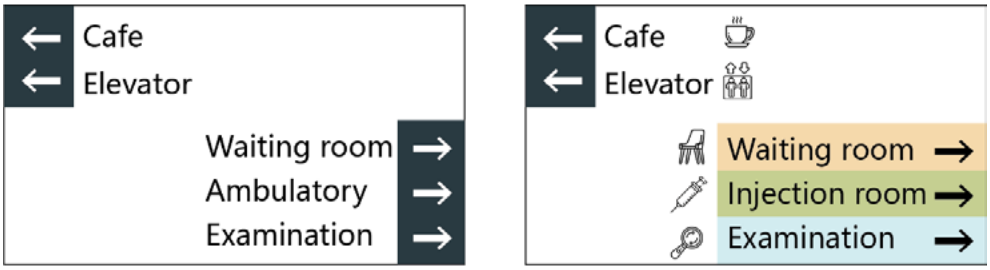


Figure 7.14 Improvement of wayfinding signpost (Source: by author)

2.3 Wayfinding mobile application

Nowadays a guide application is provided in some exhibition halls and museums with complex architectural environments to assist interior navigation (such as the Louvre's Audio Guide). The interior space of the building will be displayed in 2D plans or 3D perspectives view to help visitors know the position of themselves and find the location of the exhibit that they want to see through the guide system. This application can shorten the invalid wayfinding time for visitors, avoid getting lost in complex spaces and a large number of exhibits, which improve the quality of visits. If such products can be used in hospitals, we think it can help autistic users understand the spatial structure of hospital space and find the location of the medical services they need to prevent them from being emotionally disturbed due to getting lost.

2.4 Avoid visual stimuli -- Overused colour like a mess to ASD users

The thing needs to be noticed is that from the previous literature we already know that people with autism are sensitive to sensory stimuli, there may be many visual stimuli in the wayfinding system. On the basis of providing a clear and reasonable wayfinding, we can eliminate visual disturbance to ASD and add some aids to help them better understand the hospital space structure.

(1) No bright colours

Bright colours such as red and yellow need to be avoided.

Figure 7.15 Failed example1: Incorrect use of colour in wayfinding (Source: by author)

(2) No large coloured area

As suggested by NHS" Wayfinding" documents, colour-coding should not dominate the visual environment. Using colour in limited to define space or to specific features such as signage in a space.

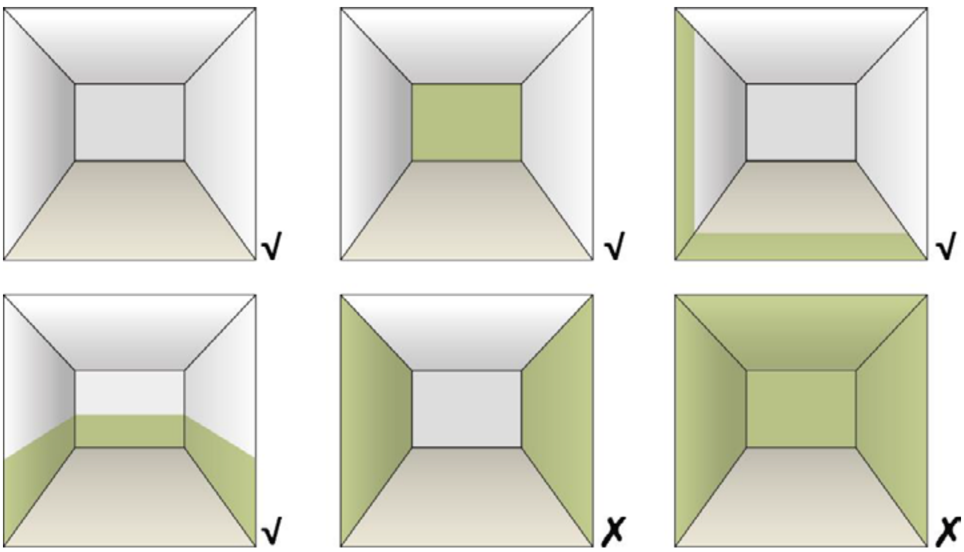


Figure 7.16 Visual effects of using colours in different way (Source: by author)

(3) No overnumbered and similar colours

Be sure to avoid using signpost like following figure, with more than 10 colours. ASD users can easily get lost in colour, colourful things can cause some people to become painful or even dizzy. Also NHS “Wayfinding” documents recommend using under 5 colours in the wayfinding system to avoid people getting confused about complex information.

Some people with autism have the same symptoms as people with visual impairment. Compared with ordinary people, they have weaker colour perception ability and cannot accurately distinguish similar colours. Some similar colours are used in this signpost, which make ASD users and people with visual impairment as well unable to read colour information.

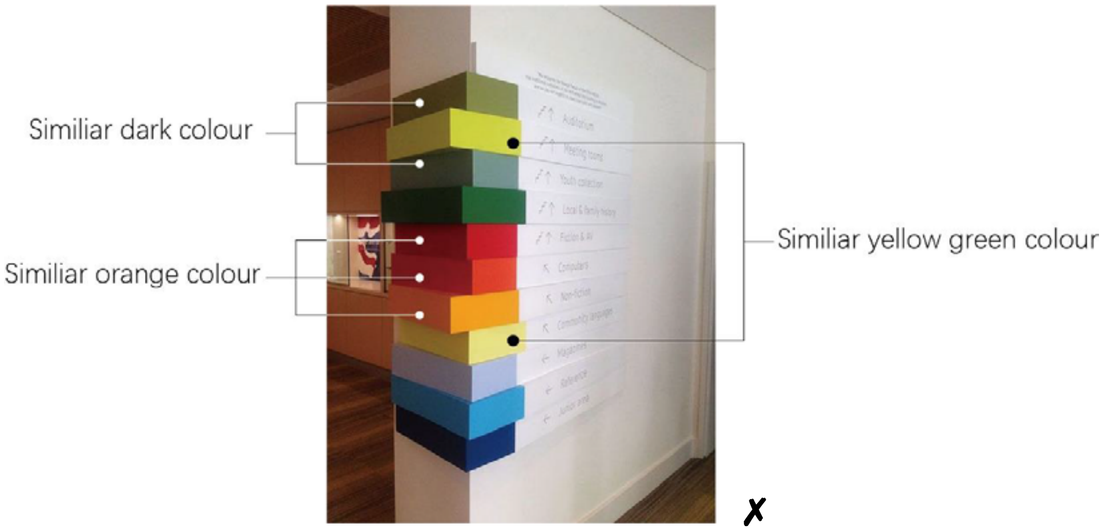


Figure 7.17 Failed example2: Incorrect use of colour in wayfinding (Source: by author)

3 Discussion and summary of wayfinding aid for ASD users

From the research, it is apparent that wayfinding is an important skill to learn for humans in general and especially important for people with ASD. However, most of the literature provided qualitative findings from small samples or presented findings from observations and surveys that need additional testing. Most of the autism friendly built environment is based on the school and home environment, which is different from the medical built environment that we studied in this paper. Although the built environment is different, we think some of the research result is repetitive and universal. Design considerations that can affect ASD users in school and home environments, we can infer that these factors will also play a role in the medical environment.

First, signposts should meet the design considerations proposed by NHS Estates, These consideration can contribute to a legible and clear wayfinding system. Then there are some aids that can be used to help ASD users better understand the spatial layout. The key concept identified is that making the environment memorable could help ASD users in wayfinding, in the meantime reduce visual stimuli produced by wayfinding system as possible.

Wayfinding aid for ASD users can be achieved by following points:

√ Using delicate colour coding system
√ Various landmarks, e.g., artworks, sculpture, murals, decoration of natural elements, etc.
√ Text signs with easy-understandable symbol.
√ Wayfinding assist technology

✗ Bright colours
✗ Large coloured area
✗ Too many colours
✗ Similar colours

4 Design considerations of ASD-friendly hospital environment

Corridor

- Wayfinding signs should be clear and uncomplicate, information should always be grouped using a logical method and be easy to understand, key information should be emphasized by bold type, separated using lines or different colour.
- Signs can be the combination of text and easy understandable pictograms, well positioned on the wall, floor, ceiling or notice boards. Printed footprints and colour track line on the floor can make great contribution to navigate in corridor.
- Signs should be in correct colour contrast with signs' background and with environment. Low contrast colour should be avoided (white and yellow, black text and dark sign background).
- Considering the use of colour in wayfinding signposts, bright colour should be avoided because it will cause visual stimuli to ASD users.
  About bright colour that can cause visual stimuli see in "Colour"
- Colour-coding should be easy to comprehend with only a few colours. The number of colours should be limited in five colours, otherwise will cause confusion.
- Artificial light can contribute to ensure signs are noticeable and legible at all times, the use of artificial light in signpost should without glare and too bright illuminance level.
- The different parts of hospital can be presented in different colour, the colour should be consistent with the colour used in wayfinding signpost.
- Colour coding can be used to help ASD users distinguish the meaning of each doors, skirtings and cornices can highlight different areas while bright colour should be avoided.
- Different tones or shades of the same colour should be avoided in colour coding.
- Colour-coding should not dominate the visual environment. In corridor, instead of the whole corridor, one wall of a corridor or lower part of the wall in corridor can be coloured to assist wayfinding.
- Art and plants can be used as a landmark to make the environment memorable.
- If it's possible, tactile wayfinding aids (touch wall) can be used to assist wayfinding in corridor and make the environment memorable.
- If it's possible, navigation technology (phone application or interactive program) can be used to assist wayfinding in corridor.

Waiting area

- The clear signpost should be placed in the entrance of waiting area
- Signs can be the combination of text and easy understandable pictograms, well positioned on the wall, floor, ceiling or notice boards. Printed footprints and colour track line on the floor can make great contribution to find the waiting area.
- Colour coding can be used in waiting area. Using one colour that represent "waiting area" and paint the colour on part of the door, wall or floor etc. The colour should be consistent with the colour used in wayfinding signpost.
- Considering the use of colour in wayfinding signposts, bright colour should be avoided because it will cause visual stimuli to ASD users.
  About bright colour that can cause visual stimuli see in "Colour"
- Art and plants can be used as a landmark to make the environment memorable.
- If it's possible, tactile wayfinding aids (touch wall) can be used to assist wayfinding in corridor and make the environment memorable.
- If it's possible, navigation technology (phone application or interactive program) can be used to assist wayfinding in corridor.

03. Sound

1 Noises in hospital’s built environment

1.1 Hospital’s noise source

Hospital, as a public building, is always noisy. Two main reasons can explain that why hospitals are noisy. First, there are many noise sources, HVAC system(heating, ventilation and air condition) is the common equipment that may create continuous hum noise, and medical equipment also contributing to the loud noise levels in hospitals, including alarms, televisions, and phones, as well as staff, visitor and patient conversations. The beds and trolleys move at high speed in the hospital space, the friction between the wheel and the ground will also generate huge noise.

Noise constantly be produced from the source is one problem. Second, the built environment also affects the transmission of sound. Environmental surfaces in hospitals, including walls, floor, and ceiling, tend to be sound reflecting rather than sound absorbing (Ulrich et al. 2004; Ulrich 2003). The presence of hard surfaces in hospitals can exacerbate hospital noise problems. Surfaces that reflect sound can cause noise to travel for considerable distances, travel down corridor and enter ambulatory rooms, waiting areas and wards, adversely affecting patients and staff over larger areas (Ulrich, 2003). The typical sound reflecting surface of a hospital produces echoes and reverberations. These two factors will cause blending and overlapping of sounds, resulting in reduced speech intelligibility. Hospital staffs, in order to make themselves heard clear, need to raise their voices, thereby compounding the noise problem even further.

Possible noise source in corridor

- Common equipment
- Movement of medical equipment
- Movement of people
- Echoes and reverberations
- Alarms
- Conversation sounds

Possible noise source in waiting area

- Common equipment
- Televisions, video, vending machine
- Movement of people
- Echoes and reverberations
- Alarms
- Conversation sounds

1.2 Impacts of sound on patients and staffs

Sound, in its different manifestations, can have profound impacts on patients, staff, and visitors in hospitals—ranging from soothing and therapeutic to stressful and disturbing. Soothing background music can help people relax and relieve tension, also can be used as a sound covering. In circulation space, especially waiting area, patients tend to have their private information communication with their escorts, where it can be heard not only by themselves but also others. Clearly, such experiences are likely to impact patient trust to discuss their health problems freely in hospital space (Barlas et al. 2001). Therefore background music is a useful strategy to help cover the conversation sound so that enhance the privacy of the space.

2 Acoustic stimuli to people with ASD

Noise can be a source of stress for hospital staff and may interfere with their ability to work effectively (Blomkvist et al. 2005). Considerable research has been conducted on the negative impacts of noise on patients and staff in hospitals. Noise like a trigger makes people's annoyance and anxiety accumulate and explode, especially in hospitals, where people often feel uneasy and anxious.

We have mentioned in the literature review that Mostafa has demonstrated through comparative experiment that improving the acoustic design of the classroom can improve student response time to a command or question (Mostafa, 2008). Beaver (2006), Whitehurst (2007), Humphrey (2008), Khare and Mullick (2010) all stated the importance of acoustics environment especially for space that people with autism people will use. In addition, in order to have a better understanding of the impact of sound on the autistic people, we conducted in-depth research and found some studies and autobiographies can provide some useful points.

2.1 Hyper- and hypo-hearing

Noises have a negative impact on common people coming to hospitals and staff, not to mention people with autism. Sensory sensitivities were already reported in the first descriptions of autism by Leo Kanner (1943), and sound is one of the most commonly reported sensory sensitivities in ASD. Hyper and hypo-sensitive users have different behaviours react to sound inputs, the presence of symptoms and reactions vary in severity, according to the condition of individuals. Following Table 7.2 lists the common symptoms of autistic people when facing various sound stimuli.

Table 7.2 Acoustic stimuli

Hyper-hearing
• Easily distracted by background sounds; • Easily frightened by sudden unpredictable sounds (e.g., telephone ringing, sirens) and overreacts to sounds as if it is a threat (e.g., scream or cry to sound); • Often covers ears when the disturbing noise is painful; • Sometimes makes repetitive noises to block out other disturbing sounds.
Hypo-hearing
• Seems oblivious to sounds of surrounding activities; • Seeks or creates for sounds to stimulate themselves (e.g., bang doors, make loud rhythmic sounds); • Enjoys the loud noises (e.g., enjoy crowds, sirens, like the ‘noisiest’ places).

Studies show that people with ASD perceive certain sounds as more intense. For instance, certain frequencies can be extremely annoying (e.g., computer fan), loud noises can be painful and combined sounds such as multiple people talking to each other at once can be overwhelming (Elwin et al. 2012; Robertson et al. 2015).

Interactive Autism Network (IAN) at Kennedy Krieger Institute, surveyed parents of 814 children with autism to understand the auditory sensitivity impacts on autistic children. Being over or under reactive to noise caused 43 percent to 52 percent of the children, respectively, to be in an unsafe situation, according to their parents. Noise sensitivities provoked some children to hurt themselves or others or led to accidental injuries. More than 40 percent of noise-sensitive children tried to run away from sounds that bothered them, and 1/4 tried to hide. An earlier study by IAN found that some children bolt to escape uncomfortable sensory experiences (Marina, 2016).

2.2 Autobiographies by people with ASD

People are generally able to adapt to varying levels of acoustics, although noises are annoying, but it will not result in painful feeling to common people. However, for ASD individuals, a slight variation of decibel may send them into a panic. Here we cite some passages from autobiography written by autistic people to feel the noise stimuli present in the environment from their perspective.

This sensitivity to noise in those with autism is vividly. explained by Temple Grandin, PhD, an individual with autism, she stated: *"When I was little, loud noises were also a problem, often feeling like a dentist's drill hitting a nerve. They actually caused pain. I was scared to death of balloons popping, because the sound was like an explosion in my ear. Minor noises that most people can tune out drove me to distraction. When I was in college, my roommate's hair dryer sounded like a jet plane taking off. Some of the sounds that are most disturbing to autistic children are the high-pitched, shrill noises made by electrical drills, blenders, saws, and vacuum cleaners. Echoes in school gymnasiums and bathrooms are difficult for people with autism to tolerate. The kinds of sounds that are most disturbing vary from person to person. A sound that caused me pain may be pleasurable to another child." (Grandin Temple, 2006).*

Some autistic people have difficulties to distinguish between foreground and background noises. Dumortier attended a lecture in a big room with excellent acoustics and a well-articulating speaker who talked clearly through the microphone. Nevertheless, she still could not follow it: *"I couldn't focus on her voice because another sound was dominating everything. A couple of tables behind me someone was clicking his pen, very slowly. For me, this sound was as much present as the speaker's voice"*. (Dumortier, 2002, p. 55)

3 The design of sound insulation for people with autism

We learned from the above that addressing acoustic sensitivity to sound is necessary when creating the environment that autistic patients will use. Considering that the corridors and waiting areas in the circulation space have different built environments and acoustic environments, and the sound insulation strategies that can be used in the two places are also different, we will discuss the two places separately.

3.1 Corridors sound insulation strategies

Corridors are busy areas in a hospital, and sound will spread along their length and into adjoining rooms. Due to their elongated shape, sound travels very fast and far and affects all rooms that are directly connected to the corridor, causing challenges for patients who are trying to wait, rest and talk with doctors. Much of the communication between staff happens in corridors, patients also communicate with accompanying persons in the corridor. The sound of speaking may be noise to other users. The transmission of sound in the corridor affects staff and users, not to mention ASD users who are very sensitive to sound. They may have unpredictable reactions and overreact to these sounds, such as screaming or crying.

Considering that the HBN series and NHS documents require that the prerequisite of the corridor space is the effective movement of people and medical equipment, the floor of the corridor must be made of hard materials. Since then, the main areas where sound insulation can be added are walls and ceilings.

(1) Sound-absorbing ceilings

Use a sound-absorbing ceiling with good absorption qualities and high efficiency in reducing sound propagation, reducing reverberation and increase speech intelligibility, potentially improving the psychosocial medical environment for patients and staffs.

We looked for companies specializing in improving acoustic design for buildings, including Saint-Gobain Ecophon (France) and Armstrong World Industries (America). We found on their website some sound-absorbing materials for ceilings that can be used in hospital corridors.

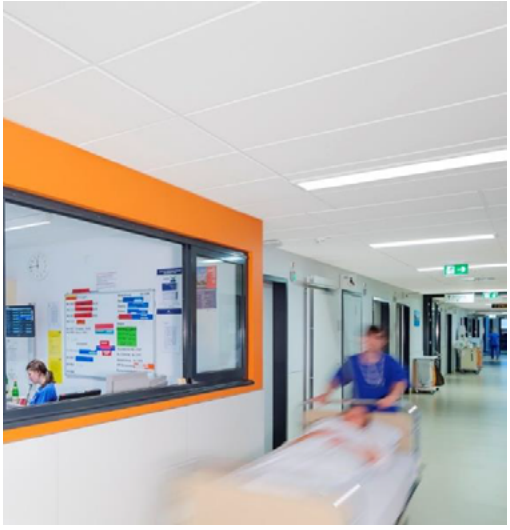


Figure 7.18 Sound-absorbing ceiling of Ecophon (Right)
(Source: https://www.ecophon.com/en/acoustic-solutions/healthcare/corridors-and-nurses-stations/)
Figure 7.19 Sound-absorbing ceiling of Armstrong (Left)
(Source: https://www.armstrongceilings.com/commercial/en-us/commercial-ceilings-walls/calla-health-zone-ceiling-tiles.html)

(2) Sound-absorbing wall construction

Wall construction is important for creating an appropriate acoustic environment. The construction of walls is difficult to change and improve, especially when the hospital has begun operation, therefore it should be carefully considered during the architectural design stage.

High quality sound insulation materials should be used in walls wherever possible, in order to reduce sound levels and sound propagation.

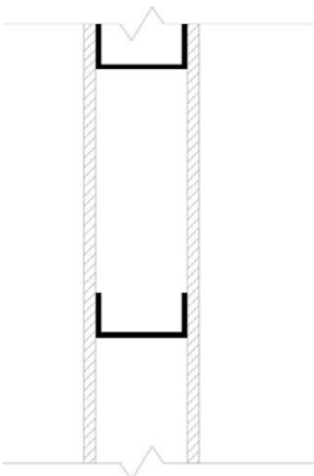


Figure 7.20 Poorly insulated wall
(Source: Gaines et al., 2017
Design for autism spectrum disorder/p.75)

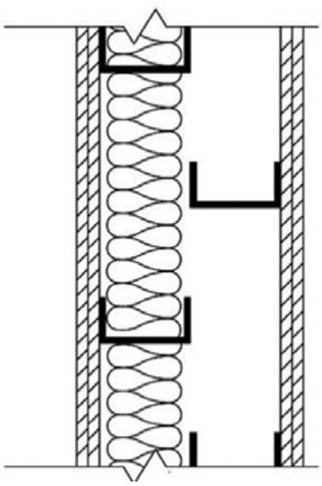


Figure 7.21 Well insulated wall
(Source: Gaines et al., 2017
Design for autism spectrum disorder/p.75)

(3) Easy-cleanable wall surface

Wall surface is also important for creating an appropriate acoustic environment. The sound-absorbing panel reduces the propagation of sound in the corridor by blocking the reflection of sounds. It is not recommended to use soft, uneasy-cleanable surface mounted materials in the corridor. Cover fiberglass or natural fiber wall panels with a thin, impermeable film (e.g., taffeta vinyl, polyvinyl fluoride) can be considered, it allows for easy cleaning in clinical areas of a hospital (Davenny, 2010).

(4) Floor materials

Carpeting in corridors may potentially create problems related to efficient movement of carts, trolley, bed, etc and cleanability, therefore is not recommended to use soft covering materials in this circulation space. The study of Davenny (2010) shows that when floor surface is made of rubber create less impact noise than others such as vinyl composition tile installed directly on concrete or terrazzo.

Compared to the use of concrete and ceramic tiles as flooring materials, the use of rubber can reduce noise generation as much as possible while ensuring effective movement. The use of ceramic tiles as a floor material creates another problem for ASD users. The high reflectivity make it easily generate reflections of natural light and artificial lighting, and form bright spots on the ground, which is a visual stimulation that will make autism users feel uncomfortable. As light spots can be clear seen in Figure 7.18 where ceramic tiles were used while there is no obvious glare in Figure 7.19 where matt materials is used for floor.

3.2 Waiting areas sound insulation strategies

The sound-absorbing ceiling, wall construction and surface materials with good sound insulation ability and the recommended floor materials that introduced above can also be applied to the waiting area. Since waiting area has different functions and sanitary requirements than corridors, besides people need a quieter space while waiting, more sound insulation strategies can be used in this space.

(5) Additional sound absorbing ceiling hanging

Waiting rooms have to be closed to reception desk where people can speak to a nurse or administrative staff. Patients and the staff should easily be able to have private conversations, not only without the risk of people overhearing, but also reduce the noise for other who are using waiting area. An additional sound absorbing ceiling hanging can be used above the reception desk to increase speech clarity and privacy, and in waiting area to absorb the noise produced inside.

(6) Sound-absorbing wall surface

Waiting areas are non-clinical areas of a hospital where regular cleaning is not required, sound-absorbing panel can be installed on the surface to insulate external noise (e.g., huge movement sounds from corridor) and absorb inside noise (e.g., conversation sounds). Fabric-wrapped wall panels, surface-mounted wall panels or other sound-absorbing wall materials effectively absorb noise from common activities in healthcare environments, especially in large areas where noise tends to build up (Davenny, 2010).

(7) Floor coverings

Soft carpets can effectively reduce impact noise (e.g., foot traffic, conversation sound) in waiting area. The selection of coverings needs to be attention, materials with high pattern should be avoided because it will cause visual stimulation to ASD users.

(8) Sound protection of legs of furniture

Movable furniture such as tables, chairs and sofas are not recommended because their flexibility makes them easy to be moved by ASD people and served as footstool for climbing, which is extremely dangerous. This is about safety issue and will be described in detail in 09. Furniture.

If some temporarily placed furniture appears in the corridors and waiting areas, the furniture in contact with the ground can be wrapped with soft materials to reduce the noise generated by moving furniture. Kristi introduces the Rio Grande High School in her book. As can be seen from the Figure 7.23, the school's classrooms use hard floor materials without carpets. The strategy they used was to attach tennis to the legs of chairs to reduce the noise caused by friction.


Figure 7.22 Additional sound absorbing ceiling hanging in waiting area (Left)
(Source: Acoustic solutions for healthcare building designed by Ecophon)
Figure 7.23 Chairs with tennis balls attached to the legs reduce noise (Right)
(Source: Kristi Gaines, 2017. Design for autism spectrum disorder/p.74)

(9) Noises from equipment

Common equipment

The hum noises from the equipment have been reported as a great interference that troubles many people with autism. Common equipment in hospitals, such as the HVAC system (machinery of heating, ventilation and air conditioning) should not produce continuous low noises. These sounds can stimulate their sense of hearing and makes them feel uncomfortable and even painful. Fans shouldn't be used for cooling and ventilation as much as possible, it not only generates humming noise, the continuously rotating fan blades are also a visual disturbance.

Communication devices

There are various types of medical communication devices in the hospital, which can transfer medical information to patients or be used for calling between medical staff, such as loudspeaker, audio systems and next patient "call". These suddenly appear and sharp sounds may frighten autistic people in space. Use partitioned call systems whenever possible to make important announcements reach in a particular doctor or department and don't disturb patients who are recovering and waiting in a different area of the building. When it is possible, use a simple screen instead of loudspeaker or audio to show the information about the next patient and the number of people in the queue, which can effectively reduce loud noise interference. When the loudspeaker is unavoidable, the use of slow-in, gentle and noise-free sound broadcast information can reduce the acoustic stimulus of sound to autistic people, help them to hear the information clearly as well.

Alarm

Alarm is used to remind emergency, and the sound is usually sudden and sharp. Not only autistic people, also ordinary people feel uncomfortable with this noise. But due to its function, the alarm sound cannot be eliminated in the hospital space. What we can do is to minimize the negative impact on ASD users when he happens. Architectural design strategies such as quiet areas away from noise sources and acoustical environment decisions such as specifying quieter alarms and machines can aid in reducing noise levels in hospitals (Sánchez, et al. 2008). Davenny (2010) suggested to use alarms with variable volumes, with loudness indicating the urgency of the problem. Placing alarm not closed to waiting area is recommended whenever possible to protect ASD users from harmful sensory stimuli.

3.3 Sound covering and distraction strategies

(10) Background music

Music and rhythm are well-known tools that make people feel good. When people stay in the healthcare building, the atmosphere or mood is relatively serious. Healthcare music improves both staffs and patient experiences when smooth music plays when people are waiting. The sound of music can cover small noises in the space, and it can help distract ASD users, so that they can pay less attention to the sounds of relatively small produced by peoples' walking and talking.

(11) Interactive technologies

Several interactive technologies have been developed for teaching and treating ASD children, often used in schools and autism treatment centres. Studies have shown that ASD children may focus on the interaction with these programs and ignore the surrounding sensory stimuli. Many children's hospitals provide a wall with interactive program in the reception hall or waiting room to help children spend the long waiting time here. Various interactive technologies that can be used in a medical environment will be introduced at 11. Assist technology in detail.

(12) Escape space

Many sounds are present in hospital environments, including those from beepers, alarms, machines, rolling carts, HVAC systems, and other sources. They can be severely irritating and at times harmful to people with autism in this space. Functional sounds like sharp alarms for emergency cannot be eliminated from the source, loud noise is generated when beds and trolleys are quickly pushed across the corridor. Although we try to minimize the generation of noise from architectural design, sometimes some noises are inevitable, what we can do is to minimize negative impact on ASD users when it happens.

Authors, such as Mostafa (2008) and Khare and Mullick (2008), Beaver (2006) suggested to provide an escape space for people with autism which can help they deal with sensory overload. Hiding into space helps them to be calm when they are unable to bear the surrounding sensory stimuli. There are many forms of escape space. It is characterized as a relative smallness and private space, and has been used in many children's hospitals, such as Nemours children's hospital in Orlando. The form they used was to inlay a square or irregularly shaped space in the wall, it is not only an escape space for ASD children, but also an interesting area for all children. The detailed information about escape space will be introduced at 12. Escape space.

4 Summary of sound insulation aids for ASD users

The challenge for an ASD-friendly built environment is minimize ubiquitous noise in the space, the following strategies will contribute to provide a fewer acoustic stimuli indoor environment. First of all, the key concept is to provide a quiet interior environment from the perspective of architectural design, this can be achieved by adding sound-absorbing materials to the ceiling, wall and floor and providing sound protection for the movement of furniture. Secondly, background music and interactive program can be used as a positive distraction. ASD users may focus on music or games while distract attention from noise in the space. Finally, an escape space is suggested to be added to the space, people with autism can hide themselves in this relatively private space when they cannot afford some unavoidable noise in the space.

Highlights:

- √ Sound absorbing solution on building structure: ceilings, walls, floors.
- √ Sound protection on furniture
- √ The reducing of noises from equipment
- √ The use of sound covering and distraction

Figure 7.24 Escape space in waiting area of Nemours children's hospital in Orlando
(Source: https://www.architectmagazine.com/project-gallery/nemours-childrens-hospital_1)

5 Design considerations of ASD-friendly hospital environment

Corridor

- Sound-absorbing ceiling with good absorption qualities
- Wall construction with sound insulation materials.
- Wall surface with sound-absorbing panel can be considered, but cleanability should be priority. When needed, impermeable film should be added to cover the surface mounted materials for easy cleaning.
- Matt materials (e.g., rubber) are recommended instead of concrete and ceramic tiles as flooring materials.
- Fixed furniture is recommended, if there are some temporary furniture in corridors, the bottom of the furniture (e.g., legs of chairs and table) should be wrapped with soft materials.
- Alarms can be placed in remote locations at reception desks.
- Interactive technologies can be provided when it is possible in corridors.
- Escape space (e.g., inlay space in the wall) can be provided in corridors.

Waiting area

- Sound-absorbing ceiling with good absorption qualities
- An additional sound absorbing ceiling hanging can be used above the reception desk and in waiting area.
- Wall construction with sound insulation materials.
- Wall surface with sound-absorbing panel.
- Soft coverings are recommended, if there are no carpets in waiting areas, matt materials (e.g., rubber) are recommended instead of concrete and ceramic tiles as flooring materials.
- Fixed furniture is recommended, if there are some temporary furniture in waiting area, the bottom of the furniture (e.g., legs of chairs and table) should be wrapped with soft materials.
- Alarms can be placed in remote locations at reception desks.
- Background music can be provided in waiting areas.
- Interactive technologies can be provided in waiting areas.
- Escape space (e.g., recessed space in the wall) can be provided in waiting areas.

04. Colour

Of all the human senses, vision is a very powerful sensory in providing information about the world around us. The visual senses provide us with information about the world around us, not only physical information about the shape, size, and colour of objects, but also the feelings of comfort, security, stimulation, and much more. Colour is a very important factor that affects the visual environment. The correct use of colour can help people make sense of their surroundings to enhance the sense of spatial hierarchy, assist space navigation, and create a comfortable indoor environment.

1 The use of colour in hospital environment

The colour white and green is mainly used in hospitals, the reason behind it is that white is a calm colour. White colour is related to purity, innocence and virginity, safe and clean. Green means the colour of life, freshness, safety, and environment. Of course, not only these two colours, many colours are widely used in hospitals. Various colours are used on walls, floors, furniture and decorations to make the indoor environment delicate and vivid. In addition to be decorations, colours are also functional and used in wayfinding system, distinguishing different space functions and reminders of danger. Many people can benefit from the above functions of colour, but it also puts pressure on some visually sensitive people, such as people with autism.

Colour in corridor
- Floor and wall finishes
- Wayfinding signposts
- Furniture (doors, handrails, etc.)
- Decorations

Colour in waiting area
- Floor and wall finishes
- Visual cues
- Furniture (chairs, tables, carpets, curtain)
- Decoration (especially artworks)

2 Visual stimuli (colour) to people with ASD

2.1 Hyper- and hypo-vision

Our sight helps us to define objects, people, colours, contrast, and spatial boundaries. People with autism have difficulty in feeling the world by using sight as a tool. Autistic people with a hyper-vision can see the stuff that normal can't feel or usually ignore while people with hypo-vision can only identify the outline of objects. Following Table X.X lists the common symptoms of individuals with ASD when facing various colour stimuli.

Table 7.3 Visual stimuli --- colour
Hyper-vision
• Sensitive to colours, especially bright ones; • Can't bear too many colours in sight • Responds to appearance of certain objects or colours by disruptive behaviours.
Hypo-vision
• Fascinated with reflections and bright coloured objects • Has trouble in figuring out the objects, as they only see just dark and outlines; • Unable to locate desired targets and identify a figure from the background;

2.2 Research on colour perception on children with autism

Anna Franklin et al. (2008) design two experiments to examined colour perception in children with autism. The result indicated that the colour memory and search accuracy of children with autism were significantly lower than children with cognitive abilities and age matched. Children with autism are less accurate than the control group children when they detect coloured targets on a coloured background.

The perception of colours by people with autism differ from the neurotypicals due to the defect in their sight because of chemical imbalances and neural deficiencies (Creedon, 2006). Therefore, most of the autistic children see colours with greater intensity than neurotypical people. For these group of people, red appears nearly fluorescent, vibrating with intensity. A small proportion of the children (children on the lower scale of the autism spectrum) see the colour as neurotypical children do and 5% of them see muted colours, they perceive every colour as grey. (Creedon, 2006).

Grandgeorge and Masataka (2016) investigated colour preference in children with autism spectrum disorder, 29 boys with ASD and 38 age-matched typically developing (TD) boys were studied regarding their preference among six colours: red, pink, yellow, brown, green, and blue, in clinical settings. They found that children with ASD were certainly likely to avoid yellow and, conversely, to favour green and brown. In order to explain these results, authors proposed that yellow colour had the highest luminance value among the colours tested. The observed aversion to this colour might reflect hyper-sensitivity of children with ASD to luminance. The perception of yellow is bearable for TD children but could be sensory overloaded for children with ASD whose sensitivity to sensory stimulation is enhanced.

Woodcock et al. completed the study about identifying differences between "lower function" and "higher function" children on the spectrum. Their findings revealed that children with lower functioning prefer red, round shapes, and low sound equipment while children with higher functioning prefer blue and round shape. The built environment is not "one rule fits all", the built environment should allow vulnerable groups to use indoor spaces without barriers and maximize flexibility to meet the preferences and needs of different groups

Visual impairments of colours to ASD children

- The ability of ASD children colour memory and search accuracy are relatively low, they cannot detect coloured targets on a coloured background accurately.
- The bright colour with high luminance value, such as red and yellow are unbearable to children with autism.
- A small proportion of the children perceive every colour as grey.
- Personal needs and preferences are also important considerations.

2.3 See the world in their eyes

Based on research on various visual stimuli in environment to people with autism, we try to simulate the views in their eyes in order to have a more intuitive cognition about the research results.

The view in our eyes | "Bright world" hyper group see

Figure 7.25 The view in common people's eyes compared to hypersensitive people (Source: by author)

The view in our eyes | "Grey world" hypo group see

Figure 7.26 The view in common people's eyes compared to hyposensitive people (Source: by author)

2.4 Autobiographies by people with ASD

A 33-year-old autistic people shared his experience of growing up with autism on a blog. He wrote: *When I see colourful things, I get overloaded. My eyes get strained and achy, my vision gets blurry, I get headaches, even migraines, I get dizzy. The severity of these symptoms varies depending on a variety of factors. But I can't ever look at colourful things and just enjoy it. It's always at the very least an exhausting experience. I can see the beauty in certain colourful things. Sadly it's always overshadowed by the harm it causes me.*

He showed on his blog the colour scheme in the space he needed and what the world is like:

What people with autism needs?

What the world is like:

Figure 7.27 The colourful world compared to the colour scheme that autistic people need (Source: Anonymous blogger, https://autistictic.com/2019/02/12/color-hypersensitivity/)

The accessibility of the hospital's colours was pointed out by him seriously in Blog, for him it was helpless and painful to use medical assistance in a sensory overloaded environment. he said:" *I understand that many people love colour. For most it makes places more inviting, friendlier, and that's perfectly valid. So I avoid the world as much as I can. However, there are things I can't simply avoid. Especially anything related to health care like doctor's offices, hospitals, and therapy and treatment centres of any kind. Finding accessible places to get healthcare is difficult. And if I have to be in a harmful environment, I will likely suffer physical harm because of it. I do wish I could just enjoy colour. But I can't. Maybe this can help people understand. It would mean so much to me if people could be mindful of how they use colour. Especially in official and professional contexts meant to be accessible.* (Anonymous blogger)

3 The design of colour for people with autism

HBN and NHS documents state that colour design in hospital needs to reflect the wide range of their users. Some key considerations were listed to help elder people, people with visual impairments, people in wheelchair and young people have a better visiting experience in hospital. Although the ASD population is not specifically marked in the documents, some colour design considerations, especially strategies related to visual impairment people, can be generalized. But it's widely known that people with autism are more sensitive to colour, bright colours can be painful or distracting for the visually hypersensitive ASD people. Therefore, some additional requirements need to be discussed to create an ASD friendly hospital space.

From the previous literature we already know that people with autism are sensitive to sensory stimuli, colour is great influencing factors of visual stimuli in hospital space. We try to find some colour design strategies that can eliminate colour disturbance to ASD while providing non-institution and low sensory stimuli environment.

3.1 Neutral colour scheme

Beaver (2006) stated colour palette should be chosen to provide a pleasant environment, but not over stimulating. Soft and cool colours can help with calm down. Other authors Humphrey (2008), Vogel (2008), Khare and Mullick (2009) all proposed that a neutral and calming colour scheme is recommended for an ASD-friendly built environment.

Mostafa proposed a colour palette in the article she published in 2018, she suggested using a neutral consistent colour palette throughout the school that her team evaluated. She also recommended that subtle, neutral colours can be used to help support navigation.

GA architects focus on projects related to people with special needs, especially for autism friendly architecture. They have proposed several ASD-friendly design considerations, considering about colour, they suggested that low arousal colour should be chosen for interior, without complicated or fussy patterns. Bright colour as red and orange should be avoided, In the meanwhile the surface shouldn't have high reflection.

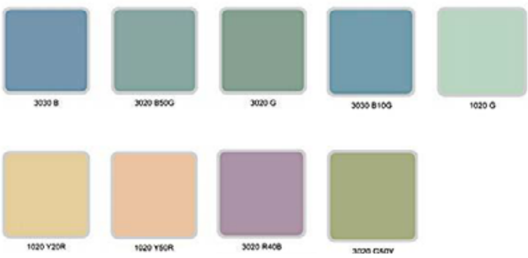


Figure 7.28 Colour palette proposed by Mostafa
(Source: Mostafa, 2018)

Figure7.29 Colour palette proposed by GA architects
(Source: www.autism-architects.com/autism-friendly-design)

3.2 The use of colour contrast

People usually don't like over-saturated colour spaces or monotonous, colourless space. The HBN documents also recommends painting floor finishes and wall surfaces in different colours to make the space hierarchy clearer. Large areas with white, light green and light blue commonly used in hospitals will make the hospital environment a very serious atmosphere, which is unfriendly for autistic patients, especially children. Most studies have shown that light, warm and home feeling environment is welcomed by autistic people.

Colour contrast is often used to make architectural elements that need to be noticed more obvious, such as different colours for the furniture and background wall in the waiting area. It will contribute to help ASD users detect the architectural elements they need to use. For example, as shown in FigureX.XX, some ASD users may be unable to find the existence of the handrails when it is coloured in the same colour with background walls. And in FigureX.XX, the handrails, doors, and artwork hanging on the walls are all distinguished from the colour of the overall background environment, which makes them easy to be found.

It is important to pay attention to avoid using bright colours (e.g., red and yellow) when increasing colour contrast, which will cause discomfort for ASD users. And there should not be too many colours in the space, the colourful interior space is chaotic and unacceptable for ASD users.

✗ Colourless space

√ The correct use of colour contrast

Figure 7.30 Colourless corridor, fittings on the wall can't be noticed clearly (Left)
(Source: https://www.behance.net/gallery/41578249/UNIMED-SHOPPING-TOTAL)
Figure 7.31 The use of contrast colour makes architectural elements obvious (Right)
(Source: https://www.pinterest.co.uk/tatit2508/hospital-design/)

3.3 Avoid colour visual stimuli

(1) No bright colours

We have introduced that because of the enhanced visual sensory of people with autism, they are extremely sensitive to bright colours and can cause discomfort and pain. So bright colours should be avoided, especially red and yellow, which have been proven to be intolerable for children with autism.

Paula Ables is an interior architecture designer, she posted on her website about the suggestion of the use of colour in autism friendly environments. Bright colours can be replaced by a slightly lighter colour of the same colour series, as shown below figure.

Figure 7.32 Lighter colours in the same colour series
(Source: Paula Ables, http://paulaablesinteriors.com/)

(2) No overnumbered colours

The interior decoration in the hospital space should avoid using too many colours as possible. As the anonymous blogger with autism said, the colourful world is loved by many people, but it makes him feel headache and painful. Especially the hospital, which is a building related to health care service, the colour scheme of interior decoration needs to be inclusive and provide a comfortable built environment for all users.

(3) No dense pattern materials

It is generally accepted that low arousal colour should be used for interior decoration and high patterned materials should be avoided. Soft furnishings should also be kept fairly plain. Walls, floor covering, tiles, and curtains decorated with dense patterns (e.g., geometric pattern) can raise the possibility of keeping their eyes on these patterns and causing dizziness. Patterned floors can be confusing to walk across and may increase anxiety or cause people to become fixated.

✗ Intricate decorative pattern

✗ Dense geometric pattern

Figure 7.33 Examples of dense pattern materials
(Source: images collected from websites)

4 Discussion of colour aids for ASD users

Many studies have focused on children as research targets and discussion how to design friendly school and home built environments for children with autism. However, we think that some research results can be extended to healthcare buildings, because the impact of colour on autism population will exist in various spaces.

The preference for colour schemes much depends on the different preferences of individuals, as some people like pink and some people like yellow. When Beaver was designing a home environment for people with autism, he thought it was a good idea to encourage people to choose the colour for their room from an approved range, since there are neutral colours, calming colours, disturbing and stimulating colour (Beaver, 2008). Temple Grandin (2006) reveals in her autobiography, that she enjoyed having bright colours in her classrooms, but these colours may be too stimulating for other ASD people. Considering hospitals, a large public building with complex functions, the colour design should not be based on the preferences of individuals or some groups, therefore an inclusive colour scheme should be first choice. Calming environment is a comfortable and welcomed for most users.

Highlights:

√ Neutral and calm colour scheme
√ Contrast colour to enhance architecture information
✗ Bright colours
✗ Overnumbered colours
✗ Dense pattern materials

5 Design considerations of ASD-friendly hospital environment

Corridor

- Neutral and calming colour scheme should be used for reducing visual stimuli of ASD users. A well colour scheme can contribute to a non-institution atmosphere.
- All finishing materials, including floors, walls, fittings, noticeboards and wayfinding signposts in corridor should be in harmony colour.
- Similar colour and monochromatic colour schemes should be avoided. (Monochromatic colour, such as blue and light blue)
- Light colours are recommended because it can reflect illuminance and make the space brighter
- Limit the number of colours in corridor, a lot of differing colours may lead to visual confusion
- When using contrast colour, try to avoid bright colours as red and orange. If in some unavoidable situation, such as bright colour for emergency signs, appropriately reduce the saturation of bright colours. For example, use red instead of bright red, yellow instead of bright yellow.
- Floor colours should contrast visually with wall colours.
- Large areas of strong colour should be used cautiously, especially strong and bright colour should be avoided.
- Colour coding can be used to get a clear space hierarchy, but don't let colour dominate the visual environment. One wall or lower part of the wall in corridor can be coloured to indicate function, instead of colouring the whole corridor which will increase the "tunnel effects" of corridors.
- Building elements as lifts, stairs, doors and non-public areas can be highlighted in contrast colour.
- Corridor fittings as light switches, litter bins, handrails and crash rails should be highlighted in contrast colour with background.
- Consider coloured handrails attached to a wall at waist height, colour contrast at dado-rail height and use colour-coding on floors.
- Highly patterned materials should be avoided.
- Reflective materials should be avoided.

Waiting area

- Neutral and calming colour scheme should be used for low visual stimuli of ASD users. A well colour scheme can contribute to a non-institution atmosphere.
- All finishing materials, including floors, walls, fittings, noticeboards and wayfinding signposts in corridor should be in harmony colour.
- Similar colour and monochromatic colour schemes should be avoided. (Monochromatic colour, such as blue and light blue)
- Light colours are recommended because it can reflect illuminance and make the space brighter
- Limit the number of colours in waiting area, a lot of differing colours may lead to visual confusion
- When using contrast colour, try to avoid bright colours as red and orange. If in some unavoidable situation, such as bright colour for emergency signs, appropriately reduce the saturation of bright colours. For example, use red instead of bright red, yellow instead of bright yellow.
- Floor colours should contrast visually with wall colours. In waiting area, light and warm colours can be used for floor and subtle greyed tones for walls as a backdrop to stronger colours for chair. Bright colour for chairs and other furniture should be avoided.
- Large areas of strong colour should be used cautiously, especially strong and bright colour should be avoided.
- Colour coding can be used to get a clear space hierarchy, but don’t let colour dominate the visual environment. The door, or part of the wall and floor in entrance can be coloured to indicate function, instead of colouring the whole waiting space.
- Fittings on the wall, such as light switches, should be highlighted in contrast colour with background.
- Highly patterned materials should be avoided.
- Reflective materials should be avoided.

05. Lighting

The light requirements in NHS documents are consistent with ASD-friendly considerations basically. By referring to these requirements, a well level of light with no glare interior environment can be provided, also with natural light and connection of outside view. The challenge for ASD users is the uncertainty in the space. For them, a controllable built environment is particularly important, the vision reveals what the touch already knows.

1 Visual stimuli (lighting) to people with ASD

1.1 Hyper- and hypo-vision

Sight is the sensory system that one uses to see their surroundings, such as nature, objects, and people. For individuals that exhibit visual impairments, it can be incredibly disruptive and challenging to cope with lighting in a public building.

Individuals on the spectrum with hyper-vision may notice everything in the environment and intensely focus on the most minute of visual details, often feel overwhelming by effects of surrounding environment. Contrary to them, hypo-vision people usually have difficulties with possessing visual issues. Those group of people may disregard people and objects in the environment, as if they are not there at all, or only see the outlines of objects. Some individuals may enjoy bright colours and bright lights, which would be overwhelming, even terrifying for an individual with visual hyper-sensitivity. In the hospital space, we try to balance the different needs of hypo-vision and hyper-vision people for the lighting environment to ensure that everyone can use medical services comfortably. Following Table 7.4 lists the common symptoms of individuals with ASD when facing various lighting stimuli.

Table 7.4 Visual stimuli --- lighting
Hyper-vision
• Dislikes bright lights and sunlight; • May be frightened by sharp flashes of light, • Easily distracted by fluorescence lighting, can see a 60-cycle flickers of lights; • Responds to appearance of glare lighting by disruptive behaviours;
Hypo-vision
• May be fascinated with bright lights, reflections and glare; • May stare at the sun or a bright light bulb.

1.2 Impacts of lighting stimuli on ASD users

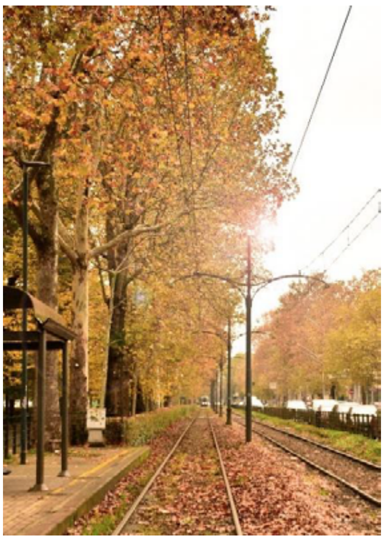
In the perspective view of ASD users, bright lighting can make environment visually-disorienting then may provoke their strong or painful responses to light. This is further compounded by the intensity of the light, the specific wavelengths and any harsh glare. As a result, the brain becomes confused, hindering one's ability to process light stimuli. (Robin, 2013)

Certain types of lighting, specifically fluorescent lighting, has been shown to have a particularly negative affect on individuals with autism. Approximately half of autistic individuals experience a severe sensitivity to fluorescent lighting. One study found that the use of fluorescent lighting increased the stereotypical repetitive behaviours of children with autism, which may be attributed to a hypersensitivity to fluorescent light flicker (Coulter, 2009).

1.3 See the world in their eyes

Based on research on visual sensitivities of people with autism, we try to simulate the views in their eyes in order to have a more intuitive acknowledge about the research results. From the perspective of ASD users, the bright light leads to sight blurred, however, artificial lights can be seen everywhere in hospital, it is necessary to reduce glare and material reflection from architectural design.

The view in our eyes



The “glare” hyper group see

Figure 7.34 The glare in common people’s eyes compared to hypersensitive people (Source: by author)

Lighting stimuli:

- ✗ Fluorescent lighting
- ✗ Bright light
- ✗ Harsh glare

Lighting stimuli may cause:

- Blurred sight
- Painful feeling
- Stereotypical and repetitive behaviours

2 The design of lighting for people with autism

2.1 Natural lighting and windows

All forms of light in an environment can be categorized as either natural or artificial light. However, natural lighting is much uncontrollable elements to built environment. For example, it can be affected by weather and time of the day. Sometime strong natural lighting can cause glaring, especially in sunny day. In the other hand, natural lighting may can't meet the illuminance level when it is cloud. Most people prefer ample amounts of natural light in a space but a space with multiple windows that do not have any window treatments, or any means to control the light, would be useless and undesirable (Kristi 2017).

As mentioned in HBN, curtains, fitting blinds or external screens can be used to control the amount of sunlight, these objects can appropriately diminish visually distracting from outside views, which effectively make the space controllable. Moreover, considering about some window coverings, curtains or blinds, may create what is described as "pattern glare." (Winterbottom et al. 2009). A glazed or frosted glass are recommended which can allow natural light to enter the space without creating sharp shadows or glare and will also diminish visually distracting views (Humphreys Lee, 2005).

Having too many windows in a space is also likely to result in an overabundance of natural light that is sometimes difficult to control lighting and outside information input. Therefore in the circulation space of hospital, the number of windows needs be considered carefully, it is vital to get a balance between natural lighting, outside view and visual distraction. The corridor of the hospital should pay special attention to the design of the windows.

The following image (left) shows the huge light spot formed by a window at the end of the corridor in an ordinary person's perspective, and the images (right) is that we simulate the views that a visually sensitive ASD user may see.

Figure 7.35 The glare in common people's eyes compared to hypersensitive people (Source: by author)

Windows in corridor:

• Windows are recommended in corridors wherever possible, but the number should be controlled.

• Windows should not be placed at the end of the corridor where can easily cause glare, like a very bright spot at the end of a long tunnel. (See in Figure 7.35)

• Windows should be with inside treatment (e.g., curtains and blinds) and outside treatment (e.g., sunshade and screens), frosted glass can be the alternative choice.

Windows in waiting area:

• Windows are recommended in waiting areas wherever possible, sunlight input need to be controlled by the position and scale of windows.

• Windows should be with inside treatment (e.g., curtains and blinds) and outside treatment (e.g., sunshade and screens), frosted glass can be the alternative choice.

2.2 Controllable artificial light

(1) Lighting without flickers

Most fluorescent light sources cause flicker. Kuller and Laike (1998) said that some of this flicker is not consciously perceived by most people, it can still cause headaches and eye strain and reduce academic performance. Eye strain can eventually negatively affect sleep patterns. They concluded that children may be more sensitive to flicker than adults, so high-frequency fluorescent ballasts that do not flicker should be used.

(2) Indirect light

Downward lighting should be avoided as much as possible, especially in circulation spaces, not just ASD patients, all patients will feel glaring and dizzy when they lay in bed through a corridor with direct lights.

(3) Colour temperature --- A “soft warm” lighting

Winterbottom and Wilkins examined classroom lighting in UK schools (normal school), identified that lights with a colour temperature of 3500K as being preferred in classrooms for students. Teachers reportedly favour soft lighting because they observe more relaxed behaviour and better academic focus under dim lighting. Although this paper didn’t research on ASD children, we thought that his findings provide us with useful information, and we will use them to discuss.

Angela Bourne (2013) observed that in a home for seven men with autism, the men preferred to keep the light levels very low. They also kept their blinds closed in their bedrooms and partially closed in the living areas. It appeared that they did not like brightly lit spaces.

But this does not mean that everyone likes warm colour and dim lighting space. Light intensity and colour temperature, just like colour, depends on preferences of individuals. For hospital buildings, an inclusive colour temperature should be first choice, and should not be based on the preferences of individuals or some groups. A light with a correlated colour temperature (CCT) of 4000K is recommended in HBN requirement. From the research we know that CCT of 3000K-3500K colour can emit a “soft warm” light, which is considered can be good in both physical environment and psychological atmosphere. In many studies on the effects of light on people with autism, they have mentioned to provide them with a non-institutional, soft and home feeling atmosphere as much as possible. We thought that correlated colour temperature between 3000-4000K, a soft white light with a bit warm feeling, can create a comfortable and calm environment, which is friendly to all kinds of users in the hospital. The most important thing is to avoid the glare caused by natural lighting and artificial lighting.

Application of colour temperature in hospital’s circulation space

Very warm: CCT around 2700, such light provides an overly warm environment which is not suitable for public spaces in hospitals. Working under strong light colours may lead to misjudgement of colour in paper.

Warm: CCT around 3000K, is often used in autism-friendly schools and home environments, which can create a home feeling atmosphere, has proven to be a welcome lighting colour for most autistic people. Such colour is without very strong colour aggressiveness, also suitable for using in public spaces of hospitals.

Soft warm: CCT around 3500K, is a softer colour. This colour is felt towards natural light, making the overall environment relaxed. It is suitable for the hospital environment and welcomed by ASD users.

Natural white: CCT around 4000K, is a light colour usually used in work environment. This natural and neutral colour create a very calm environment that helps people focus on work or study, also suitable for treatment environment and working environment in hospitals, but for ASD users, it is a little bit serious.

Cool white: CCT around 6000K, such light creates a space environment that seems without any emotions. Few studies have proven children or adults with autism like to be involved in such cool and serious atmosphere.

Meaning of icons in following figure:

✗ Means it is neither suitable for hospital space nor for ASD users.

√ Means it is suitable for circulation space of hospital while are acceptable by ASD users.

√ √ Means it is both suitable for circulation space of hospital and welcomed by children and adults with autism.

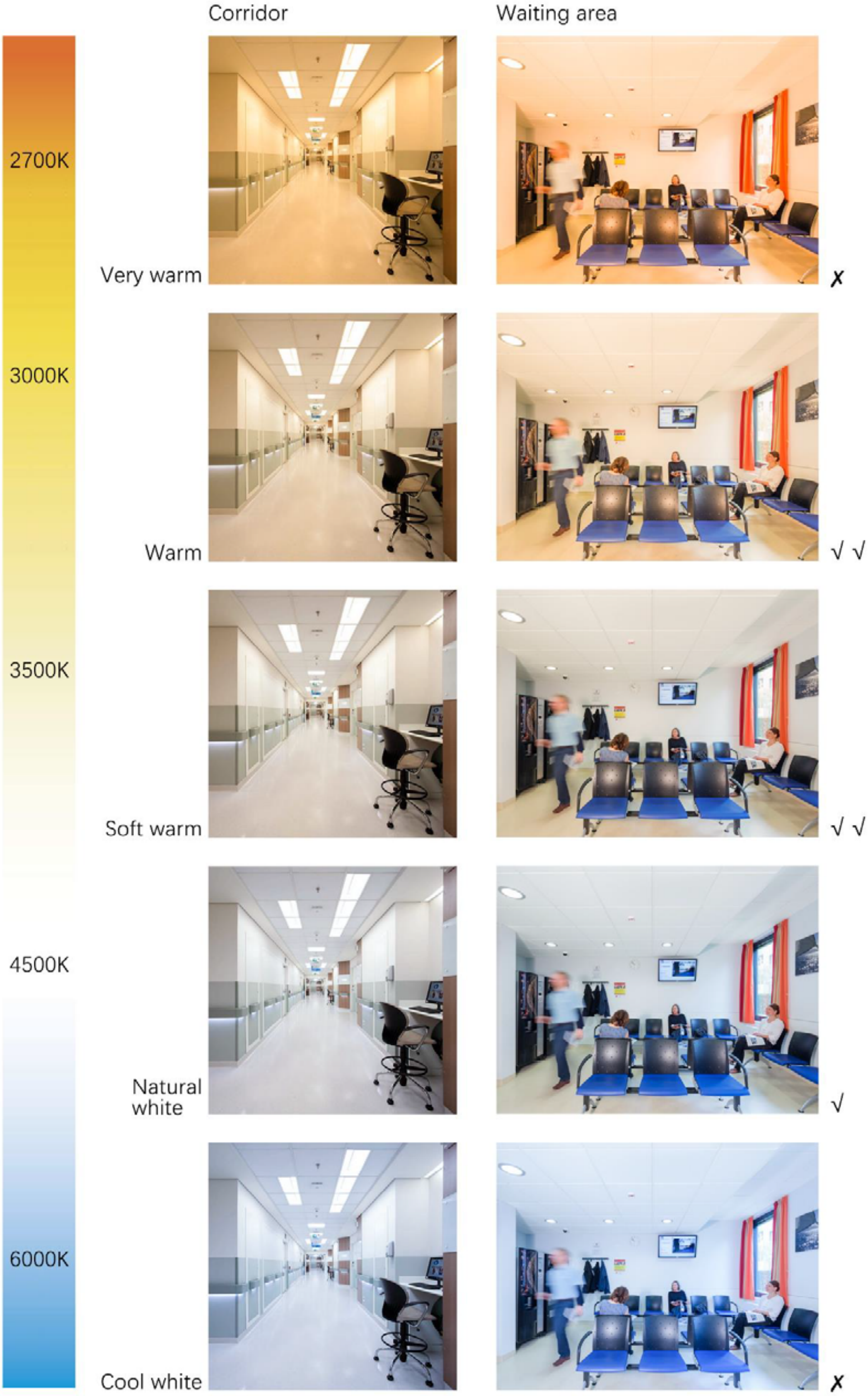


Figure 7.36 Comparison of effects of light with different colour temperatures in the circulation space
(Source: Images from website, edited by author)

(4) The use of adjustable lighting

- **Brightness adjustable lighting for circulation space**

HBN has emphasized the importance of lights with adjustable light intensity. Because relatively low light levels are required at night, dimming or step-switching can be used to reduce corridor lighting at night. Adjustable light is also very important for ASD-friendly space. Light level can be appropriately increased or decreased when some ASD users cannot accept the current light level.

- **Brightness and colour adjustable in some special space**

More modern Snoezelen rooms and autism therapy room has a program to change colour of lighting and can be controlled to meet the needs of the students. When in operation, the sensory room lighting emits a variety of colours and shapes that engage students' senses and enable them to manage their sensory sensitivities. The sensory space allows the entire space to be flooded with a preferred colour of light that may be changed based on individual preferences.

Considering the different needs of individuals for light and the overall hospital environment, we do not recommend the use of warm or cold light in a large area in the circulation space. However, a dimmable and changeable luminaire that colour temperature and light intensity can be controlled, can be used in some small spaces, such as the "Escape space" designed for ASD users, reading area, interactive area and other relatively private small areas, This controllable light can help ASD users better adapt to the hospital environment and enrich their space experience For example, a hypersensitive ASD user can dim the brightness of a small space when he come here to wait; when a hyposensitive ASD child is waiting for a parent in the play area, a colour light can provide a better space experience and pass the boring waiting time. This is like "Task illuminance" which means different illumination for different tasks is equally important in HBN. Different intensity and colour of light can be used for different group of people. Besides, In the same space, the difference colour and brightness of light can also make the spatial hierarchy clearer.

Shown in the Figure 7.37 is an interactive game area that can be placed in corridors and waiting areas. Interaction with the game can help distract attention from sensory stimuli in the space. This area is designed as a recess in the wall. The surrounding structure blocks the light so that it has a relatively dim light environment, which is suitable for some autistic users who prefer a dark environment. Adjustable light can be provided in this place, colour temperature ranges from warm light such as yellow, orange, pink to cold light such as white, green, blue, etc while the intensity ranges from dim to bright to meet different needs of individuals.

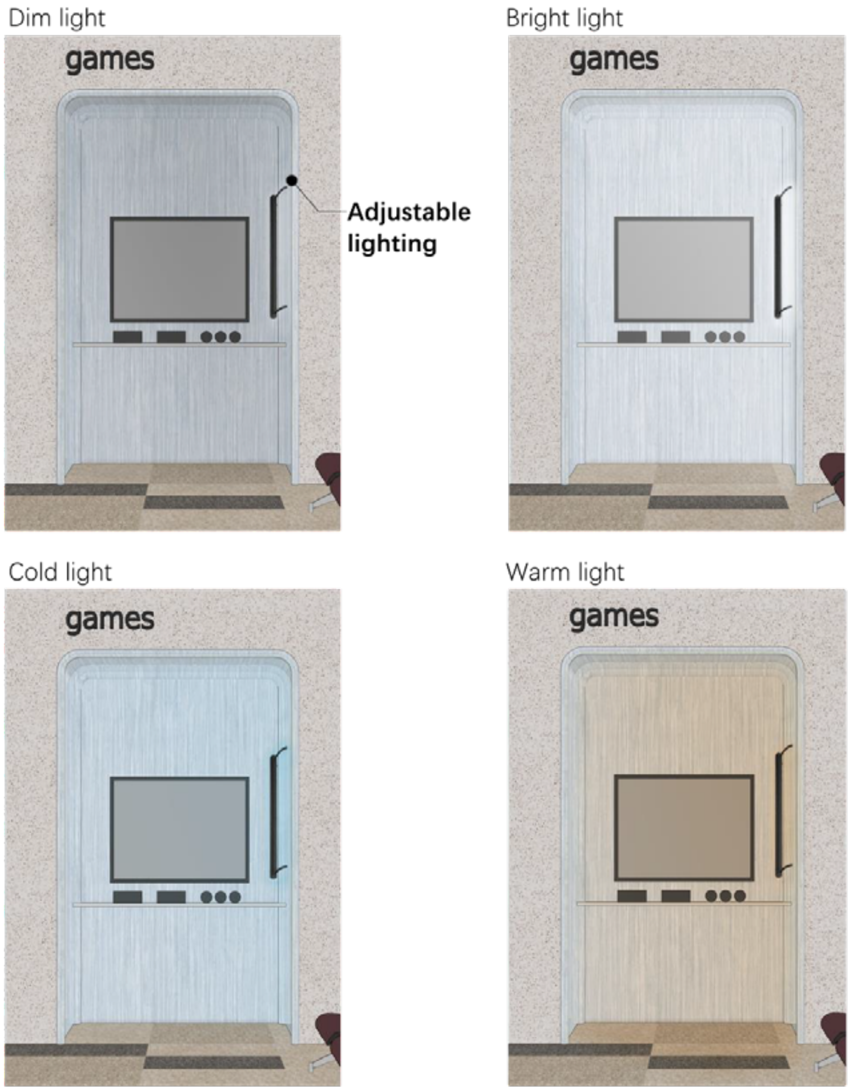


Figure 7.37 Brightness and colour adjustable lighting in an interactive game area (Source: by author)

(5) Avoid lighting with visual stimulating colours

As we already discussed in "02. Colour" part., due to the impairment of sight, some ASD people cannot accept bright colours like red. Creedon (2006) research shows that only a small number of ASD children have the same colour perception ability with normal children, 5% ASD children perceive every colour as grey. Light and colour are complementary, so we thought that when considering the colour of light, we should also pay attention to the usage of red light that may cause visual stimuli to some ASD users.

2.3 Glare and reflection

Glare occurs when one area of the visual environment is brighter than the general brightness of the rest of the environment. (Winterbottom et al. 2009). Glare can come from artificial or natural sources, and the reflection off of surfaces is also considered glare. Sensitive individuals may be distracted by sunlight coming in through the windows. As individuals on the spectrum pass down public spaces, glare from the light reflecting off of surfaces may blur the lines of definition in the architecture and furnishings. Be aware of glare when introducing natural light into interior space, as we introduced in "1. Controllable natural lighting". In the meanwhile, we should pay attention to the selection of materials, the low-reflective and matte materials are recommended which can effectively reduce the glare caused by natural lighting and artificial lighting.

3 Summary of lighting aids for ASD users

General speaking, lighting is one of the most important components of design and one of the factors that most greatly influences how a space will be perceived. This is partially because lighting allows various elements in an environment to be seen. The most important aspect of lighting design of ASD users is control. Within control of lighting, can eliminate the sensory distraction of light to ASD users.

Highlights:

√ The provision and glare protection of natural lighting

√ Artificial lighting should be without flicker, glare-free, controllable, soft and warm, adjustable.

✗ Glare and reflection from lighting and materials

Figure 7.38 Corridor with reflective ceramic tiles (Source: website)

Figure 7.39 Circulation space with matt materials
(Source: http://studiomda.com.br/projeto/unimed-canoas) (Left)
(Source: https://www.pinterest.co.uk/tatit2508/hospital-design/) (Right)

4 Design considerations of ASD-friendly hospital environment

Corridor

- Natural light should be provided where possible.
- Curtains, fitting blinds, external screens and etc can be used to reduce sunlight glare and control the solar gain, control the connection of outside view as well. Besides, a glazed or frosted glass can contribute to provide natural light without creating sharp shadows or "pattern glare" of curtains.
- Artificial lighting must be without flickering.
- Lighting should be well and evenly lit, with low-contrast glare-free background illumination.
- Colour temperature should be comfortable and calm, correlated colour temperature between 3500-4000K is recommended.
- When the tubular fluorescent is used is corridor, tubes should be positioned longitudinally down corridors to aid orientation.
- Lighting should be offset or indirect.
- The intensity of light should be adjustable to meet the needs of different situations.
- Low reflective building and decoration material can help to reduce glare in space.

Waiting area

- Natural light should be provided where possible.
- Curtains, fitting blinds, external screens and etc can be used to reduce sunlight glare and control the solar gain, control the connection of outside view as well. Besides, a glazed or frosted glass can contribute to provide natural light without creating sharp shadows or “pattern glare” of curtains.
- Artificial lighting must be without flickering.
- Lighting should be well and evenly lit, with low-contrast glare-free background illumination.
- Colour temperature should be comfortable and calm, correlated colour temperature between 3500-4000K is recommended.
- Lighting should be glare-free for people looking in viewing directions, such as towards a reception desk, or TVs or illuminated displays in waiting area.
- Lighting should be offset or indirect.
- The intensity of light should be adjustable to meet the needs of different situations.
- A changeable luminaire can be introduced in some relative private area, which colour temperature and light intensity can be adjustable by individual.
- Low reflective building and decoration material can help to reduce glare in space.

06. Smell

1 Smell in built environment

To many people smell seems of little significance, yet it is a powerful sense, some study reported that smell evolved earlier than the more complex senses of sight and hearing. Smell is a sense which have an intimate connection with the brain. When the smell information enters the brain and be detected by neurons system, it can affect people's emotions, memories, and behaviours (Stafford, 2012).

Smell can be generally divided into two categories, unpleasant odour and pleasant smell. One study showed that when participants are exposed to what they consider as "bad odour", these odours can lead them to bad mood, high anxiety, fatigue and sadness. By contrast, pleasant smells may have a positive effect on well-being, it can increase alertness and calmness, reduce anxiety, and produce an overall relaxing effect (Naja et al. 2011).

As pleasant smell has been proven that can improve people's mood and perception of the environment, in recent years, many aromatherapy machines and scented air freshener and heater have been used in offices, exhibition halls, shopping malls and hospitals to improve the quality of the air environment and to bring people a more pleasant experience in the building (Scent Pression, 2017). Smells can also be used as wayfinding information, as the smell of coffee can guide you to a nearby bar, the smell of food represents restaurants is not far away from here.

2 The sense of smell of people with autism

Most people can accept and benefit from a variety of fragrances used to improve environmental quality, but for sensory-sensitive autistic people, some strong smells in public places exceed their sensory load, causing pain and anxiety to them. The scent is just one of many strong smells, others like people’s hair spray and perfume, the pungent odour of food, and the unpleasant odour of toilet were reported that have negative influence on people with autism (Joyce, 2009). The effect of smell on autistic people varies in different according to the individual situation, as each of them has different sensory profiles, their tolerances and preferences vary substantially different from person to person. Hypo and hyper sensitivities autistic people show different behaviours in reacting with smell environment.

Hyper- and hypo-smell

Chemical receptors in the nose tell us about smells in our immediate environment and the sense of smell can help people to identify danger in our life, such as smoke, escape gas or food that is burnt.

Compared to ordinary people, the smell sense of hyper-sensitivity individuals is enhanced and strengthened. Everyday smells, such as spicy food, scented shampoos or petrol may overwhelm people with autism, sometimes they may react in unsafe behaviours to avoid that smell. But hypo-sensitivity individuals on spectrum vice versa, they have a lack of smell and may not be able to identify things based on smell. Following Table 7.5 lists the common symptoms of individuals with ASD when facing various smell stimuli.

Table 7.5 Smell stimuli

Hyper-smell
• Cannot tolerate some smell of objects, easily overreacts to smells in environment; • Smell-defensive, may refuse to go to a place with scents products; • Dislikes people with distinctive perfumes, shampoos, etc.
Hypo-smell
• Has no sense of smell and fails to notice extreme odours; • Tends to seek out for strong smell like curry power, herbs, flowers, essential oils and perfumes for sensory experience; • May lick and sniff things to get a better sense of what they are, as a means of exploring environment and gaining information.

3 Special smell environments in hospital

In the medical environment discussed in this paper, there are many hospital-specific smells such as alcohol, iodine, and some smell from medical products. Hospital environmental need to be cleaned by medical speciality cleaning supplies which kill bacteria on an ongoing basis. Odour from these types of cleaning solutions can compromise the healthcare environment but also have a strong odour. Sometimes the scented air fresheners mentioned above are also used in hospitals. In addition to these medical smells, the bad odour can accumulate quickly in all shared public spaces in healthcare facilities, such as toilet, laundries and public garbage, if these spaces are cleaned infrequently and struggle with poor ventilation.

Potential strong smell source in hospital

- Smell of medical products: alcohol and disinfectant
- Speciality cleaning supplies
- Potential bad odour source: toilet and public garbage
- Aromatherapy or scented air freshener

4 Smell protection for people with autism in hospital

Based on the different reactions of people with autism to smell, some protective strategies should be used to ensure their safety and comfort in the hospital environment.

4.1 Easy-cleanable materials and products

The clean environment plays an essential part in helping to reduce the risk of infection in hospital, providing a clean and safe environment for all patients and visitors is a priority of hospital.

With patients always entering and leaving the hospital, easy-cleanable building and decoration materials help to ensure that disease doesn't spread. All area in the hospital should be cleared on time, including floors, walls, seats, tables, railings and handrails. Toilet and trash can are the potential sources of strong bad odour, these places need to be cleaned more frequently. Garbage in public areas should not be exposed to the air, and the garbage on the day should be cleaned in time to prevent the foul odours are generated. The accumulation of food residues can produce foul odour, so coffee machine and vending machine areas also need to be kept clean. These odours may not be noticed by ordinary people, but hyper-sensitive autistic people may smell them when passing by. For hypo-sensitive autistic people, any dirt in the hospital may have a potential risk to their health since they may lick or sniff thing for a better sense of them. Keeping environment clean and free of bad odour to make sure all hospital users have the best experience possible.

4.2 Good ventilation

While many of us go to hospital to get better, we also know that this is a place where many sick and injured people are gathered in one space. In closed area of a hospital, it can be easy for bacteria and viruses to be transported through the air, but it’s also important to notice that more daily things can have a big impact on air quality of hospital. The smell of cooking food from the canteen, of the speciality cleaning supplies or of the incinerator dealing with medical waste, can also affect air quality and comfort levels of patients.

These odours often exist in hospitals and cannot be removed from the source. Ventilation can effectively dispel indoor odours and increase air circulation to keep indoor air fresh. Besides natural ventilation can establish a connection between the indoor environment and nature, breathing fresh air helps people feel reassured when visiting the hospital. Considering indoor sound insulation, risk of infection, privacy, outdoor air quality and weather, natural ventilation is not available at all times, so it is also necessary to provide a mechanical ventilation system to filters incoming and outgoing air. Good ventilation can help to provide a high quality and well-filtered air, creating a healthier place for all hospital users to stay and work.

4.3 Fragrance-free products

Fragrant consumer products, such as cleaning products and air fresheners, may have an adverse effect on the health of some people when removing indoor odours. The study of Steinemann investigates the effects of fragranced products on autistic individuals ages 18–65 in the United States, Australia, and United Kingdom. The results shown that autistic adults report health problems or uncomfortable feeling due to exposure in the place with fragranced product, scents are from air fresheners or deodorizers and from being near someone wearing a fragranced product as well. Autistic individuals prefer the workplaces, health care facilities, and health care professionals were fragrance-free rather than fragranced (Steinemann, 2018).

While perfumes, scented deodorants, lotions or creams may help people feel more attractive, they may result in unintended harm to those who are vulnerable, particularly people with asthma, or other upper airway or skin sensitivities. Therefore the air fresheners and other detergents should be unscented so that the environment can be as fragrance-free as possible. Moreover, hospital staff and patients coming to the hospital should avoid wearing perfume which can contribute to a more autism-friendly hospital environment. In fact not only people with autism, but all the vulnerable group can also benefit from a fragrance-free environment.

Some individuals or groups, such as government, agencies, industries, organizations, institutions have been aware of there are differences between individuals and carry out a “fragrance-free policy”, which is a protocol or principle that is implemented to promote an environment without fragrance. It can be applied to a range of physical environments, to the whole building or only a specific area or floor in a building. The Figure 7.40 below is a poster designed by the owner of a yoga room to implement a fragrance-free policy. We believe that this strategy can also be carried out in a hospital environment, in order to keep hospital accessible to everyone and support to people who are sensitive to fragrances and the products containing fragrant substances.

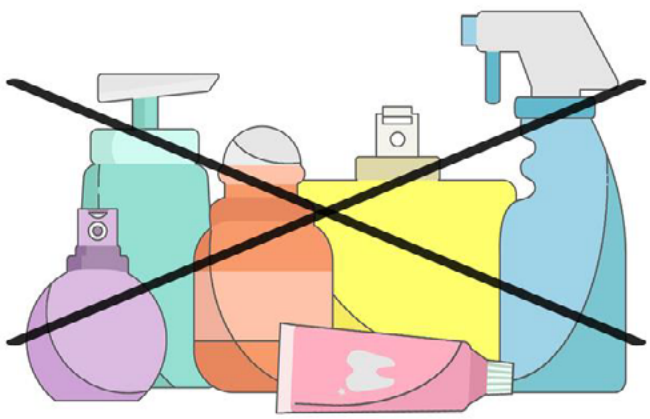


Figure 7.40 Fragrance-free products
(Source: https://www.rryogaroom.com/the-yoga-room/2019/5/20/important-studio-update)

5 Design considerations of ASD-friendly hospital environment

Corridor and waiting area

- The built environment of hospital circulation space is associated health-related outcome, all areas of the hospital should be kept clean, neat and in order to create a safe medical environment.
- Toilets and public waste must be cleaned in time to prevent dirt accumulation that cause foul odours.
- The coffee machine and vending machine should be cleaned in time to avoid the accumulation of food residues that cause foul odours.
- Garbage in the circulation space should not be exposed to the air to prevent foul odours existing in the surrounding air.
- Circulating indoor air through natural ventilation and indoor mechanical ventilation can help keep indoor air fresh and improve air quality.
- A fragrance-free medical environment is recommended. Fragrance products that often used to cover indoor odours should be prohibited, such as scent air fresheners and aromatherapy. These daily products may threaten the health of some sensitive people.
- The hospital's management can implement a fragrance-free policy to suggest hospital staff, patients and visitors do not use fragrance products when they come to the hospital, this can make the medical environment more accessible and friendly for everyone, especially the vulnerable group.

07. Tactile

1 The sense of tactile of people with autism

The sense of tactile helps us to interpret information and tells a person what an object feels like, one of the largest sensory systems is located on the skin, which delivers information on stimuli such as pressure, texture, movement, vibration, pressure, pain, and temperature (Asmika et al. 2018). It also provides people with information that we need for visual perception that reveals what the touch already knows. For example, when people see a large velvet covering on a bed, they know from past experience that the material is soft, and this knowledge evokes a feeling of comfort, warmth, and safety.

1.1 Hyper- and hypo-tactile

We all experience the sense of touch differently, for people, especially children, tactile participation is particularly important because we learn and feel the world through physical contact with various materials, and it also allows us to feel pain. Tactile impairment is the most prevalent sensory characteristic observed by children with sensory dysfunction (Freed et al. 1998). Autistic people may experience difficulty with processing tactile information and fail to get a 'feel' on daily stuff. Hypo-sensitive autistic people usually can't feel things by touching while hyper-sensitive group refuses to tactile experiences. Following Table 7.5 shows the common symptoms that hyposensitive and hypersensitive autistic people exhibit when facing various touch stimuli.

Table 7.5 Tactile stimuli
Hyper-tactile
• Does not like to be touched or hugged, even the slightest touch can send them into a panic attack; • Dislikes having anything on hands or feet; • Avoids tasks with strong tactile element (glue, clay, water, paint, sand and etc.); • Only likes certain types of clothing or textures; • Responds negatively to textures in foods, toys, furniture
Hypo-tactile
• Does not seem to notice touch of others; • Tends to seek out tactile experience to stimuli themselves (e.g., physical touch and different textures); • Holds others tightly for pressure sensations and enjoys heavy objects (e.g., weighted blankets) on top of them; • Has high pain threshold, unaware of danger because of low response to pain.

1.2 Tactile defensiveness and deep touch pressure

Autistic people in hyper-sensitive are usually with tactile defensiveness, this term means a condition in which the tactile system is immature or working improperly. Some types of tactile stimuli that most people would find to be non-painful may cause their brain to become overactive. They tend to withdrawal from or avoidance of certain tactile experiences and simple touch may feel unpleasant or even painful.

Some individuals with autism are touch defender, but they would like to seek deep touch pressure, the term means a form of tactile sensory input which is often provided by firm holding, firm stroking, cuddling, hugging, and squeezing. Temple Grandin, a well-known author who has autism, reported how she would flee from an embrace, and yet seek out "deep pressure" sensations elsewhere:

"From as far back as I can remember, I always hated to be hugged. I wanted to experience the good feeling of being hugged, but it was just too overwhelming. It was like a great, all-engulfing tidal wave of stimulation, and I reacted like a wild animal. Being touched triggered flight; it flipped my circuit breaker. I was overloaded, and would have to escape, often by jerking away suddenly." (Grandin, 2006)

Despite the need to flee away from a random hug, she was eager to seek the sense of deep pressures so much that she built her own "squeeze machine", which is a device that can cover her entire body and put pressure on her. She explained that this stress helped release from anxiety and panic attacks (Grandin, 2006). The idea of squeeze intervention has been implemented to some sensory integration therapy and it has been proven that shows beneficial results when used with children with ASD. Wrapped in a weighted blanket or wearing a heavy vest or shawl are other ways to get physical pressure.

Figure 7.41 An example of how autistic children seek for deep touch pressure
(Source: https://www.bigrentz.com/blog/sensory-friendly-home-modifications-autism sensory-processing-disorder)

1.3 Some acceptable materials to ASD users

Shin and Gaines (2015) found that organic bamboo and organic cotton are two of the most favourite textiles for autistic individuals because they can benefit from the soft touch and moisture-wicking properties of materials, which are the most positive feature for ASD users. Although this research was aimed at clothing materials, its research results can also be applied to the selection of interior decoration materials for buildings.

For most people, furry materials and materials with soft textures and surfaces are generally seen as more pleasant and preferred to hard ones. Research finished by Bourne (2013) reported that individuals with ASD prefer their personal belongings such as pillows and toys are made by soft materials and furry materials, or in contrast, use the minimal and simple decoration for personal space items. The inferred reason is that the soft texture gives them a feeling of warmth and pleasance, but rough textures have too much of an effect on them which the sensitive people found unpleasant.

Quora is a platform to ask questions and connect with people who are related or expert that can contribute to quality answers. We found on the website the question which is "What textures do people with autism like best?" Although this is not an official publication, some responses by people with autism in the comments provided us with useful information.

Among various materials, nylon is reported to be a material that is not welcome by autistic groups, they expressed their preference to fuzzy things like velvet, blankets and fur of cats, and material with smooth surface. The reason mentioned is that the soft materials can bring them happiness, the cool smooth surface looks clean and feels comfortable to touch.

Feature of materials that can be accepted by ASD users

√ Moisture-wicking materials
√ Soft-touch, such as furry and stuffed materials
√ Smooth and clean surface
✗ Rough surface

2 Tactile protection for people with autism

Several architectural design strategies can be manipulated to support the comfort tactile environment of ASD users. Some of these strategies include offering private space and providing enough space to wander through the environment without touching other people. Other tactile aids for people with autism that can be applied in medical environment are introduced as following.

2.1 The use of materials in hospital environment

First and foremost, the choice of materials in hospitals must meet the requirements of medical hygiene. Building materials and decorative materials should be durable, easy to clean, and can inhibit the proliferation of bacteria and viruses. In addition, for an autism-friendly environment, the surfaces of the indoor materials should be smooth and need to be cleaned on time. Dust accumulated on the surface, water and glue spilled on the table and the floor, all these unclean elements cause the uncomfortable tactile experience to some autistic users. Because of the rough surface of linen and nylon products, they are marked as a disliked material by people with autism. Therefore seats and sofas made of smooth materials (e.g., leather, plastic, wood and etc.) are recommended. Rough surfaces not only cause uncomfortable touch but also have the risk of scratching the skin, such as vases made of coarse stone. Such objects with safety hazards should be avoided in the space.

√ Soft surfaces

✗ Rough surfaces

Figure 7.42 The materials that people with autism like and dislike
(Source: image collected on website)

2.2 Positive intervention --- Soft-touch or pressure ball

The soft material that ASD users loved is not easy-cleanable, so it cannot be used in a large amount in a medical environment. Waiting autistic people, especially children of them, may tend to fiddle with surrounding objects. Where medical hygiene is permitted, some soft material products can be implemented into the space as positive tactile interventions for autistic visitors in hospitals, such as covering the armrests of seats with soft blankets and providing a furry pillow. Especially the "escape space" that designed for them, a comfortable seat and a plush toy will help them calm down their tension and cope with unbearable sensory stimuli.

As mentioned above, some people with autism would like to seek some deep touch pressure. A pressure ball or a massage ball that can be squeezed in their hands for obtaining strong sensory input can also be used as a positive tactile intervention. Overall, in the hospital space, when people are waiting for medical services, providing their favourite tactile experience, such as soft touch and stressful touch, can help autistic people to combat anxiety and sensory panic.

Offer a soft touch

Offer a pressure ball

Figure 7.43 The examples of positive tactile intervention (Source: by author)

2.3 Constant temperature

Finding a balance in temperature may be challenging for individuals with ASD, the unstable temperature and uncomfortable temperature (e.g., too warm or cold) can be alarming and painful. Overheated environment might direct increase unpleasant bodily odours that create an unpleasant environment for smell sensitive people. The tactile defensive person may feel the need to cool off by insulating themselves away from others when the interior space is too warm or humidity in the air is high. There are three common types of heating equipment in buildings. We will discuss the possibility of applying them to medical environment and the friendliness of autism users.

Radiators

Some autistic people who are hypo-sensitive have high pain thresholds, their response to pain is much slower than normal people, even does not show any response to the hurt of the body. This symptom makes them vulnerable, and a safe environment is especially important for them. When there are exposed radiators in space, some of them may touch with the hotter surfaces for a long time and finally result in skins burns. Even so, they may still not scream out for help signal. Therefore, this kind of equipment with potential safety hazards should be placed out of accessibility. The strategy that can be implemented is to hide the radiator in the furniture or building structure. Putting the radiators in the cabinet is safer for the ASD users in this space.

Central aircon system

The central aircon system is suitable for medical buildings and can be used to regulate the temperature, eliminate the safety issue as well. It is common equipment that is usually used in large public buildings, placed in the building structure to provide air conditioning and heating for the interior space of the building through vents.

Underfloor heating

Because the heat emitted from an underfloor system instead of a single radiator, the advantage of underfloor heating is that it can provide more evenly heating, keeping the indoor temperature and humidity at a comfortable level, with no high-temperature surface exposed in the air makes it safer for people with autism. However, due to the difficulties of installation and high cost, as well as the requirements of medical sanitary, underfloor heating is difficult to use in large areas in hospitals, especially in circulation spaces. It can be designed in some special therapy rooms and wards, such as rooms that offer treatment for patients with special needs, to provide people with a maximum comfort environment.

Highlights: the use of heating equipment

✗ Exposed radiators
√ Central aircon system
√ Underfloor heating (but difficulty to apply in hospital)

3 Design considerations of ASD-friendly hospital environment

Corridor and waiting area

- Provide enough space to wander through the environment or seat individually without touching other people.
- The building materials, decorative materials, and furniture should have smooth and clean surfaces, accumulated dust, water stains and other dirt on the surface should be cleaned in time.
- Select seats and sofas made of plastic or wooden materials with smooth surfaces. Rough surface furniture (e.g., made by linen and nylon) should be avoided as much as possible.
- There should not have products with vert rough surfaces in the space, such as rough stone vases, which may scratch the skin.
- In the case of medical hygiene permitted, provide a favourite tactile experience for autistic people, which can help them to combat anxiety and sensory panics, such as soft-touch (e.g., a furry toy or a soft blanket) and stressful touch (e.g., a pressure ball).
- Keep indoor temperature and humidity stable and even to provide people with a maximum comfort environment.
- Objects with high surface temperatures, such as heating radiators, should not be exposed to the air. This equipment can be placed and hidden in building structures or furniture to eliminate potential threats.

08. Safety

Hospital as a place where medical services are provided for the people, the safety of people in the space must be guaranteed. Hospital design may directly impact safety in hospitals, adverse events in hospitals are related to unidentified steps, slippery flooring surface, sharp angles and overhead obstructions. The HBN series of documents proposes the basic requirements for the safety of the circulation space of the hospital, it aims to minimize the security risks in the hospital's interior environment. But considering that some people with autism have weaker perception ability to situation of surrounding, they lack awareness of danger which puts both them and others at risk continually. Therefore, based on the basic considerations of hospital safety issues of HBN documents, some additional strategies need to be introduced to eliminate potential risks in space as much as possible.

1 The needs of a safe environment for people with ASD

The first challenge facing some people with autism, especially the hypo-sensitive group and children, is lack of awareness to realize that they are or will be in danger. Less fear may explain why children with autism often run into traffic or deep bodies of water. Here we list a set of behaviours that may lead them more susceptible and exposed to danger.

Table 7.6 Some symptoms and behaviours with potential risks

Hyper-sensitive autistic people may:
• Easily over reacts to various sensory input; • Has poor balance ability;
Hypo-sensitive autistic people may:
• Does not react to sounds indicating potential danger. • Frequently puts things into mouth, chews on non-food items (e.g., soil, grass); • May lick and sniff things to get a better sense of what they are; • Has high threshold for bad smell and tastes, dangerous substances are not noticed; • Has high pain threshold and doesn't respond to hurts, even may tend to self-harm; • Does not response to pain after being hurt or touch extreme temperatures. • Tends to move around unnecessarily and enjoys spinning in circles; • Hard to navigate rooms and avoid obstructions.

2 Safety considerations for people with autism

2.1 Basic safety requirements of hospital's circulation space

On the one hand, it is important for parents and caregiver, education staffs to teach people, especially children who lacks an appropriate sense of danger to develop awareness skills of protecting themselves. On the other hand sometimes it can be easier to modify the environment the person uses in rather than correct their behaviour. There are some basic safety requirements that the circulation space of hospital have to meet, proposed by HBN documents.

(1) Fall protection

Falling down is the most common patient safety incident. The risk from slips and trips must be reduce by using non slippery surfaces, identifying steps obviously and clearing obstacles on the floor, such as bare wires, torn surfaces of carpet and etc. Anti-slippery floor materials are recommended, especially for corridor where people usually walk and even run in hurry, additional mat or carpets can be placed on the entrance of toilet, washroom and dispenser to wipe the water on the bottom of their shoes.

(2) Dangers warnings

If there are potential dangers, such as obstacles, slippery area, untouched objects, steps and so on, it should be clearly told to people by warnings signal or visual cues, for example clear text and symbol, coloured in contrast, or a physical protection barrier.

(3) Protruding obstacles protection

Furniture and fitting protruding from their surface should be avoid, these obstacles with sharp angle are dangerous for ASD users in daily time and especially when they are overacting to various sensory input and running aimlessly in space.

Here we list some common protruding obstacles in circulation space of hospital. We recommend inlaying fire extinguishers and wall fixed cabinets into the wall surface so that they have the same plane with the wall. Sharp angle of windowsills should be avoided as much as possible, or make protruding areas rounded and smooth to reduce the risk of injury. HBN documents suggested obstacles should be avoided, if these exist, and cannot be removed, they should be emphasised by contrasting colour or preferably by erecting a physical barrier.

Fire extinguisher box

Wall fixed cabinet

Fire extinguisher

Corner of windowsill

Figure 7.44 Common protruding obstacles in hospital (Source: images from website)

(4) Security of windows

The opening of windows should be restricted, mechanical switches can be used or the width of opening of the windows are limited. Tilt and turn windows that protrude into interior space should be avoided. Easily-opening windows, especially the low windows bring ASD users the risk of climbing over and falling from the window or balcony.

(5) Restricted and inward doors

Outward opening doors into main circulation routes and corridors are not recommended. Where it cannot be avoided that a door opens into the corridor, the door should be recessed so that when fully open it does not restrict the clear corridor width. Doors access to non-public area should be with enter control in case ASD users accidentally entering a dangerous place.

(6) Fixed furniture

It is better to make all furniture unmoveable so that it will not be used as a foothold to climb, especially the easy moveable chairs should be fixed to the floor or to each other in case it is used as potential weapons or foothold. Shown in Figure 7.44 yellow square, these flexible and individually chair in corridor it is better to remove, if there have to be equipped with seats for waiting, the chairs fixed with each other are recommender.

(7) Durability and cleanability of material

As required in HBN, materials and finishes should be selected to minimize maintenance and be compatible with their intended function. Building elements that require frequent redecoration or are difficult to service or clean should be avoided. Cleanability of material is important to ASD users, because one of the common behaviours is that they tend to put thing into mouth frequently. The material should be easily cleanable and not support the propagation of bacteria etc, in case they put hands into mouth after touch the wall with dirt, bacterial and virus, which will seriously threat their health.

(8) Wall guards

By installing a wall guard, reduce the noise produced by wheelchairs, hospital beds and service carts crash on the wall surface, also protecting the wall materials from scratches and scrapes, besides it can be used as a handrail for people who with movement difficulty.

Figure 7.45 Wall guards
(Source: Inpro, Architectural products)

Figure 7.46 Corner protection
(Source: Inpro, Architectural products)

2.2 Additional protection for people with autism

Considering the insufficient awareness of danger and self-protection of people with autism, in addition to the basic requirements above, we proposed some additional protection for them.

(9) Hard edges protection

One of common behaviours that people with autism have is they tend move around unnecessarily and enjoys spinning in circles. ASD users may accidentally collide various hard edges in the space, such as furniture. This potential danger can be eliminated by using chamfered edges or curved furniture to replace the original one (See in Figure 7.47). Readings materials are usually provided in the waiting area. Books and magazines are better placed in bookcases rather than iron shelves with sharp corners. Wall corner and windowsill are another place where accident may happen, the edges of building structure should be chamfered, round and smooth or covered with soft materials. Figure 7.46 show a kind of product to hide the hard edge of wall corner.

(10) Inaccessible plants and artworks

Their presence of indoor potted plants and artwork, as a landmark, enhances the characteristics of this space, making the space memorable. One the other hand, the condition of plants and artworks affects the safety consideration of the built environment. Plant and artwork, especially the small one, can easily be knocked over and hurt people, and even used by autism people as a weapon to hurt themselves and others. Therefore, these decorative objects should be fixed in building structure so that they cannot be easily accessible (See in Figure 7.47). Artworks like sculpture and furnishings can be fixed on a table or placed in a cabinet with clear glass.

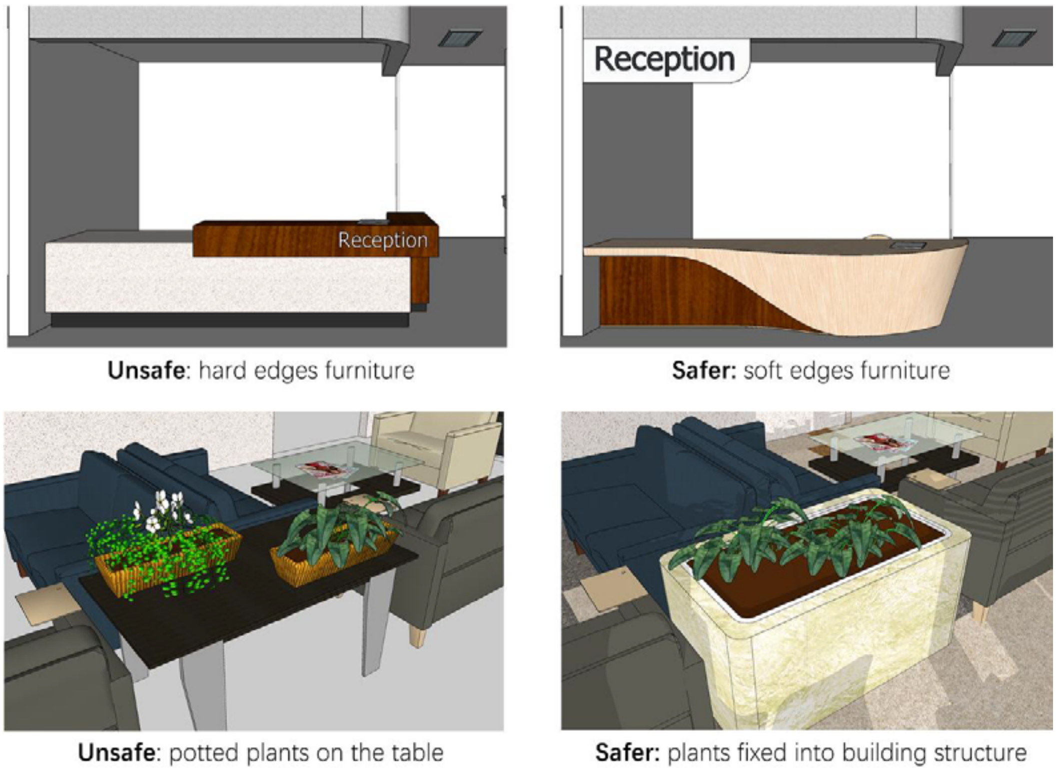


Figure 7.47 comparison of unsafe and safer condition of furniture and plants (Source: by author)

3 Design considerations of ASD-friendly hospital environment

Corridor

- Floor materials should be anti-slippery to prevent patient's falling down.
- Mats and carpets can be place on the entrance of toilets, washroom and water dispenser area where water will often drip on the ground.
- There should be no obstacles on the ground, such as bare wires torn surfaces of carpet and etc.
- Warnings signal should be used in front of dangerous area, such as protruding obstacles, slippery area, untouched objects, unclimbed area, steps and so on.
- Any protruding obstacles should be avoided, if these exist and cannot be removed, they should be emphasised by contrasting colour or by erecting a physical barrier. Fire extinguishers, wall fixed cabinets can be inlayed in walls, the edges and corner of windowsill should be chamfer or round.
- Windows should open outwards and have restricted openings.
- Doors should be open inwards, equipped an access control for non-public area.
- Furniture, especially chairs should be fix to the floor or to each other.
- The material should be durable, easily cleanable and not support the propagation of bacteria etc.
- Install a wall guard to reduce the noise from medical equipment bumping to the wall.
- The edges of building structure like wall corner should be round or covered by protection materials.
- Decorative objects, such as potted plants and artworks, should be fixed in building structure or placed in a cabinet with clear glass.

Waiting area

- Floor materials should be anti-slippery to prevent patient's falling down.
- Mats and carpets can be place on the entrance of toilets washroom and water dispenser area where water will often drip on the ground, or on the entrance of waiting area to wipe the water on the bottom of users' shoes.
- There should be no obstacles on the ground, such as bare wires, if a carpet is used indoors to eliminate noise, the carpet must be undamaged.
- Warnings signal should be used in front of dangerous area, such as protruding obstacles, slippery area, untouched objects, unclimbed area, steps and so on.
- should be used in front of dangerous area, such as protruding obstacles, slippery area, untouched objects, steps and so on.
- Any protruding obstacles should be avoided, if these exist and cannot be removed, they should be emphasised by warning signals, contrasting colour or by erecting a physical barrier.
- Wall fittings such as fire extinguishers, cabinets can be inlayed in walls, the edges and corner of windows should be chamfer or round.
- Windows should open outwards and have restricted openings.
- Doors should be open inwards, equipped an access control for non-public area.
- Furniture, especially chairs should be fix to the floor or to each other.
- The material should be durable, easily cleanable and not support the propagation of bacteria etc.
- It is better to use furniture with chamfered edges or curved furniture.
- The edges of building structure like wall corner should be round or covered by protection materials.
- Decorative objects, such as potted plants and artworks, should be fixed in building structure or placed in a cabinet with clear glass.

09. Hospital equipment

1 The sensory overload caused by hospital equipment

As we already know, people with autism are sensitive to the sensory stimuli in built environment. To mitigate sensory triggers, patients with autism may benefit from modifications to the physical environment, as we suggested above. But in addition, technology products have become an indispensable part of modern life. Their fast, convenient and efficient features greatly facilitate and improve the quality of people's live and work. On the other hand, these technologies bring new sources of sensory stimulation to autistic people. From many studies we know that some technologies

Many studies have shown that some common technology products in life can negatively affect people with autism. For example, in the school environment, HVAC system （heating, ventilation and air Conditioning), blow heaters produce continuous hum noises, children with autism who are sensitive to sound can always hear these noises, which will hurt their hearing and prevent them from focusing on study. In the home environment, some autistic people can always hear the noises created by fans in the bathroom, by the running refrigerator and oven in the kitchen, by computer's radiator as well, these continuous noises input to their acoustic can cause them headaches and anxiety.

2 Reduce the impacts of hospital technologies

Visiting the hospital is a stressor for most people, the experience contains unique challenges for those with ASD. They need to overcome various sensory challenges in the environment and eventually get medical services. The technologies exist in the circulation space of the hospital mainly include alarms, lightings, illuminance signposts, displays, TV screens and vending machines. By means of architectural design, the negative impacts of these devices on the ASD users in the space can be reduced appropriately.

(1) Alarms

As we proposed in 01. Sound / (9). part, the key point is that alarm is used to inform emergency, although it generates sudden and sharp noise but cannot be eliminated or replaced. Keeping the alarms away from waiting areas where people need to wait quietly and the reception area where people need to communicate with hospital can help to minimise the impact of alarm noise.

(2) Lightings

It has been mentioned in many studies that lighting has a great impact on people with autism, both visually and acoustically. The most important consideration is that the selected artificial lights should be free of flicker and continuous hum noise. The direction and position of the light is also important, lighting should be glare free for people looking in viewing directions, such as towards a reception desk and screen. The use of indirect lighting and upwards lighting whenever possible can contribute to avoid glare. More detail design considerations we proposed refer to in 05. Lighting part.

(3) Illuminance signposts

Illuminated signposts and handrails are sometimes used in the hospital's circulation space to ensure that they can be clearly seen at all times. It should be noted that these lighting should be able to emit stable lights without flicker and the brightness of the lights should be moderate to avoid glare when patient look towards this direction. Brightness adjustable lighting is recommended, because sometime intensity of light is suitable for normal people, but it may be extreme and unbearable bright for some autistic people who are visually hyper-sensitive.

(4) Vending machine

When the vending machine is in the same space with the waiting area, people may queue and chat in front of it. The noise of machine, blinking lights and the crowd of people will cause noise disturbance and visual pressure to the ASD patient in waiting area (See in Figure 7.48, Situation A). As we introduced in the 06. Space hierarchy, the vending area can be treated as a high stimuli zone like the toilet, be placed slightly away from the waiting area. At the same time, clear wayfinding signposts should be added to guide people its direction and location. The alternative strategy is that a partition wall can be used to separate the snack area from the waiting area, blocking the visual connection between the two spaces. A wall with sound insulation effect is recommended, which can reduce the transmission of the noise of people chatting to the quiet waiting area (See in Figure 7.48 Situation B).

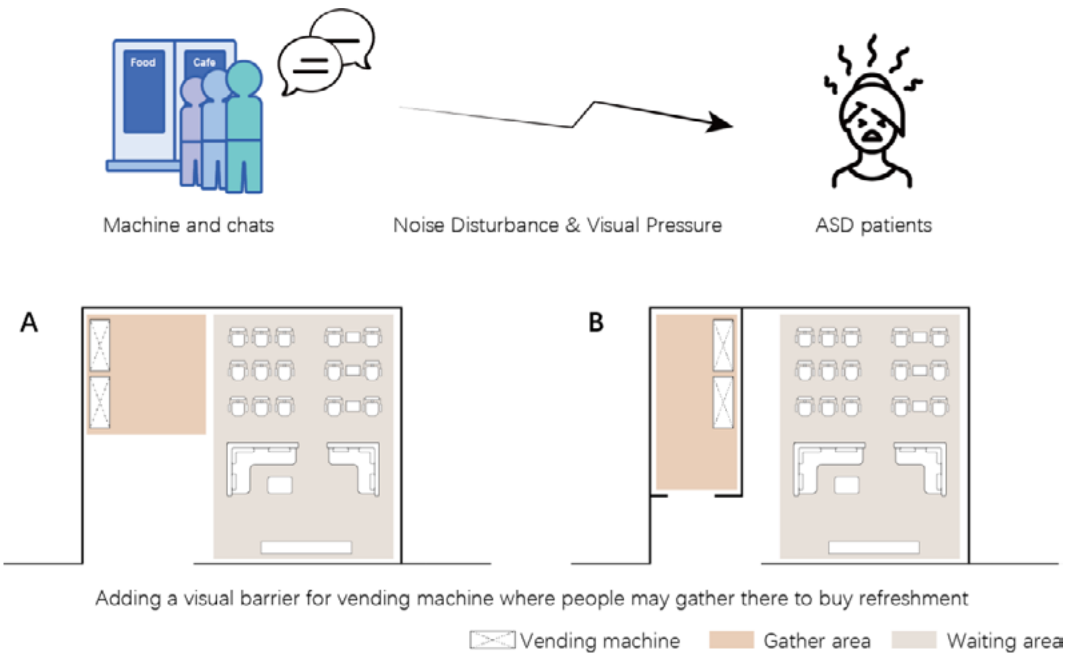


Figure 7.48 Reduce sensory stimuli of vending machine to waiting area (Source: by author)

(5) Electronic screen

In the corridors and waiting areas, there are usually electronic screens for conveying latest medical messages. In order to help ASD patients easily read medical information, the displayed information should be neatly and orderly arranged, with easy-understanding text and number. Overnumbered and bright colours to emphasize and categorize items should be avoided, appropriately cutting down the screen brightness can reduce visual stimuli and help ASD users read information on the screen.

Moving the location of these medical necessary communication devices will cause inconvenience to other patients. The alternative solution is to provide some interactive gaming device to distract their attention from electronic screens. Some available interactive products will be introduced in 09. Assist technology part.

Sometimes television will be provided in waiting area, displaying news or programs to help patients spend the boring waiting time and relieve their tension. It is inevitable that colourful and bright images which visually stimulate ASD users will appear on the screen. The solution adopted by Mitford Hospital Autism Inpatient Unit, is to place the electronic screen in a cabinet with sliding doors, TVs can be taken out of patient's view by closing the door. Not only these electronic devices, but also some daily equipment like clocks, interactive game device and medical communication device can be hidden behand the door of cabinet to make these objects less of target for ASD users' attention (See in Figure 7.49).

Case study: Mitford Hospital Autism Inpatient Unit


Figure 7.49 Electronic device are hidden in cabinet of corridor (Left) and inpatient's room (Right) (Source: Autism Inpatient Unit of Mitford Hospital)

(6) Blinking lights of machine

Some machines have always-on light or blinking light while running or to indicate the error of running. This kind of light goes unnoticed commonly by others, but it is a visual interference for autism users, some of them would stare at these flashing lights and eventually result in dizzy and visual blurring. These repeated blinking lights should be avoided as much as possible, or can be turned off in time, or offer a shelter to cover the lights and move it out of sight.

3 Design considerations of ASD-friendly hospital environment

Corridor

- Emergency alarms should be placed not close to reception desk in corridor.
- The lighting intensity of illuminance signposts and handrails should be suitable and glare free.
- The information displayed in screen should be neatly and in order, avoid using too many colours to emphasize and categorize items, the brightness of screen in suitable level.
- The electronic device which is not patient-necessary, such as some interactive game device and staff to staff paging device, can be placed in a recessed space with a visual cover (e.g., cabinet with sliding door) to remove visual stimulation.

Waiting area

- Emergency alarms should be placed away from waiting area.
- The lighting intensity of illuminance signposts should be suitable and glare free.
- The vending machine should be placed in a separate space in the waiting area to avoid sensory disturbance to ASD users. If it is placed away from waiting area, easy-understandable wayfinding signposts should be used to inform their direction and location.
- The information displayed in screen should be neatly and in order, avoid using too many colours to emphasize and categorize items, the brightness of screen in suitable level.
- The electronic device which is not patient-necessary, such as some interactive game device, staff to staff paging device and television in waiting area as well can be placed in a recessed space with a visual cover (e.g., cabinet with sliding door) to remove visual stimulation.

.10. Assistive technologies

1 Assistive technologies as a tool in autism education and treatment

An assistive technology refers to any item, piece of equipment or product system that is used to increase, maintain, or improve functional capabilities of individuals with disabilities. There are no medications that can cure ASD or treat the core symptoms. However, there are strategies that can help some people with ASD behave better. Throughout the years, a large variety of technologies have been used to greatly improve a child's development in order to help them adapt to social environment better.

Many studies showed that technologies-based intervention have proven successful in teaching children with autism new skills. Many autistic individuals are visual learners and thinkers with strong technological skills, interactive pictures and videos, such as those on a touchscreen, are their language. Different forms of technologies, robotics, interactive multimedia games, virtual reality, mobile phone and tablet application and so on, can possibly work as a teaching and treating tool to enhance their communication skills, social emotional ability, cognitive ability and functional life skills.

1.1 Multimedia interactive programs

Many individuals on the autistic spectrum often struggle with communication, tend to avoid eye contact with people, in some cases, some of them would not communicate at all in a social environment. They feel more comfortable to interact with inanimate objects like a computer, iPad and robotics as well.

Table 7.7 Some cases of educational computer programs

Authors	Program	Characteristics	Purpose
Hetzroni, Tannous (2004)	An interactive program *I Can Word It Too*	• Interactive screen • Animation scheme • Audible message	Building functional language skills
Whalen et al. (2006)	An interactive program *TeachTown*	• Direct feedback • Animated video • Games	Learning expressive language skills
Golan et al. (2006)	An interactive multimedia program *Mind Reading*	• Video • Audio • Written text	Teaching emotion recognition
Silver, Oakes (2001)	A multimedia program *the Emotion Trainer*	• Photographs of people • Emotional expressions • Consistent feedback	Anticipating emotions of others
Beaumont, Sofronoff (2008)	A multimedia program *Junior Detective Training*	• Groups involvement • Setting missions	Enhancing social skills and understanding

Multimedia computer programs are usually based on video, animation, exotic sounds, attractive text, photography, colour, some of them is interactive and task involvement, all these characteristics make computer programs fun and entertaining and can greatly attract their attention. When these qualities are combined with education purpose, it can be a very powerful and helpful teaching tools for children and adolescents with ASD.

Large scale multimedia interactive devices are mostly used in schools and medical centres for education, treatment and also constantly research. Devices such as smart phones, tablets and iPad are more portable and ultimately, accessible to parents and caregivers to interact with their adolescent children with ASD and teach them independent ability, as some studies reported that only a few adults with ASD live can live by their own. Developing skills like cooking, getting dressed and cleaning are essential to promoting autonomy and self-determination and improving quality of life.

1.2 Interactive robotics

Compared with multimedia interactive programs, robotics is a more concrete object that can intelligently allow presentation of a simplified social environment and gradual increase in the complexity of social interactions. It is used to help people with ASD to socially interact and to communicate with others.

Stanton et al. (2008) invented a robotic dog, prepared a mechanical toy dog as well, to see which one children with autism preferred to play with. The robotic dog used in this study can behave like a real dog, with moveable parts and sensors that can detect distance, acceleration, vibration, sound and pressure. It can walk, shake itself, sit down, lie down and rest, can locate a pink ball, walk towards it, kick it or head butt it. More importantly, it can initiate interaction with humans, such as offer its paw, and respond with either a positive (green) light or negative (red) light. The study showed that the children preferred the robotic dog over the mechanical toy dog. They spoke more with the robotic dog, and also interacted more with the experimenter under companion of robotic dog.

1.3 Virtual reality application

Virtual reality is one of the most exciting technologies that could prove useful in treatment of ASD, because of its countless possibilities. This technology allows the opportunity to experience a three-dimensional, computer-generated world in which people can behave and encounter responses to their behaviour.

The notable advantage of virtual reality technology is that it may offer a highly realistic but safe environment without various sensory stimuli, in which to teach some functional skills, such as communication and social skills, awareness of dangers (e.g., pedestrian safety, stranger safety, etc.). It can be used to simulate real or imaginary situations, the skills they learn from virtual environment can be transfer to the natural environment.

1.4 Multisensory intervention (Snoezelen room)

In addition to learn various functional skills, languages, emotional recognition and social skills, another challenge that people with autism have to face is to feel the complex environment by their sensory, especially for hypo-sensitive group whose certain senses are impaired.

Nowadays, many children development centres and autism medical centres can offer a multisensory sensory room, which combines a range of stimuli to help individuals develop and engage their senses. These can include lights, colours, sounds, sensory soft play objects, aromas all within a safe environment, by encouraging the user to engage and explore the environment then it can have positive effects on their ability to react and interact with the larger world around them. It is a place where people with sensory integration disorder can explore and develop their sensory skills, but also where they can relax and relieve stress and anxiety.

Some cases of multisensory room

a. The sensory room for waiting was open in the Emergency Department of Careggi Hospital in Florence, it is the first example of a sensory waiting emergency room in Italy and one of the few examples in Europe. See details in Case study chapter.

b. LudoMi project, create a new educational strategy based on an innovative technological solution called Magika, Magika transforms any ordinary room in a Magic Room, where lights, projections, music, sounds, aroma, and tangible materials are digitally controllable and interactive.

Figure 7.50 Magic Room of LudoMi project
(Source: https://ludomi.polimi.it/en/ludomi-welcome/)

2 The use of assistive technologies in medical environment

2.1 Technologies assisting wayfinding

For people with autism, indoor wayfinding is sometimes a challenge. They may not be able to understand the complex and unfamiliar hospital environment through signposts in a short time. Their poor communication skills prevent them from asking for help, but they may feel more comfortable to interact with inanimate objects rather than communicate with hospital staff. As we mentioned in 07. Wayfinding, an indoor wayfinding application great helpful for ASD users to find their way in hospital and prevent emotionally disturbed because of getting lost.

We found an indoor wayfinding solution produced by MazeMap, also AppAtlas offer the similar indoor navigation products, showing people how to go from A to B between buildings and rooms. It provides service such as time estimates from your location to destination and see which entrance and stairs you need to use to find your destination. With the help of application, hospital visitors can interpret information much faster, save time and avoid misunderstandings and errors. Hospitals can provide such interactive navigation systems in the reception hall and circulation space in fixed equipment or generate an application that can be run on a mobile phone system, so that users can use wayfinding services anytime and anywhere.

Case: MazeMap Application

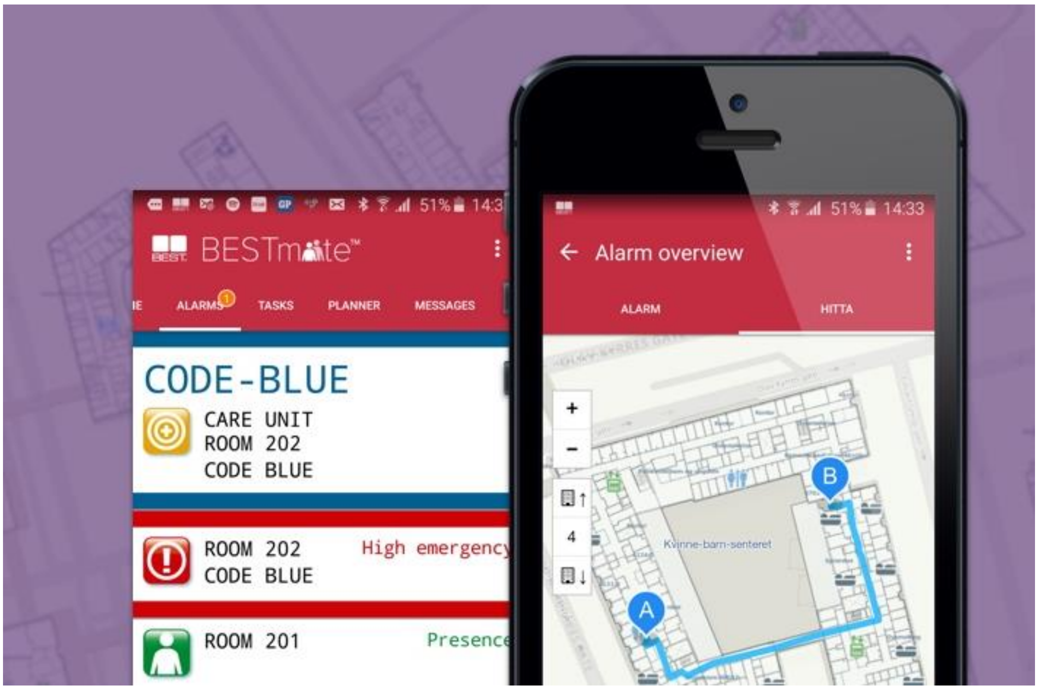


Figure 7.51 MazeMap indoor wayfinding application (Source: https://www.mazemap.com/indoor-wayfinding)

2.2 Technologies attracting attention --- Interactive games

The aforementioned multimedia programs for education (1.1), which are fun, interactive, entertaining and task involved, are proved that can attract the attention of children with autism and make them focus on programs that are displayed on the screen. We believe that this type of product can be applied in a medical environment such as the waiting room. The selected application may not have educational functions, but it can be more entertaining and interactive. Focusing on gaming tasks can help them distract from sensory stimuli in the surrounding environment. For example, when a visually hyper-sensitive child concentrates on interactive games on a portable device, he may ignore the changing numbers on the electronic display in the waiting room and ignore the crowds of people.

Large-scale interactive devices are widely used in waiting rooms and reception halls of children's hospitals, shown in the following cases. On the one hand, highly interactive features can attract children's attention, but its various bright colors and bright screens may cause discomfort to some ASD patients with sensitive visual. We recommend appropriately reducing the scale of interactive gaming devices and reducing the screen brightness to make the overall indoor built environment more friendly to autistic users. Interactive gaming applications that can be loaded on portable mobile devices are recommended because they neither produce sensory stimuli but also provide a positive distraction.

a. British Columbia Children's Hospital

Figure 7.52 The virtual aquarium program in BC Children's Hospital
(Source: https://ngxinteractive.com/work/bc-childrens-hospital-virtual-aquarium-and-mobile-website/)

Some cases that applying interactive games in hospital's waiting area

a. British Columbia Children's Hospital --- Gesture Virtual Aquarium Program

The Virtual Aquarium, situated in the new Emergency Department waiting room, is an immersive and interactive digital art installation combined with gesture technology and embodied cognition. Gesture-based interactions like moving and hand waving guide visitors travel through marine environments. The interactive artwork in this project provide a delightful distraction to transport users away from the stress and anxiety of their immediate surroundings and enable children to immerse themselves in an exploratory journey that calms and delights.

b. Nemours Alfred I. duPont Hospital for Children, Wilmington, DE, U.S. --- Interactive Wall

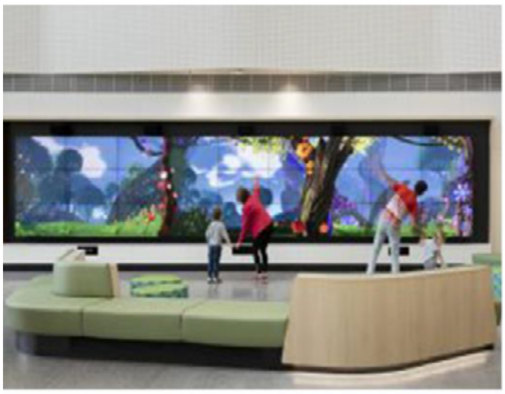
c. Nicklaus Children's Hospital, Miami, FL, U.S. --- Interactive Aquarium

d. Monash Children's Hospital, Melbourne, Australia --- Interactive Wall

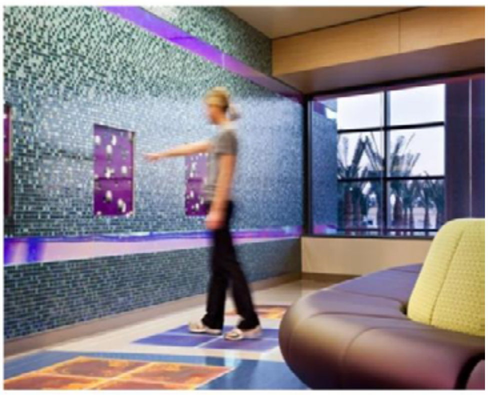
e. Phoenix Children's Hospital, Phoenix, AZ, U.S.--- Holograohic Wall

b. Nemours Alfred I. duPont Hospital

c. Nicklaus Children's Hospital



d. Monash Children's Hospital



e. Phoenix Children's Hospital

Figure 7.53 Cases of interactive game programs applied in children's hospitals

(Source: a: https://www.cannondesign.com/our-work/work/nemours-alfred-dupont-hospital-children/

b: https://intermediatouch.com/portfolio-posts/interactive-aquarium-nicklaus-childrens-hospital/

c: https://www.aecom.com/without-limits/article/acoustic-design-health-environments/

d: https://health.usnews.com/best-hospitals/area/az/phoenix-childrens-hospital-6860210)

2.3 Technologies assisting medical service --- vi.co Hospital

vi.co Hospital is an application available on mobile devices developed by the Fondazione Bambini e Autismo, Italia (Children and Autism Foundation, Italy), in collaboration with the l'ospedale di Pordenone (Pordenone Hospital), to help people with ASD and more generally, with people who have difficulties of communication in a hospital setting.

"vi.co" represents Visual Communication. The application offers a very simple interface, which facilitates immediate access to all users. By transferring the language to visual language which is based on symbols, photographic or video to assist people with autism understand medical messages. It can show and demonstrate the way of visits, how the physical examinations, medical tests will carry out and etc in detail and step by step. Visual language, in fact, being more immediate in nature and intuitive therefore they can be easily understood by those who suffer from communication disorders. vi.co Hospital is like a communication bridge between ASD patients and medical and nursing staff, therapeutic operators, family members and caregivers.

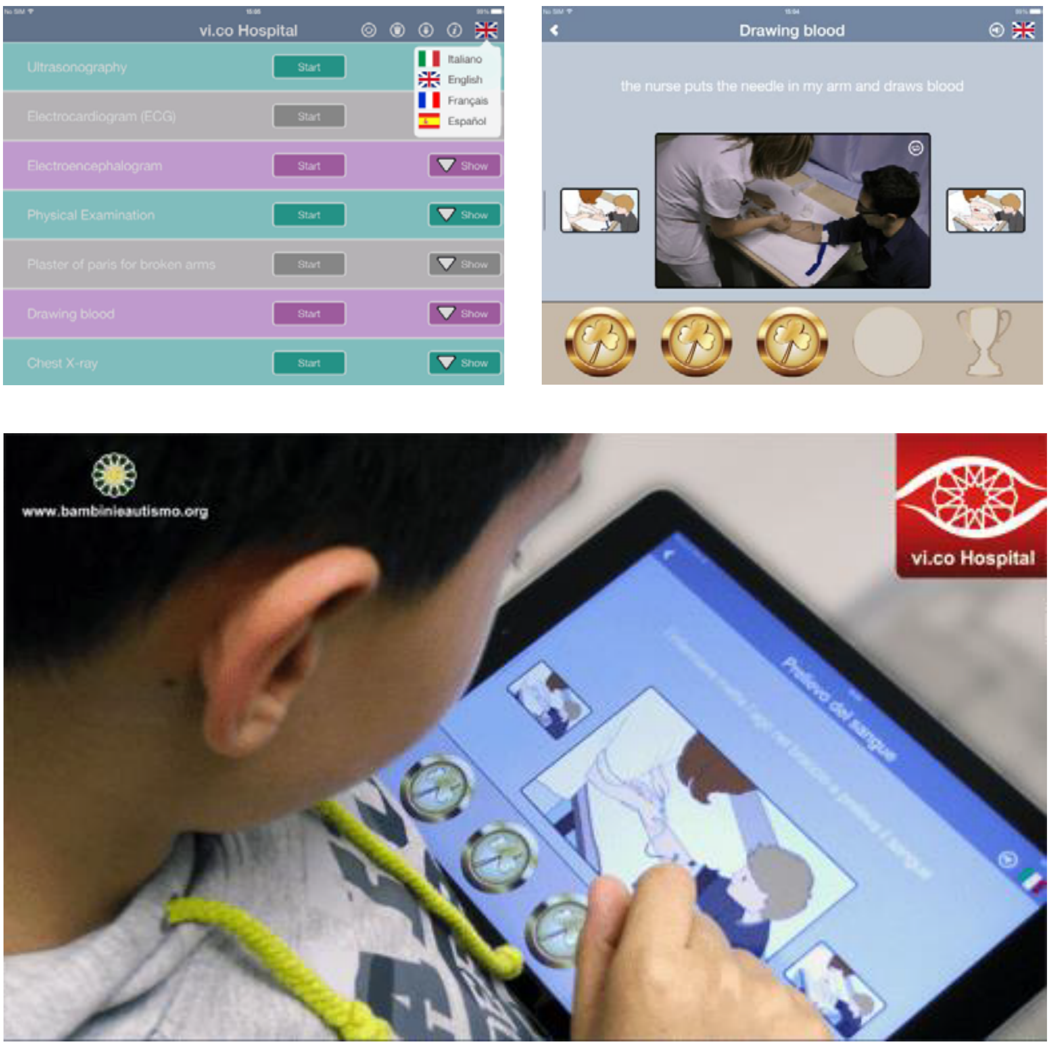


Figure 7.54 "vi.co Hospital" application
(Source: https://www.bambinieautismo.org/vi-co-hospital/)

3 Design considerations of ASD-friendly hospital environment

Corridor

- Provide a navigation application to assist wayfinding between buildings and rooms.

Waiting area

- Provide an interactive games device as a positive intervention to distract ASD patient's attention away from sensory stimuli in the waiting area.
- If the selected interactive device is in large scale, there shouldn’t be too many and bright colours on the screen, appropriately reducing the screen brightness can help people with autism to play with it. Game apps that can be loaded on a portable mobile device are a good choice

11. Escape space

1 Theory of escape space

Individuals with autism require help adjusting to their new space and may need to be provided with opportunities to escape and have some privacy. Escape spaces were created for people with autism who prone to feel sensory overload, especially hyper-sensitive autism people who are easily overwhelmed when too much stimulation in the environment or simply because something triggers his or her anxiety. From the literature review, we noticed that many authors suggested providing an escape space, retreat space or a quiet area for people with autism (Richer and Nicoll; Beaver, 2006; Mostafa, 2008, 2014; McAllister and Keith, 2010). It should be a relatively private and narrow space, where anxious people can be free from external interference and gradually clam down.

When they are experiencing sensory overload and feel stressed. in the escape space they can calm down and regain control, away from things that make them anxious. Many individuals on the spectrum reported feeling a sense of control and release when they had a designated place for relaxation. The presence of escape space has shown the positive effect of such spaces, particularly in learning environments. The following describes a study by Mostafa in which author observed the change of student's behaviour before and after an escape space was introduced in the classroom:

Before an escape space was implemented in a classroom, student with autism often removed herself away from the group activities to sit in the corner of classroom alone. After a few minutes, they can come back to rejoin the group. Once an escape space was made available, at the beginning students retreated to this quiet space frequently, but eventually the space was used less frequently, and the children spent decreasingly less time inside. It was observed that the student looked over to check that the escape space was still there but could remain focusing on the educational task at hand as if knowing the escape space was available was sufficient for her. (Mostafa, 2008)

2 Characteristic and application of escape space

2.1 Characteristic of escape space

Following opinions proposed by Mostafa on her website: Such spaces may include a small partitioned area or crawl space in a quiet section of a room, or throughout a building. These spaces should provide a neutral sensory environment with minimal stimulation that can be customized by the user to provide the necessary sensory input.

Kristi Gaines et al. (2016) proposed the features of escape space in her book as following: This space should be equipped with minimal furnishings, soft lighting, soothing music, and comfortable pillows to sit on. A few outside items can be provided in the space for sensory stimulation, if they are not overwhelming to the child and will be a source of comfort. Items should be small, like a piece of fabric or sandpaper (Figure 7.55). Escape spaces can be stress-reducing interventions for individuals with ASD at school or home.

2.2 Application in school environment

Escape spaces in the classroom have been very successful and are especially helpful to children that tend to be hyper-sensitive, as the environment is particularly stressful for them. Attention span, learning performance, and focus improved while negative behaviours decreased (Mostafa, 2008). McAllister and Keith proposed that the escape space should be placed inside the classroom for teachers to be able to continue observing students when they retreat there. In this case, the space can be divided from the rest of the classroom using screens, bookcases and other pieces of furniture.

2.3 Application in home environment

It is important for children to have an escape space that is their personal space to relieve tension and stress. Several beanbag chairs or other seat components can be used as an escape space (Figure 7.56). It also can be a spare closet that has been emptied of its contents or a screened-off corner of a quiet room, a quiet reading room as long as any books and other materials are completely hidden away from view. If necessary, a few outside items for sensory integration can be brought in like a stereo or an item with a pleasing texture. The escape space means a personalized and private area where the child can retreat to relax and regain control.

The proposals of design of escape space by Kristi Gaines et al., published in their book "Design for Autism spectrum disorder", 2016

Figure 7.55 A window seat as an escape space

Figure 7.56 A residential escape space

3 Case study

3.1 Children's educational buildings

Based on the characteristics of the escape space described above, we tried to find design strategies of how to implement it in building environment from the case. We found that some similar spaces often are deigned in children-related buildings, the presence of them enriches the space form, makes the overall indoor environment more interesting, and increases the fun of children in group activities. At other times, it also serves children who want to read or rest quietly alone.

a. Escola São Domingos (School of São Domingos), Brasil

The children's library was commissioned with the challenge of enhancing the students' teaching experience, always respecting their individualities. The layout provides reading in several ways. At the study table it is possible to carry out group activities, or with the help of teachers. In the background, the padded niches in the wall were designed for those who prefer a more peaceful reading. The synthetic grass texture stimulates touch and defines the space for video learning.

b. Early Education Centre, Changning, Shanghai, China

The partition panel between the corridor and the classroom were thickened to make it a multi-functional place that incorporates lighting, parent-child activity, children's games and teaching aid storage. In the recessed space below the stairs in the lobby, a ball pool is designed to provide children with space to play, both individually and group.

c. Kanagawa kindergarten, Japan

The architects said that the kindergarten was expected as a woodland, the small and large house-shaped nooks are part of a wider strategy to encourage and protect various activities of children. Some of huts are attached to the building structure while others are freestanding, all of them are with a soft cushion and provide a hiding place where children can draw a picture, chat with each other or read a book inside.

Figure 7.57 a. Escola São Domingos

(Source: https://www.archdaily.com.br/br/900207/escola-sao-domingos-angatu)

Figure 7.58 b. Early Education Centre

(Source: https://www.archdaily.com/895337/early-education-center-near-the-horse-farm-l-and-m-design-lab)

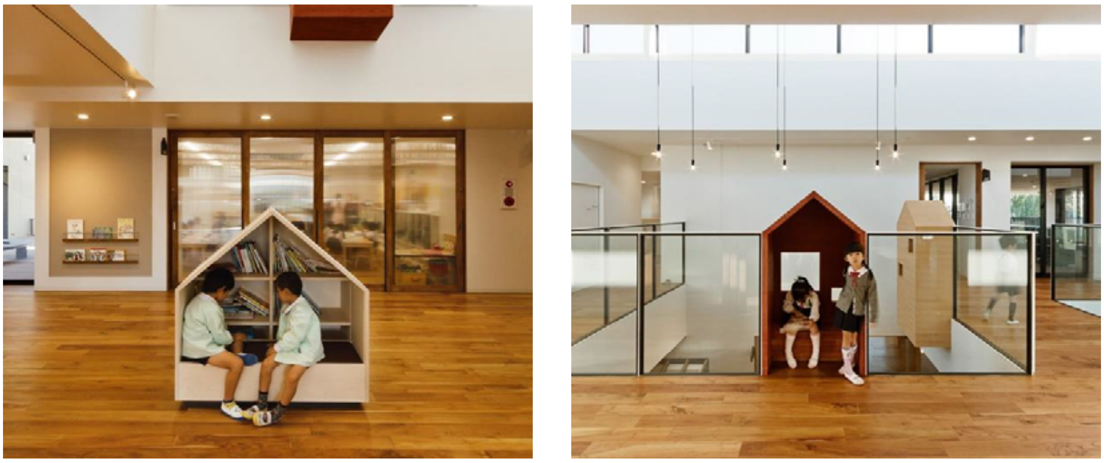


Figure 7.59 c. Kanagawa kindergarten

(Source: https://www.archdaily.com/781271/an-kindergarten-hibinosekkei-plus-youji-no-shiro)

3.2 Healthcare buildings

Some healthcare buildings, especially children's hospital has such spaces that people are drawn to for escape. Some of them are intentional take advantage of architecture elements, using building structures as shelters while others are freestanding in circulation space. Nooks, alcoves, wall recessed space and free space under stairs often can be used as an escape space that autism patients needed, where meet their requirements of hiding themselves away from sensory and human activities.

d. Emma Children's Hospital, Amsterdam

All social programmes on offer at Emma Children's Hospital are situated along the street, turning it into a place for informal social interaction, a playground for children, a space for parents, and a meeting zone for staff. New lounges positioned along this main street offer wonderful views of the city and polders. Its sofa is surrounded by a wooden screen, which provides good privacy for the patients waiting inside. The wall surface of the corridor directly opposite is designed with a recessed space to form a single-person rest area. The irregular shape can attract children's attention and increase the space experience, and the rounded edges ensure the safety of the space.

The key to the design, and an important area consideration in its elaboration, is the spatial quality of all intermediary areas. Considerable attention was devoted to creating an ambiance that is not primarily medical in character. Instead, children experience the area as home, even if only temporarily.

e. Nemours Children's Hospital, Orlando, FL, U.S.

A main corridor in the hospital combines waiting functions. Various sofas and seats are placed on the open side near the window for people to rest, relax and enjoy the sun. Some recessed spaces are designed in the wall of the inner corridor. The round form of space allows children to curl up inside and relax, beside the environment here is relatively private and quiet.

f. Oxleas Children's Development Centre, UK

We think that in the waiting area of Oxleas Children 's Development Centre, the area near windows where some beanbag sofa is placed can be regarded as "escape space". Although there is no screen or building structure as a shelter to make the space more private, it still provides a place for some people who want to be alone temporarily. As described by Mostafa and Kristi Gaines et al., a small partitioned and quiet area in the space can be used as an escape space for autistic people.

Figure 7.60 d. Emma Children's Hospital

(Source: http://www.dvdp.nl/en/work/emma-childrens-hospital-amsterdam)

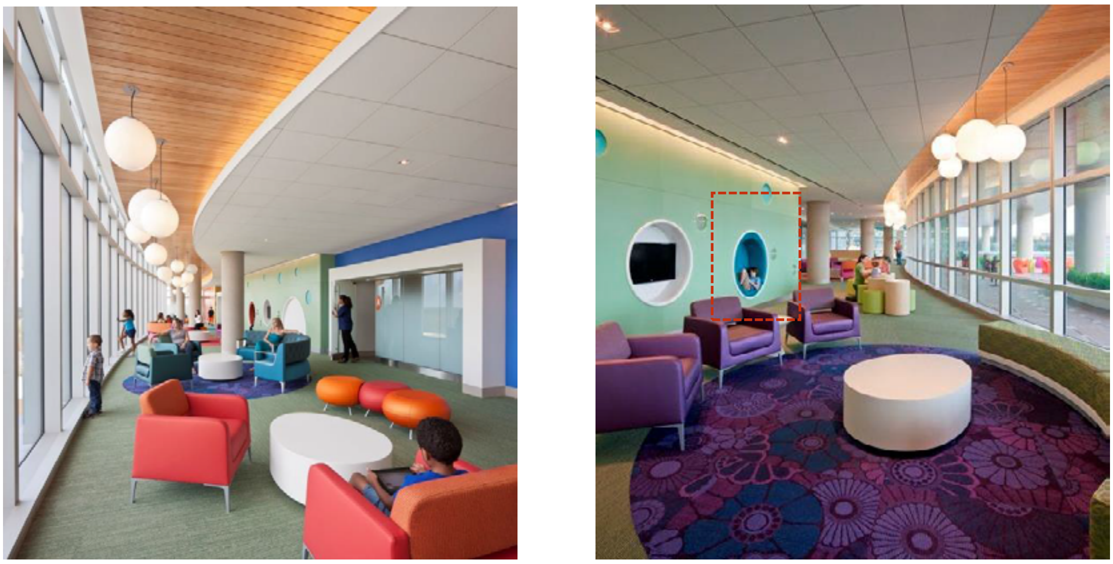


Figure 7.61 e. Nemours Children's Hospital

(Source: https://www.archdaily.com/439396/nemours-children-s-hospital-stanley-beaman-and-sears)

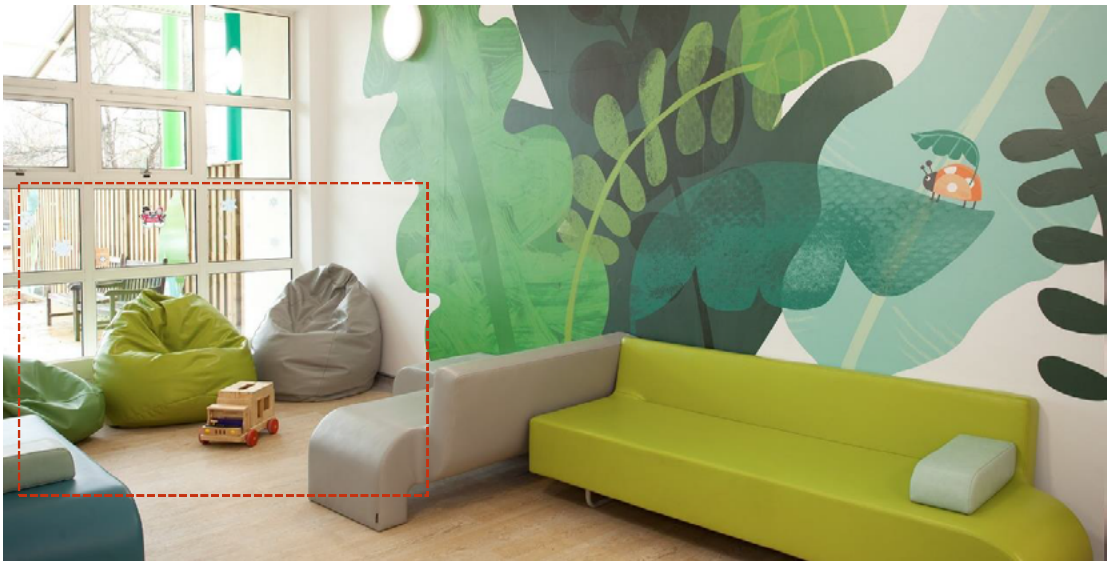


Figure 7.62 f. Oxleas Children's Development Centre

(Source: https://www.boex.co.uk/portfolio/oxleas-childrens-development-centre/)

3.3 Autism-friendly buildings

In buildings designed for people with autism, the space that provide physical, acoustic and visual separation and allow people retreat from multiple stimuli are usually implemented. The environments are designed to be as calming as possible with neutral colours, soft light and materials.

g. Sweetwater Spectrum Community, Sonoma, CA, U.S.

The aim of Sweetwater Spectrum Community is to create appropriate, high-quality, long-term housing for adults with autism in a way that could be replicated nationwide. All spaces were designed to reduce sensory stimulation and provide a serene environment. Forms are familiar, colours and finishes are subdued, and lighting is mostly indirect. One of their design keywords is "preview and retreat", which means residents have the opportunity to preview spaces and activities, and they can access places of retreat for quiet and calm. (See projects details in Case study chapter)

Figure 7.63 g. Sweetwater Spectrum Community

(Source: https://www.archdaily.com/446972/sweetwater-spectrum-community-lms-architects)

4 Design considerations of ASD-friendly hospital environment

Corridor and waiting area

Provide partitioned area as an escape space for autistic users to hide themselves away from sensory stimuli and human activities, such as quiet corner, wall recessed space, a freestanding screened-off space, a beanbag sofa behind the screen or furniture. The escape space should be equipped with a neutral sensory environment with minimal stimulation, such as natural colour scheme, soft and warm lighting, soft materials for comfortable sitting.

12. Transition area

1 Theory of transition area

Although the built environment can be modified through architectural design to minimize the sensory stimuli, each space still has a different physical environment and sensory stimulus level due to different space functions, such as different human activities, floor materials, arrangement of furniture, interior decoration and so on. People with ASD usually have a fear of difference, both of sensory environment and physical environment, they require clear and consistent orientation, predictability of the unknown space. An overall map to illustrate the layout of the building allows users to know where they are and what to expect next. But this is far from enough, 2D floor plan it is not intuitive and not easy for every to understand in a short time. The presence of transition area helps the user recalibrate their senses as they move from one space to another, allows people with autism to preview and adapt these changes in advance.

2 Design strategies of transition area

2.1 A transition space between inside and outside

Transition area is mainly divided into two categories, one is the transition space between outside and inside space. This is a particularly difficult period, when ASD users enter the hospital, they have to confront a huge change in sensory environment, especially when entering a building for the first time, difference and strangeness of environment may lead to a sense of anxiety. The transition areas in the entrance of hospital should provide opportunities to stop and sit away from heavy traffic movement and offer opportunities for localised preview into adjacent spaces. It should be a soft space with low stimulus environment, the presence of some interior landscape can be helpful to transit from natural environment to architectural space, windows that can preview the outside view can help them adapt their sensory and psychological when they walk out of the building.

2.2 A visual connection between indoor space

Another transition space exists between indoor spaces, such as connection between circulation spaces and ambulatory rooms in hospitals, between corridors and classrooms in schools, living rooms and bedrooms in homes as well, Since people with ASD prefer routine and order, transitioning from one space to another or from one activity to another present challenges for them. Some of them may become overwhelmed if transitions between spaces are too abrupt. A visual connection can provide ASD users with the opportunity to familiarize themselves with the new environment, a preview of the environment will help them prepare for next activities in this space. It usually appears in the form of a small window in a suitable position, or a recessed space that allows people to stay here temporarily. Some design practices of transition area in the building are introduced in the following case study.

3 Case study

a. The Advance School for Developing Skills of Special Needs Children, Cairo, Egypt

A sensory garden as transition zone

When Mostafa was involved in designing the school for children with special needs, she implemented a sensory garden as transition zone, which can help users adjust their sensations as they transition from one stimulus level to another and are especially important when the user transitions from a high stimulus area to a low stimulus area.

She recommended: "High-stimulus zone like music, art, crafts and psychomotor therapy, that requiring a high level of alertness, can be grouped together, while low stimulus zone like speech therapy, one-to-one instruction and general classrooms, requiring a high level of concentration, can be grouped together. Services, which are usually high-stimulus, including bathrooms, kitchens, staff-rooms and administration, should be separated from the student areas. Buffer areas such as gardens, free-play, sensory curriculum rooms and some other open spaces may act as transitional areas between the high-stimulus zone and low-stimulus zones." (Mostafa. 2014)

Figure 7.64 a. The sensory garden of Cairo Advanced School designed by Mostafa (Source: https://www.worldarchitecturenews.com/article/1504785/sensory-perfection)

b. Acland Burghley School, London, UK

A visual connection between space

The Acland Burghley School's is a mainstream school serve for students who are diagnosed with autism spectrum disorder. The conducive characteristics of the centre, as stated by designer GA architects, are the use of subdued colours, indirect lighting, optimized acoustics, curved walls and natural materials. Beside a crescent shaped window are place on the door and wall, offering an opportunity for students to glimpse into the built environment and activities in the next space. (See projects details in Case study chapter)

c. Sweetwater Spectrum Community, Sonoma, CA, U.S.

A visual connection between space

This project has already been introduced in 11. Escape space the new community is designed to address the full range of needs of individuals with autism spectrum disorders, maximizing residents' development and independence. As we mentioned "preview and retreat" is one of design keywords, which means residents have the opportunity to preview spaces and activities to the adjacent spaces and they can access places of retreat for quiet and calm. The presence of transitions between spaces allows individuals to orient themselves and creates understanding and sense-making of the environment. (See projects details in Case study chapter)

d. New Struan School, Scotland, UK

Recessed thresholds area for temporarily staying as transition space

New Struan is an advanced centre in the world for the education of children with autism was designed by Aitken Turnbull architect. The connection between classrooms and circulation street, are integrated with the recessed threshold spaces or so called 'lay-bys' space, facilitating transitions by aiding the children in their visuo-spatial processing, allowing the children to assimilate the environmental and spatial change from the corridor to the classroom, and providing natural bays for pupils and staff to utilise for socialising or for respite from the classroom. (See projects details in Case study chapter)

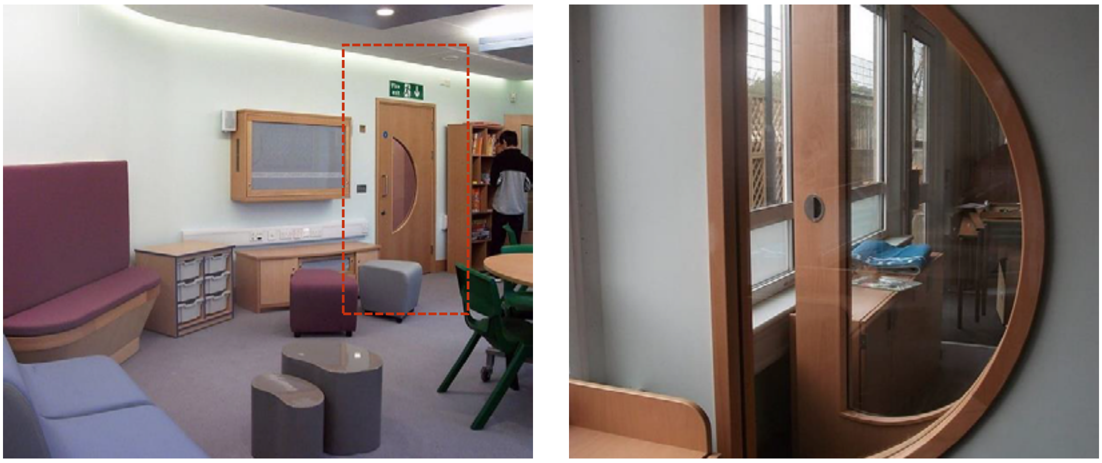


Figure 7.65 b. Acland Burghley School

(Source: GA Architects, https://www.autism-architects.com/)

Figure 7.66 c. Sweetwater Spectrum Community

(Source: https://www.archdaily.com/446972/sweetwater-spectrum-community-lms-architects)

Figure 7.67 d. New Struan School, Scotland

(Source: https://www.scottishautism.org/about-autism/research-and-training/design-autism)

4 Design considerations of ASD-friendly hospital environment

Corridor

Transition area is usually implemented in autism-friendly building, such as the case study b & c & d we introduced above. Considering of circulation space of hospital, a recessed space can be placed in the entrance of corridor and waiting area for temporarily staying to offer people a chance to preview the physical and sensory environment of the next space, prepare themselves to adapt to the new space and new human activities. Transition space should be designed with low stimulus and simple environment, including natural colour scheme, soft lighting and some comfortable seats. (See in Figure 7.68)

Waiting area

In addition to a space for temporarily staying can be used as a transition in waiting area, a small window which provides a visual connection between different space is alternative design consideration, but the staff's and patient's privacy should be given priority. The size, shape and position of windows need to be well considered to avoid people's privacy exposed to public spaces such as corridors. Privacy is especially important for orthopaedic clinics' waiting areas where injured people are waiting and resting inside. The window can be equipped with a curtain or blinds to block the view between the private space and the public area when it is not needed. (See in Figure 7.69)

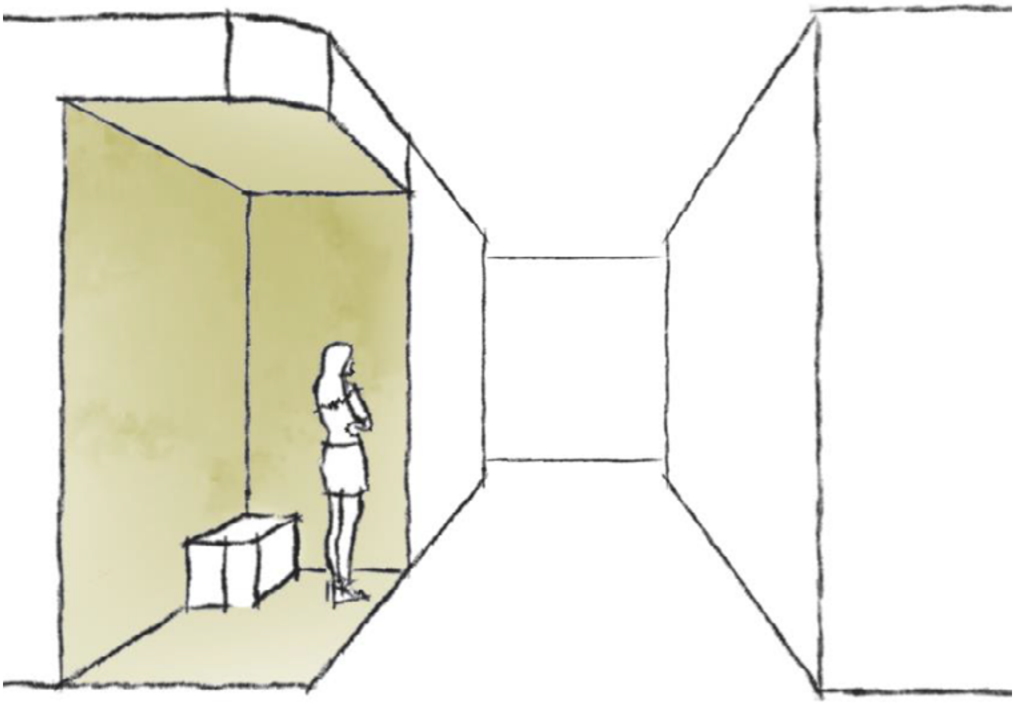


Figure 7.68 A recessed space in the entrance of corridor can be used as transition area (Source: by author)

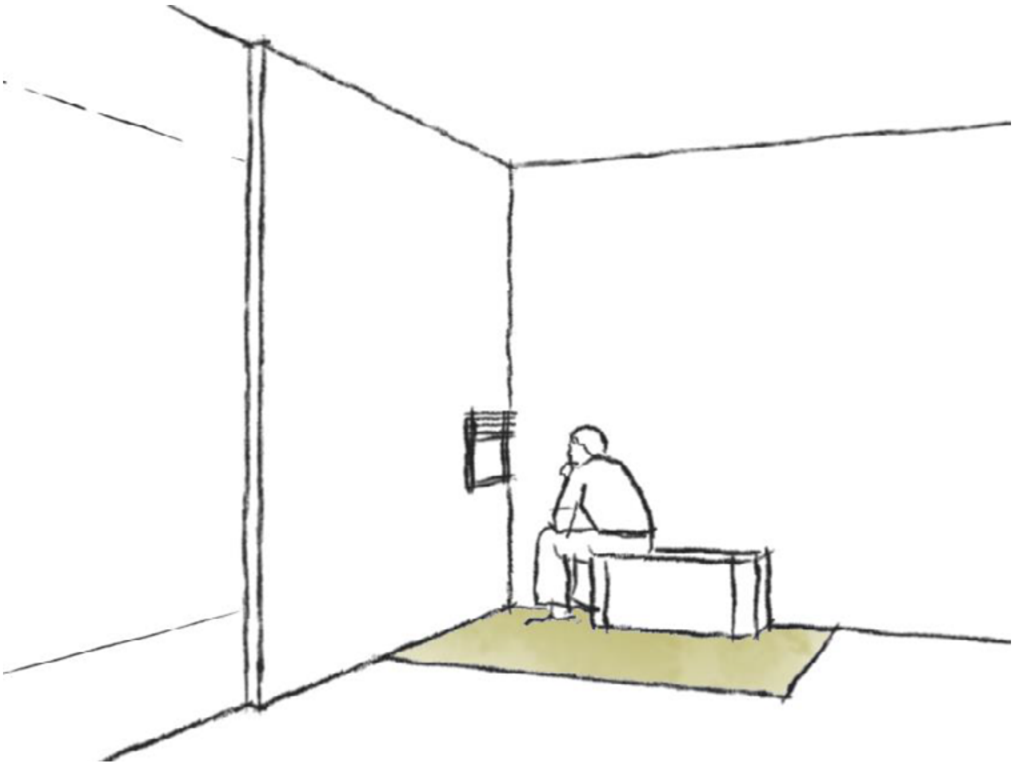
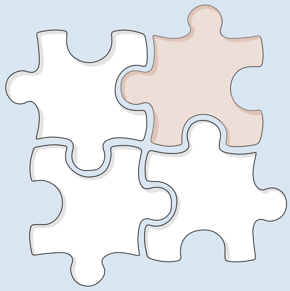


Figure 7.69 A well-positioned windows provide a visual connection between corridor and waiting area (Source: by author)



7.5 Evaluation tool construction :

Evaluation of hospital environments for ASD users

1. Autism-friendly tool : 3STI for Hospital

Introduction

Based on previous research, we develop an evaluation tool to measure the accessibility and comfort of the hospital environment to ASD visitors when they are using the different functional areas of the hospital. The tool is divided into two parts, Part A is used to measure the general environment, and Part B is about 12 important autism-friendly built environment criteria we have proposed.

Scoring system

According to the symptoms and common behaviours of autistic users, we propose the requirements and audit checklist of each criterion, the performance of the built environment is measured by a ranked score. The audit checklist consists of a series of needs of the autism-friendly environment, was designed to assist rate the score. At this stage, we suppose that every evaluation criterion is the same importance and score equally. Inside each criterion would have a different number of indicators depend on the complexity of the criterion but not the weight. If the indicator is implemented in the space, select the "Yes" box next to the indicator, otherwise, select the "No" box. All the indicators of the same criteria are divided equally and the score of the criterion depends on how much indicators the space implemented. In order to calculate easily, each criterion would multiply by 10 that means the maximum of each criterion is 10 points. For example, if there are 4 indicators in the "03 sound" criterion, each indicator would be deserved 0.25 points. When all the 4 indicators are implemented in the space, it would get 10 points which means the optimal performance for the criterion. If there are only 3 indicators are implemented the score would be 7.5 points (o.25*3*10 = 7.5). In general, the score of the criterion could be formulated as "Score of each criterion=x/n * 10" ("x" means the number of indicators the space implemented, "n" means the number of indicators inside the criterion).

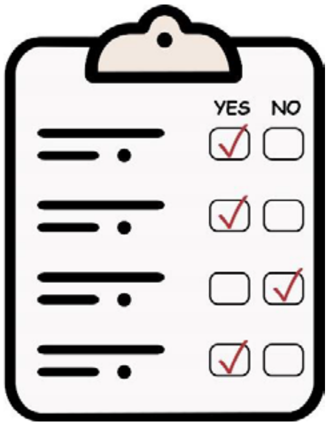
It is common that the number of indicators inside the criterion can not be capable of being divided by 1 exactly. In this case, the score would be rounding-off to one decimal. For example, there are 3 indicators of one criterion but just two of them are implemented in the space, the score of the criterion should be 2/3 * 10= 6.7 according to the formula.

Score of each criterion = x/n * 10

"X" means the number of indicators answer "Yes"
"n" means the number of indicators inside the criterion
the result is rounding-off to one decimal

For example, there are 4 indicators inside the criterion and on the left, all the indicators are met while on the right, 3 of them are met. Therefore, the score would be 10 and 7.5 respectively.

Score : 4/4 * 10 = 10



Score : 3/4 * 10 = 7.5

Final score and evaluation standard

The maximum score of the evaluation tool is 130 points, including 10 points for the general environment and 120 points of 12 criteria (10 points of each). According to our research on the autism-friendly hospital environment, we give the following evaluation standard:

Each criterion is rated from 0 to 10 points and is divided into 5 ranks. When it is rated from 7.5 to 10 points, this indicator represents the top quality of the autism-friendly environment. Similarly, rated from 5 to 7.4 represents medium-high quality, 2.5 to 4.9 represents medium-low quality, 0 to 2.4 points represents low quality. There are 13 criteria in the 3STI tool, thereby the hospital environment with an overall score between 97.5 and 130 has a high level of friendliness to autism users , corresponding to 65 to 97.4 points is medium-high, 32.5 to 64.9 points is medium-low, below 32.5 points is a low level of autism friendliness, the evaluation standard is shown in the table below.

Rank		**Score of each criterion**	**Total score**
A	Top quality	7.5-10	97.5-130
B	Medium-high quality	5-7.4	65-97.4
C	Medium-low quality	2.5-4.9	32.5-64.9
D	Low quality	0-2.4	<32.5

2. Evaluation tool for Hospital's Corridor

PART A: General Environment

Requirements:

The hospital should be comfortable with a good sanitary environment, everything is clean and arranged in order, without bad smell caused by garbage or dirt accumulation. Due to the function, decoration and office furniture, the atmosphere of the hospital always make ASD users afraid and nervous when they come to hospital. Creating a welcoming and home feeling atmosphere as much as possible can help ASD users feel relax reduce pressure and is good for them to seek and use medical service.

Auditing checklist:

(1) The materials and products used in the hospital are easy-cleanable in order to keep the overall environment clean. Yes ▢ No ▢

(2) There are enough storage areas to put medical equipment, daily necessaries and non-patient stuff to keep the general environment in order. Yes ▢ No ▢

(3) The indoor space doesn't have a peculiar odour, especially the toilet, storage room and public trash near the waiting area and other facilities commonly used by the public. Yes ▢ No ▢

(4) By the use of warm lighting, cosy colour scheme and furniture, the overall indoor atmosphere is homey, welcoming and informal. Yes ▢ No ▢

(5) The indoor environment is pleasant and comfortable, with stable and uniform temperature and humidity, there are not heating radiators with high temperature exposed to the air. Yes ▢ No ▢

Score of general environment: ___ /5 * 10= _____

Example:

✓ Clean and in order environment

✗ Messy interior space

✓ Homey atmosphere

✗ Institutional atmosphere

PART B: 12 Criteria of Autism-friendly Built Environment

01. Space hierarchy

Requirements:

The overall building layout should be simple and easy to understand. Avoiding intersections of visiting flows and activities will help them quickly find the location of the medical service they need. Use visual cues to clearly inform the ASD users who have the weak cognitive ability of the functions of each area and their current location.

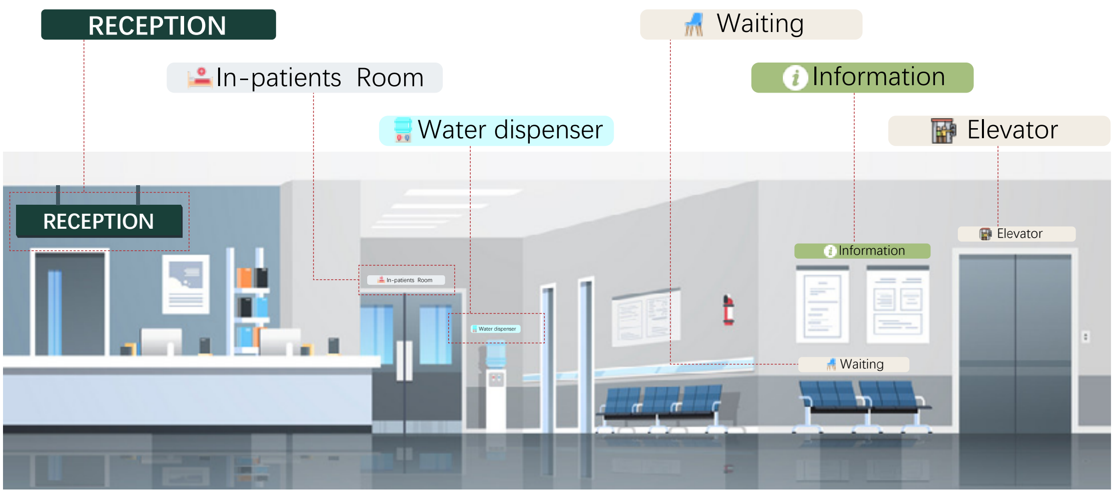
Auditing checklist:

(1) The overall layout of the hospital is simple and clear.	Yes ☐	No ☐
(2) Each functional area is equipped with clear signposts or visual cues to explain its function. (e.g., “water” text and symbol to indicate the water dispenser; “information” text and symbol to indicate the notification board)	Yes ☐	No ☐

Score of space hierarchy: __ /2 * 10= ____

Example:

✓ Clear visual cues to identify the function of each area



02. Wayfinding

Requirements:

The wayfinding system should be simple and easy to understand, with clear text, symbols and the use of colours. Signposts can clearly inform people of the overall function layout of the hospital, current location and the direction of the required medical services. The colour coding system that represents different medical departments with colours can effectively help ASD users to find their way, but visual stimuli and confusing information should be avoided.

Auditing checklist:

(1) The use of colour coding is applied in wayfinding system. (e.g. colour coding means doors, different departments or functional area are represented by different colour) Yes ☐ No ☐

(2) There are landmarks to help ASD users find and identify each space. (e.g., distinguish coloured wall, different floor materials, artworks, sculpture, murals, special decoration can be used as landmarks) Yes ☐ No ☐

(3) There are easy-understandable symbols in wayfinding signposts. Yes ☐ No ☐

(4) The bright colours and large coloured areas are avoided in wayfinding solution. There are not too many colours and similar colours in wayfinding solution. Yes ☐ No ☐

(5) There are not too many disorder advertisements and notification leaflets attached to the wall which make patients confused about wayfinding signposts. Yes ☐ No ☐

Score of wayfinding: ___ /5 * 10= _____

Example:

Point (1)

✓ The use of colour coding

Point (4)

✗ Overnumbered and similar colours

03. Sound

Requirements:

The general acoustic environment of hospital should be quiet. By the design of architectural elements, minimize all kinds of harsh and sharp noises that interfere with senses of people with autism in space, including blocking external noises and reducing the generation and spread of internal noises.

Auditing checklist:

(1) The walls of corridor are sound insulated. Yes ▢ No ▢

(2) The ceiling of corridor is with sound-absorbing materials. Yes ▢ No ▢

(3) The surface of floor materials is made by less noise impact materials. (e.g., rubbers) Yes ▢ No ▢

(4) The furniture in corridor are with sound protection. (e.g., legs or bottom of chairs in corridor are with soft materials) Yes ▢ No ▢

(5) The background music is provided for releasing the tension and covering various noises, such as the sounds of movements and conversations. Yes ▢ No ▢

(6) The machinery of the HVAC system doesn't produce noisy sounds, including heating system, ventilation, air conditioning, and fans are avoided. Yes ▢ No ▢

(7) The sound of hospital communication devices, such as loudspeakers, audio calling and the next patient "call" system does not occur suddenly and harshly, the voice is slow-in, gentle, clear and noise-free. Yes ▢ No ▢

(8) There is a simple electronic screen, with easy-understandable text and numbers showing the medical communication message to replace the next patient audio "call" when necessary. Yes ▢ No ▢

Score of sound: ___ /8 * 10= _____

04. Colour

Requirements:

The interior of the building should be calm, without various visual disturbance that stimulate the senses of autism users. Considering that some of them have weak visual ability, the fittings on the wall or the furniture in the space can be clearly distinguished from the background.

Auditing checklist:

(1) The indoor space is decorated by neutral and nature colour scheme.	Yes ▢	No ▢
(2) The floor and wall of corridor are coloured in different and not similar colour.	Yes ▢	No ▢
(3) The handrails, doors, fittings and other furniture are coloured in contrast colour with its background so that they can be clearly noticed.	Yes ▢	No ▢
(4) The bright colours are avoided in interior environment. (e.g., bright red, bright yellow and etc.)	Yes ▢	No ▢
(5) There are not overnumbered colours in interior environment.	Yes ▢	No ▢
(6) The decoration materials with dense pattern are avoided.	Yes ▢	No ▢

Score of colour: ___ /6 * 10= _____

Example:

Point (3)

✓ The use of contrast colours

Point (4) & (5)

✗ Bright and overnumbered colours

05. Lighting

Requirements:

The indoor lighting should be soft and uniform, and the light intensity should be moderate. The brightness can be appropriately reduced at night to create a comfortable and restful environment. Reduce the visual stimulus caused by the lighting system, such as avoiding flickering lights and glare caused by natural light, artificial light and surface reflections of materials in the building environment.

Auditing checklist:

(1) The natural lighting is provided wherever possible — Yes ▢ No ▢

(2) Windows have glare protections to control the shining sunlight. — Yes ▢ No ▢
(e.g., curtain, window blinds or frosted glass, external screen, etc.)

(3) The lighting is soft and uniform, without shadows produced by uneven lighting. — Yes ▢ No ▢

(4) All lightings are with diffuser and without flicker. — Yes ▢ No ▢

(5) The artificial lightings are glare-free, especially when people look into typical viewing directions. — Yes ▢ No ▢
(e.g., looking towards a central desk or illuminated displays)

(6) There are no glaring and reflection from various materials. — Yes ▢ No ▢

(7) The intensity of lighting can be adjusted according to the time of day. — Yes ▢ No ▢

(8) The artificial lighting can create a warm, welcoming and informal interior environment. — Yes ▢ No ▢

(9) The corridor doesn't have a "tunnel effect". — Yes ▢ No ▢
(e.g., the dim lighting or uneven lighting can make long corridors looks like a tunnel.)

Score of lighting: ___ /9 * 10= _____

Example:

Point (2)

✗ Windows at the end of corridor causes glaring

✓ The use of window blinds

Point (6)

✗ Reflection of materials cause glare

Point (6)

✓ Matt materials

Point (9)

✗ Uneven lighting causes “tunnel effect”

✗ Dim lighting causes “tunnel effect”

06. Smell

Requirements:

The indoor environment should be clean with flowing and fresh air, the odour due to the accumulation of dirt and garbage must be avoided. In addition, a fragrance-free environment is important for ASD user since they are sensitive to various smell, the use of scented cleaning products and air fresheners should be avoided much as possible in the hospital.

Auditing checklist:

(1) The overall hygienic environment of corridors is neat, clean and in order. Yes ▢ No ▢

(2) There are no strong odours near toilets, washrooms, coffee machines, vending machines, public trash can and other frequently used public facilities. Yes ▢ No ▢

(3) The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through good ventilation, both natural and mechanical. Yes ▢ No ▢

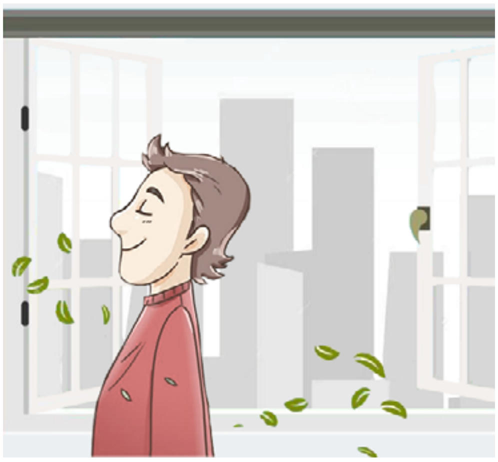
(4) Products such as cleaning supplies and air purifiers used in hospitals are fragrance-free. Yes ▢ No ▢

Score of smell: ___ /4 * 10= _____

Example:

Point (3)

✓ Keep good ventilation



Point (4)

✓ Fragrance-free products

07.Tactile

Requirements:

There should be enough space to avoid touching people nearby when wandering or waiting in circulation space. The surface of building structures and furniture should be smooth and clean. Water stains, glue and clay on the surface and rough surface which result in an uncomfortable feeling should be avoided. Indoor temperature and humidity are stable and comfortable.

Auditing checklist:

(1) There is enough space for people to go in and out or seat individually without touching other people.	Yes ☐	No ☐
(2) The surfaces of building structure, fittings and furniture have a smooth and clean surface, without the touch feeling of rough. (e.g., walls, floors, tables, chairs, handrails and etc.)	Yes ☐	No ☐
(3) There are not objects with a rough surface that have the potential risk of scratching the skins.	Yes ☐	No ☐
(4) There are some positive tactile interventions. (e.g., offer a soft touch toy or a pillow in the seating area, or a pressure ball when they are waiting for medical service.)	Yes ☐	No ☐

Score of tactile: ___ /4 * 10= _____

Example:

Point (2)

✓ Smooth and clean surface

Point (4)

✓ Positive tactile interventions

08. Safety

Requirements:

A safe built environment is very important for ASD users, especially some of them who have high pain thresholds that cannot respond to body injuries in time. Any potential risk factors in the environment should be avoided or added with protections, including the hard edges, sharp corners, slippery flooring, moveable furniture and so on.

Auditing checklist:

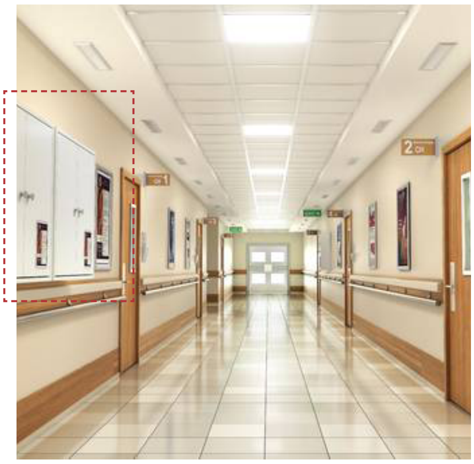
(1) The floor materials are anti-slippery.	Yes ▢	No ▢
(2) There are not obstacles that could trip people on floor. (e.g., bare wires, easy-knocked down vase and etc.)	Yes ▢	No ▢
(3) There isn't falling risk when patient go in and out wet area such as toilets, washroom and water dispenser area.	Yes ▢	No ▢
(4) There are clear warning signals or physical barriers to inform risks of protruding obstacles, slippery area, untouched objects, unclimbed area, steps and etc. in corridor space. (if there are not dangerous area, answers "Yes".)	Yes ▢	No ▢
(5) There are not protruding obstacles with the risk of patients may bump into. (e.g., fire extinguishers, wall fixed cabinets, windowsill, etc.)	Yes ▢	No ▢
(6) The opening of windows is inaccessible or within the restricted distance, there is no potential risk of falling down from windows.	Yes ▢	No ▢
(7) Doors are open inwards with restricted locker, there is no potential risk of bumping into the opening doors.	Yes ▢	No ▢
(8) The furniture is unmovable, chairs can be fixed to each other or fixed on the floor.	Yes ▢	No ▢
(9) The decorative objects are inaccessible, these stuffs can be put in cabinet with glass windows or fixed in building structure (e.g., potted plants, artworks and etc.)	Yes ▢	No ▢
(10)The building materials are durable and easy-cleanable.	Yes ▢	No ▢
(11)There are ward guards to protect surface of the wall and reduce the crashing noises.	Yes ▢	No ▢
(12)The corners of walls are rounded or with corner protections.	Yes ▢	No ▢

Score of safety: ___ /12 * 10= _____

Example:

Point (5)

✗ Protruding obstacles on the wall



✗ Protruding obstacles on the wall

Point (9)

✗ Easy-movable potted plants

✓ Inaccessible plants

Point (11)

✓ Wall guards

Point (12)

✓ Corner protections

09. Hospital equipment

Requirements:

The technologies used in hospital not only bring convenience to people's lives but also increase the sensory burden of sensitive autism people. In the environment, the various sensory stimuli generated by electronic equipment should be minimized, such as flickering and blinking lights, bright and colourful screens, continuous buzzing noises, or sudden sharp alarm sounds.

Auditing checklist:

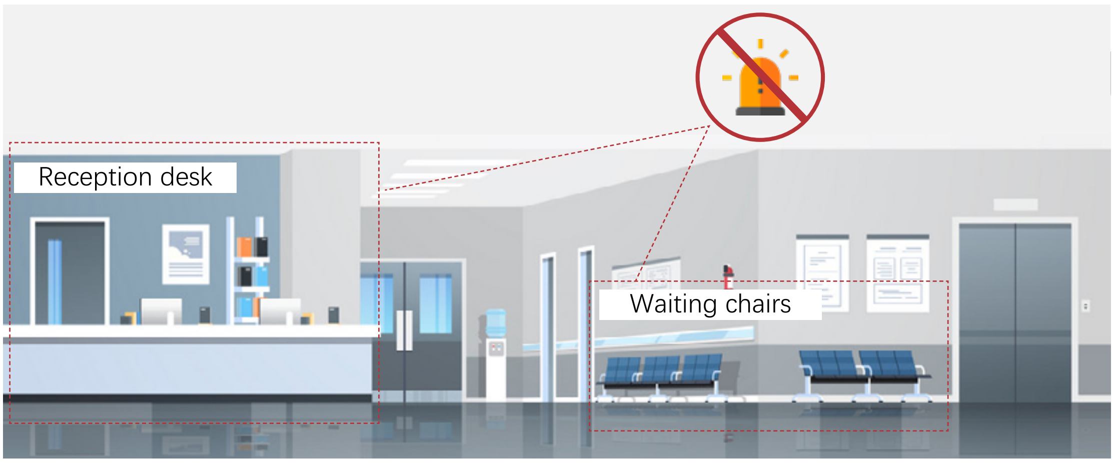
(1) The non-patients-necessary electronic device such as clocks or TV screens can be removed out of sight. (e.g., these devices can be put in cabinet with sliding door or recessed space)	Yes ▢	No ▢
(2) There are not too many electronic screens for notifying information.	Yes ▢	No ▢
(3) The emergency alarm is away from reception desk and waiting chairs in corridor.	Yes ▢	No ▢
(4) The illuminance signposts and handrails are with suitable brightness and glare free.	Yes ▢	No ▢
(5) Machines do not have repeated blinking lights while running, or there is a covering provided to block the visual connection between autism users and the blinking lights.	Yes ▢	No ▢

Score of hospital equipment: ___ /5 * 10= _____

Example:

Point (3)

✓ No emergency alarm near reception desk and waiting chairs



10. Assistive technologies

Requirements:

Currently, many technology products are being developed for the education and treatment of children with autism and have proven to be effective. In the medical environment, assistive technology products can be implemented to help them use the medical space and services. The use of some interactive game programs can distract their attention from sensory disturbances in the surrounding environment, helping to maintain calmness and relieve stress.

Auditing checklist:

(1) There is a navigation application to assist wayfinding. Yes ▢ No ▢

(2) There is an interactive game device for distracting ASD patient's attention away from sensory stimuli. Yes ▢ No ▢

(3) The interactive device does not cause sensory stimuli to ASD users. Yes ▢ No ▢

Score of assistive technologies: ___ /3 * 10= _____

Example:

Point (1)

✓ An example of wayfinding application

Point (2)

✓ An interactive game device

11. Escape space

Requirements:

There should be an escape space where allow people with autism to retreat and hide into and can help them calm down and release anxieties and tensions when they can't deal with the sensory stimuli in the built environment. The characteristics of this space are relatively quiet and private compared with the surrounding area with neutral and minimal decoration and comfortable seating. It can be a small partitioned area, a curl-up space such as a recessed space on the wall or a beanbag sofa in a quiet area of a room.

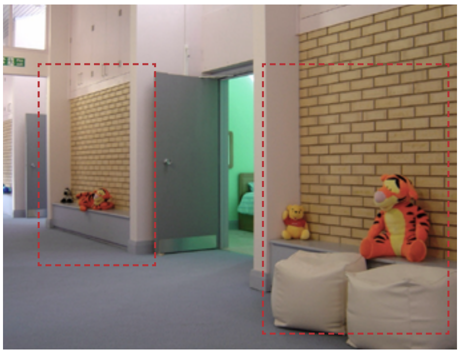
Auditing checklist:

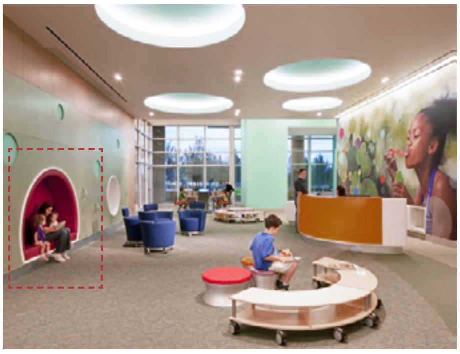
(1) There is a quiet and safe space that can help ASD users escape away from sensory overload and hide themselves for relaxing or calming down. Yes ▢ No ▢

Score of escape space: __ /1 * 10= _____

Example:

✓ A relatively quiet and private area





12. Transition area

Requirements:

People with autism usually have a fear of difference, both the sensory environment and physical environment, they require clear predictability of the unknown space. There should be a transition area between different functional space where allow them to preview the environment and human activities happen in the next space. It can be a recessed threshold space for temporary staying and observation or a visual connection such as a well-position window.

Auditing checklist:

(1) There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance. (e.g. the transition area of the corridor can be a recessed threshold in the entrance for temporary staying and previewing)	Yes ▢	No ▢

Score of transition area: ___ /1 * 10= _____

Example:

✓ A recessed threshold

✓ A visual connection

Score statistics

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: Hospital Corridor		Score (0-10)
PART A: **General Environment**		
PART B: **12 Criteria for Autism-friendly Built Environment**	01. Space hierarchy	
	02. Wayfinding	
	03. Sound	
	04. Colour	
	05. Lighting	
	06. Smell	
	07. Tactile	
	08. Safety	
	09. Hospital equipment	
	10. Assistive technologies	
	11. Escape space	
	12. Transition area	
Final Evaluation Score *(total score 130)*		
Rank		

3. Evaluation tool for Hospital's Waiting Area

PART A: General Environment

Requirements:

The hospital should be comfortable with a good sanitary environment, everything is clean and arranged in order, without bad smell caused by garbage or dirt accumulation. Due to the function, decoration and office furniture, the atmosphere of the hospital always make ASD users afraid and nervous when they come to hospital. Creating a welcoming and home feeling atmosphere as much as possible can help ASD users feel relax reduce pressure and is good for them to seek and use medical service.

Auditing checklist:

(1) The materials and products used in the hospital are easy-cleanable in order to keep the overall environment clean. Yes ▢ No ▢

(2) There are enough storage areas to put medical equipment, daily necessaries and non-patient stuff to keep the general environment in order. Yes ▢ No ▢

(3) The indoor space doesn't have a peculiar odour, especially the toilet, storage room and public trash near the waiting area and other facilities commonly used by the public. Yes ▢ No ▢

(4) By the use of warm lighting, cosy colour scheme and furniture, the overall indoor atmosphere is homey, welcoming and informal. Yes ▢ No ▢

(5) The indoor environment is pleasant and comfortable, with stable and uniform temperature and humidity, there are not heating radiators with high temperature exposed to the air. Yes ▢ No ▢

(6) Both individual seating and group seating are provided. Yes ▢ No ▢

Score of general environment: ___ /6 * 10= _____

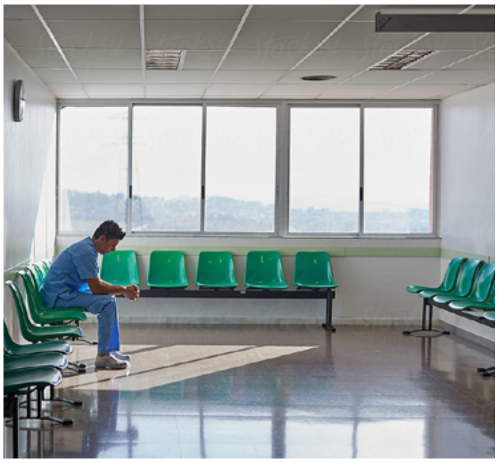
Example:

✓ Clean and in order environment

✗ Messy waiting area

✓ Homey atmosphere

✗ Institutional atmosphere



PART B: 12 Criteria of Autism-friendly Built Environment

01. Space hierarchy

Requirements:

The location of high sensory stimulus areas (e.g., toilet, vending machine and etc.) are away from low sensory stimulus areas where people are quietly waiting and talking. Or use furniture, partition walls, etc. as screens to block the sensory interference of noise, flashing lights and human activities. Use visual cues to clearly inform the ASD users who have the weak cognitive ability of the functions of each area and assist wayfinding.

Auditing checklist:

(1) Common facilities such as toilets and vending machines that accompanied by noises and the crowd of people are placed away from the quiet waiting area. Yes ▢ No ▢

(2) Clear visual cues are provided to assist wayfinding for these facilities. Yes ▢ No ▢

(3) Each functional area has clear definition or visual cues to explain its function.
(e.g., use a different floor colour or materials to identify the boundary of waiting area; use "book" text and symbol to indicate the place of magazine or reading materials, and other function area as well) Yes ▢ No ▢

(4) There are relaxing or entertainment facilities in the waiting area, such as reading materials, games. Yes ▢ No ▢

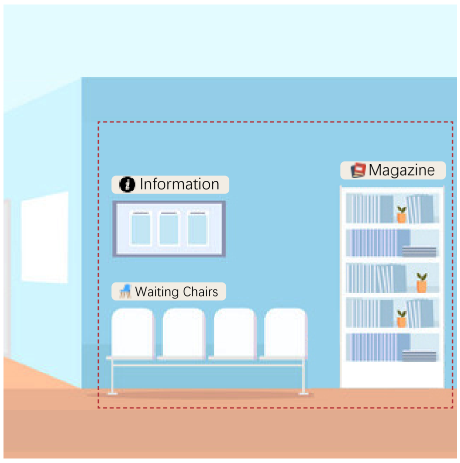
Score of space hierarchy: ___ /4 * 10= _____

Point (3)

✓ Different floor material as visual cues

Point (4)

✓ Text and symbol to inform function



02. Wayfinding

Requirements:

The wayfinding system should be simple and easy to understand, with clear text, symbols and the use of colours. Signposts can clearly inform people of the overall function layout of the hospital, current location and the direction of the required medical services. The colour coding system that represents different medical departments with colours can effectively help ASD users to find their way, but visual stimuli and confusing information should be avoided.

Auditing checklist:

(1) There is a clear signpost to tell the entrance of waiting area.	Yes ☐	No ☐
(2) The signpost of waiting area have easy-understandable symbol.	Yes ☐	No ☐
(3) There are landmarks that help ASD users to find, identify and remember this waiting area. (e.g., distinguish coloured wall, artworks, sculpture, murals, special decoration can be used as landmarks)	Yes ☐	No ☐
(4) The bright colours, similar colours and large coloured area are avoided when waiting area is involved in colour coding wayfinding.	Yes ☐	No ☐
(5) There are not too many disorder advertisements and notification leaflets attached to the wall which make patients confused about wayfinding signposts.	Yes ☐	No ☐

Score of wayfinding: ___ /5 * 10= ______

Example:

Point (1) & (2)

✓ Text and symbol sign to identify arriving

Point (3)

✓ Special decoration as a landmark

03. Sound

Requirements:

The general acoustic environment of hospital should be quiet. By the design of architectural elements, minimize all kinds of harsh and sharp noises that interfere with senses of people with autism in space, including blocking external noises and reducing the generation and spread of internal noises.

Auditing checklist:

(1) The wall of waiting area is sound insulated.	Yes ▢	No ▢
(2) The surfaces of wall in waiting area are with sound insulated panels, or the ceiling of waiting area are with sound-absorbing material or additional sound absorbing ceiling hanging.	Yes ▢	No ▢
(3) The reception desk close to waiting area have an additional sound absorbing ceiling hanging.	Yes ▢	No ▢
(4) There is a soft covering on the floor, or the surface of floor materials is made by less noise impact materials (e.g., rubbers).	Yes ▢	No ▢
(5) If the floor is made of hard and firm materials, furniture in the waiting area should have sound protection. (e.g., legs or bottom of chairs with soft materials)	Yes ▢	No ▢
(6) There is background music to cover inevitable noise, such as the sounds of movements and conversations.	Yes ▢	No ▢
(7) The machinery of the HVAC system, including heating system, ventilation, air conditioning, doesn't produce noisy sounds, and fans should be avoided as much as possible.	Yes ▢	No ▢
(8) The sound of hospital communication devices, such as loudspeakers, audio calling and the next patient "call" system does not occur suddenly and harshly, the voice is slow-in, gentle, clear and noise-free.	Yes ▢	No ▢
(9) There is a simple electronic screen, with easy-understandable text and numbers showing the medical communication message to replace the next patient audio "call" when necessary.	Yes ▢	No ▢

Score of sound: ___ /9 * 10= _____

04. Colour

Requirements:

The interior of the building should be calm, without various visual disturbance that stimulate to sensitive autism users. Considering that some of them have weak visual ability, the fittings on the wall or the furniture in the space can be clearly distinguished from the background.

Auditing checklist:

(1) The interior environments are decorated by neutral and nature colour scheme.	Yes ▢	No ▢
(2) Tables, chairs, windows, fittings and other furniture can be clearly noticed, coloured in contrast colour with its background.	Yes ▢	No ▢
(3) There are not overnumbered colours in interior environment.	Yes ▢	No ▢
(4) The bright colours are avoided in built environment.	Yes ▢	No ▢
(5) The decoration materials with dense pattern are avoided.	Yes ▢	No ▢

Score of colour: ___ /5 * 10= ______

Example:

Point (1)

✓ The use of neutral colours scheme

Point (3) & (4)

✗ Bright and overnumbered colours

05. Lighting

Requirements:

The indoor lighting should be soft and uniform, and the light intensity is moderate. The brightness can be appropriately reduced at night to create a comfortable and restful environment. Reduce the visual stimulus caused by the lighting system, including avoid flickering lights and glare caused by natural light, artificial light and surface reflections of materials in the building environment.

Auditing checklist:

(1) The natural lighting is provided wherever possible — Yes ▢ No ▢

(2) Windows have glare protections to control the shining sunlight. (e.g., curtain, window blinds or frosted glass, external screen, etc.) — Yes ▢ No ▢

(3) The lighting is soft and uniform, without shadows produced by uneven lighting. — Yes ▢ No ▢

(4) All lightings are with diffuser and without flicker. — Yes ▢ No ▢

(5) The artificial lightings are glare-free, especially when people look into typical viewing directions. (e.g., looking towards a central desk or illuminated displays) — Yes ▢ No ▢

(6) There are no glaring and reflection from various materials. — Yes ▢ No ▢

(7) The intensity of lighting can be adjusted according to time of a day. — Yes ▢ No ▢

(8) The artificial lighting can create a warm, welcoming and informal interior environment. — Yes ▢ No ▢

(9) There is a brightness and colour adjustable lighting provided in some special space. (e.g., reading area, interactive games area or escape space) — Yes ▢ No ▢

Score of lighting: ___ /9 * 10= _____

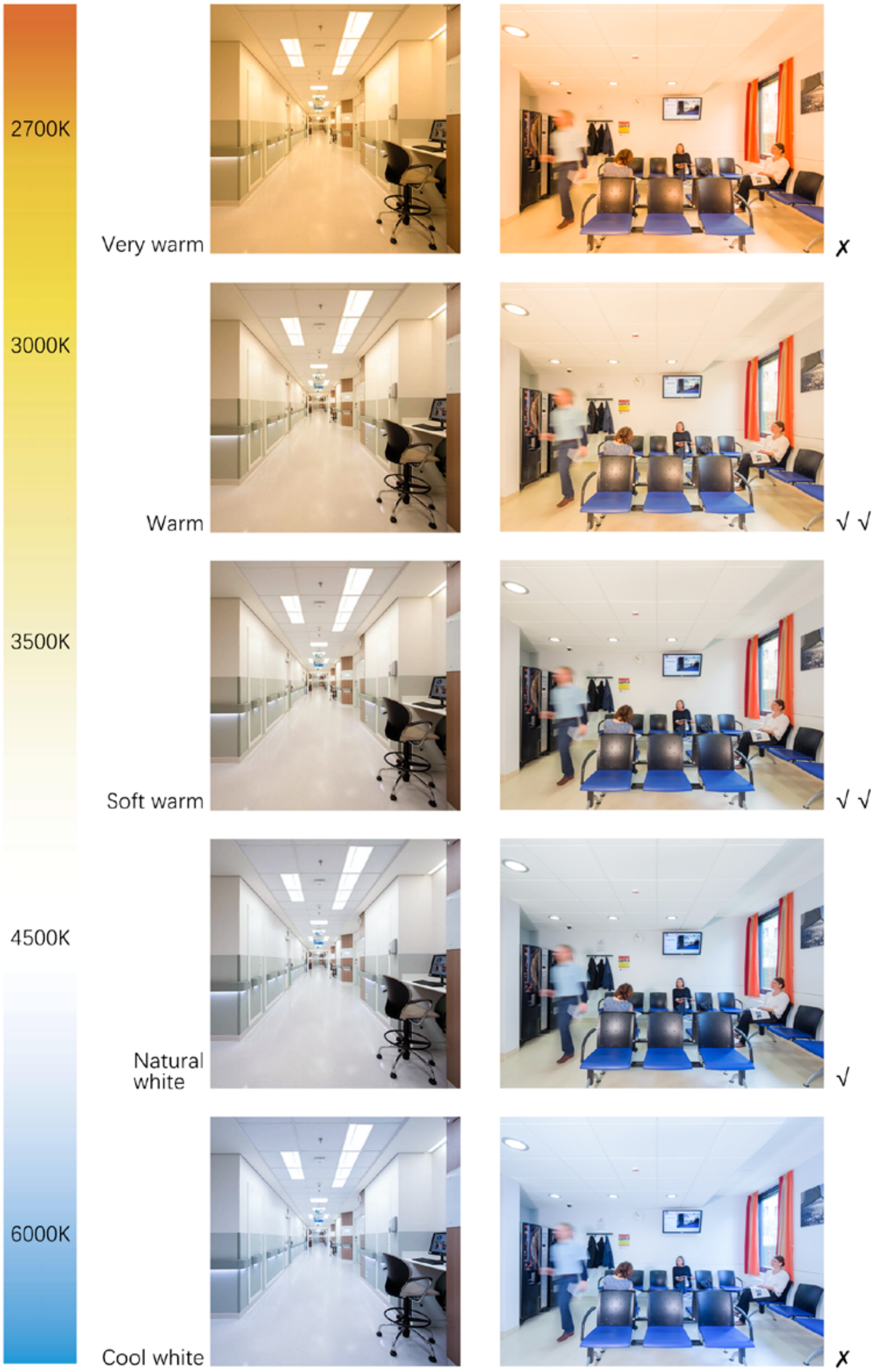
Example:

Point (6) Interior lighting environment

✗ Means it is neither suitable for hospital space nor for ASD users.

✓ Means it is suitable for circulation space of hospital while are acceptable by ASD users.

✓✓ Means it is both suitable for circulation space of hospital and welcomed by children and adults with autism.



06. Smell

Requirements:

The indoor environment should be clean with flowing and fresh air, the odour due to the accumulation of dirt and garbage must be avoided. In addition, a fragrance-free environment is important for ASD user since they are sensitive to various smell, the use of scented cleaning products and air fresheners should be avoided much as possible in the hospital.

Auditing checklist:

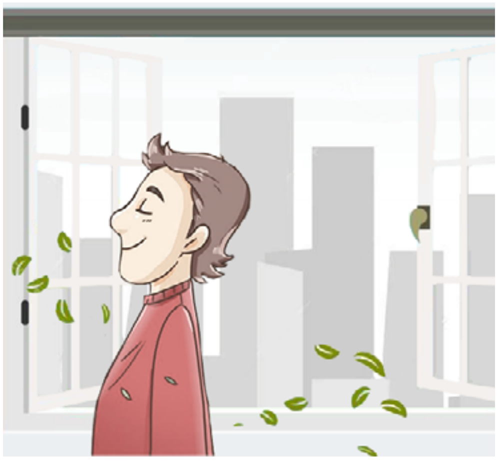
(1) The overall hygienic environment of corridors is neat, clean and in order.	Yes ▢	No ▢
(2) There are no strong odours near toilets, washrooms, coffee machines, vending machines, public trash can and other frequently used public facilities.	Yes ▢	No ▢
(3) The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through natural or mechanical ventilation.	Yes ▢	No ▢
(4) Products such as cleaning supplies and air purifiers used in hospitals are fragrance-free.	Yes ▢	No ▢

Score of smell: ___ /4 * 10= _____

Example:

Point (3)

✓ Keep good ventilation



Point (4)

✓ Fragrance-free environment

07.Tactile

Requirements:

There should be enough space to avoid touching people nearby when wandering or waiting in circulation space. The surface of building structures and furniture should be smooth and clean. Water stains, glue and clay on the surface and rough surface which result in an uncomfortable feeling should be avoided. Indoor temperature and humidity are stable and comfortable.

Auditing checklist:

(1) There is enough space for people to go in and out or seat individually without touching other people.	Yes ▢	No ▢
(2) The surfaces of building structure, fittings and furniture have a smooth and clean surface, without the touch feeling of rough. (e.g., walls, floors, tables, chairs, handrails and etc.)	Yes ▢	No ▢
(3) There are not objects with a rough surface that have the potential risk of scratching the skins.	Yes ▢	No ▢
(4) There are some positive tactile interventions. (e.g., offer a soft touch toy or a pillow in the seating area, or a pressure ball when they are waiting for medical service)	Yes ▢	No ▢

Score of tactile: ___ /4 * 10= _____

Example:

Point (2)

✓ Smooth and clean surface

Point (4)

✓ Positive tactile interventions

08. Safety

Requirements:

A safe built environment is very important for ASD users, especially some of them who have high pain thresholds that cannot respond to body injuries in time. Any potential risk factors in the environment should be avoided or added with protections, including the hard edges, sharp corners, slippery flooring, moveable furniture and so on.

Auditing checklist:

(1) The floor materials are anti-slippery.	Yes ▢	No ▢
(2) There are no obstacles on the floor that may cause stumble down. (e.g., bare wires, torn surfaces of carpet, etc.)	Yes ▢	No ▢
(3) There is no falling risk when patient go in and out wet area such as toilets, washroom and water dispenser area.	Yes ▢	No ▢
(4) The warning signals or physical barriers are provided to inform risks of protruding obstacles, slippery area, untouched objects, unclimbed area, steps and etc. in waiting area. (if there are not dangerous area, answers "Yes")	Yes ▢	No ▢
(5) The protruding obstacles with the risk of patients may bump into are avoided or with soft protection. (e.g., fire extinguishers, wall fixed cabinets, windowsill, etc.)	Yes ▢	No ▢
(6) The opening of windows is inaccessible or within the restricted distance, there is no potential risk of falling down from windows.	Yes ▢	No ▢
(7) Doors are open inwards with restricted locker, there is no potential risk of bumping into the opening doors.	Yes ▢	No ▢
(8) The furniture is unmovable, chairs can be fixed to each other or fixed on the floor.	Yes ▢	No ▢
(9) The decorative objects are inaccessible, these stuffs can be put in cabinet with glass windows or fixed in building structure (e.g., potted plants, artworks and etc.)	Yes ▢	No ▢
(10)The building materials are durable and easy-cleanable.	Yes ▢	No ▢
(11)The hard edges and sharp corners of furniture and building structure that may hurt ASD users are avoided.	Yes ▢	No ▢
(12)The corners of walls are rounded or with corner protections.	Yes ▢	No ▢

Score of safety: ___ /5 * 10= _____

Example:

Point (5)

✗ Protruding obstacles on the wall

✗ Protruding windows sill

Point (11)

✗ Furniture with sharp corner

Point (12)

✓ Furniture with soft edges

Point (9)

✗ Easy-movable potted plants

✓ Inaccessible plants

09. Hospital equipment

Requirements:

The technologies used in hospital not only bring convenience to people's lives but also increase the sensory burden of sensitive autism people. In the environment, the various sensory stimuli generated by electronic equipment should be minimized, such as flickering and blinking lights, bright and colourful screens, continuous buzzing noises, or sudden sharp alarm sounds.

Auditing checklist:

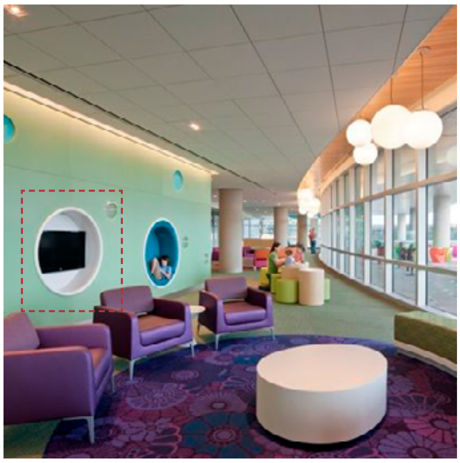
(1) The non-patients-necessary electronic device such as clocks or TV screens can be removed out of sight. (e.g., these devices can be put in cabinet with sliding door or recessed space)	Yes ▢	No ▢
(2) There are not too many electronic screens for notifying information.	Yes ▢	No ▢
(3) The emergency alarm is away from reception desk and waiting area.	Yes ▢	No ▢
(4) The illuminance signposts and handrails are with suitable brightness and glare free.	Yes ▢	No ▢
(5) Machines do not have repeated blinking lights while running, or there is a covering provided to block the visual connection between autism users and the blinking lights.	Yes ▢	No ▢
(6) There is no visual connection between the waiting area and the vending machine.	Yes ▢	No ▢

Score of hospital equipment: ___ /6 * 10= _____

Example:

Point (1)

✓ Non-patients-necessary electronic device can be removed out of sight



10. Assistive technologies

Requirements:

Currently, many technology products are being developed for the education and treatment of children with autism and have proven to be effective. In the medical environment, assistive technology products can be implemented to help them use the medical space and services. The use of some interactive game programs can distract their attention from sensory disturbances in the surrounding environment, helping to maintain calmness and relieve stress.

Auditing checklist:

(1) There is a navigation application to assist wayfinding.	Yes ☐	No ☐
(2) There is an interactive game device for distracting ASD patient's attention away from sensory stimuli.	Yes ☐	No ☐
(3) The interactive device does not cause sensory stimuli to ASD users.	Yes ☐	No ☐

Score of assistive technologies: ___ /3 * 10= _____

Example:

Point (1)

✓ An example of wayfinding application

Point (2)

✓ An interactive game device

11. Escape space

Requirements:

There should be an escape space where allow people with autism to retreat and hide into and can help them calm down and release anxieties and tensions when they can't deal with the sensory stimuli in the built environment. The characteristics of this space are relatively quiet and private compared with the surrounding area with neutral and minimal decoration and comfortable seating. It can be a small partitioned area, a curl-up space such as a recessed space on the wall or a beanbag sofa in a quiet area of a room.

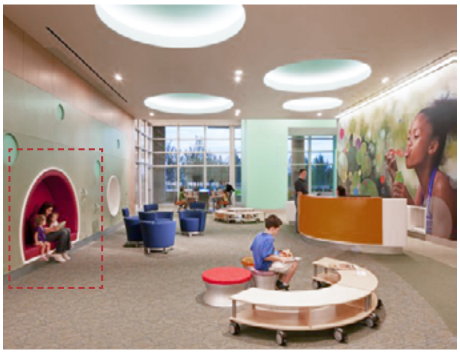
Auditing checklist:

(1) There is a quiet and safe space that can help ASD users escape away from sensory overload and hide themselves for relaxing or calming down. Yes ▢ No ▢

Score of escape space: ___ /1 * 10= _____

Example:

✓ A relatively quiet and private area



12. Transition area

Requirements:

People with autism usually have a fear of difference, both the sensory environment and physical environment, they require clear predictability of the unknown space. There should be a transition area between different functional space where allow them to preview the environment and human activities happen in the next space. It can be a recessed threshold space for temporary staying and observation or a visual connection such as a well-position window.

Auditing checklist:

(1) There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance. (e.g. the transition area of the waiting area can be a recessed threshold in the entrance or a well-positioned window that visually connect two different spaces)	Yes ▢	No ▢
(2) The window used for visual connection does not expose patient's privacy to public.	Yes ▢	No ▢

Score of transition area: ___ /2 * 10= _____

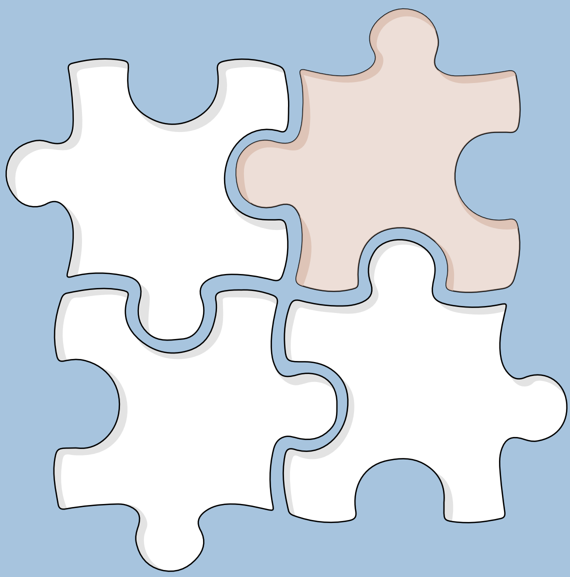
Example:

✓ A recessed threshold

✓ A visual connection

Score statistics

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: Hospital Waiting Area		Score (0-10)
PART A: General Environment		
PART B: 12 Criteria for Autism-friendly Built Environment	01. Space hierarchy	
	02. Wayfinding	
	03. Sound	
	04. Colour	
	05. Lighting	
	06. Smell	
	07. Tactile	
	08. Safety	
	09. Hospital equipment	
	10. Assistive technologies	
	11. Escape space	
	12. Transition area	
Final Evaluation Score *(total score 130)*		
Rank		



8. Research on Hospital's Ambulatory Space

Author: Xu Lingyang

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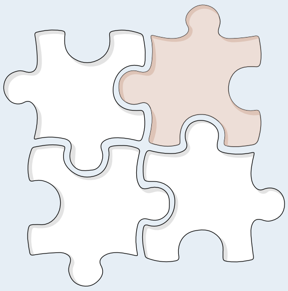


8.1 Official design guidelines for hospital spaces

Design requirements for ambulatory space

Space description

An outpatient clinic is the part of a hospital designed for the treatment of outpatients, people with health problems who visit the hospital for diagnosis or treatment, but do not at this time require a bed or to be admitted for overnight care. We focus on the consulting and examination room of the outpatient clinic which is a medical facility in which one or more medical doctor, usually general practitioners, receive and treat patients. It is the primary place where ambulatory is given and are often the first place that a patient would go for care. The room will be used for consultation, examination, taking and recording of blood pressure, and for minor diagnostic and treatment procedures. General practitioners will also ask the patients about mental health problems that they may be experiencing. When considering the medical examination room, visual and acoustic privacy is important for the patient. A calming and welcoming atmosphere which reduces apprehension would be recommended. The Colour should be in a light natural tone and a window view to provide a positive experience by connecting the individual to the outside world.

Summary of ambulatory built environment requirements

1. Size of ambulatory rooms
2. Location
3. Space hierarchy
4. Privacy
5. Specific hospital technologies
6. Colour
7. Lighting
8. Interior environment
9. Accessibility and security
10. Connection with nature

Source:

Health Building Note 00-01 General design guidance for healthcare buildings
Health Building Note 00-03 Clinic and clinical support spaces
Health Building Note 00-09 Infection control in the built environment
Health Building Note 11-01 Facilities for primary and community care service
Health Building Note 12 Out-patients department
Health Building Note 12-01 Consulting, examination and treatment facilities
National Health Service: Lighting and Colour for hospital design
The Chartered Institution of Building Services Engineers: Lighting for healthcare premises

Health Building Note is abbreviated as HBN below;
National Health Service is abbreviated as NHS below;
The Chartered Institution of Building Services Engineers is abbreviated as CIBSE below.

1. Size of ambulatory rooms

(1) For future flexibility (adaptability) the size of a standard consulting room or examination room should be around 12 m2. Combined consulting/examination rooms should be around 16 m2.

The combined rooms require less space and offer greater utilization than separate rooms. A standard consulting and examination room should be large enough to enable a minimum of two clinicians to move freely around the examination couch/trolley and be able to examine and treat the patient from either side. There should be sufficient space for an escort with children, and also a buggy or push-chair and/or wheelchair. C/E rooms may be used for teaching purposes, so there should also be space for 1–2 observers. To sum up, a consulting and examination is needed:

-A desk with computer facilities
-Chairs
-Double-side examination couch screened by curtains
-Ceiling-mounted examination lamp
-Hand-washing facilities
-Storage facilities

The specific size requirements for consulting/ examination room are show as the following table:

Space	Dimension Requirement
Consulting workstation	• Space for consulting workstation 2200*2400=5280 mm^2 • Space for consultation desk (700+50)*(900+50)mm • Space for occupied upright chair 800 mm • Space for occupied upright chair with person's legs extended and withdraw 1250 mm • Space to withdraw chair from desk 900 mm • Space for wheelchair access/withdrawal 1500 mm
Clinical wash-hand basin	• Fixing height of a lever tap on clinical wash-hand basin 1095 mm • Clinical wash-hand basin projects 400 mm from the back wall • Clinical wash- hand basins vary from 350 to 500 mm projection • Total height to use basin is 1800mm from floor level
Double-side couch access	• Space for examination area 2800*2450=6860 mm^2 • Dimension of couch 650*1900 mm • Space for changing 1000 mm • Space for examination 800 mm • Height range of couch 400-900 mm

Dressing and undressing: ambulant	• Height of full arm movements 2050 mm • Maximum height of permissible low-level obstructions 800 mm • Space at floor for dressing and undressing 1000 mm • Space for arm movements (left and right) 1500 mm • Space for arm movements (front) 1200 mm

(Source: HBN 00-03 Clinic and clinical support spaces/3.1)

2. Location

(2) Direct relationship to the main waiting area

Consultation and examination suit should be directly related to the main waiting area and possibly enable patients to be referred on from their initial consultation to a specialist consulting/examination room or treatment room.

(Source: HBN 11-01: Facilities for primary and community care service/7.38)

3. Space hierarchy

(3) Consulting workstation

The activity space is based on the practitioner sitting at the desk with the patient/client seated diagonally opposite. The desk should not be located between the practitioner and patient/client. Two chairs should be needed for both patients and their parents. The consultation desk should be positioned so that the practitioner can acknowledge a patient/client on entry to the room. A small lockable drawer should be available to store prescription pads.

(Source: HBN 00-03 Clinic and clinical support spaces/3.6-3.11)

(4) Examination area

It includes a double-sided or single-sided couch screened by curtains. In order to maximize the flexibility and adaptability double-sided couch access is generally recommended. Examination lights should be provided above the couch. Clinical hand-washing facilities are required.

(Source: HBN 00-03 Clinic and clinical support spaces/3.47,3.48)

(5) Clinical wash-hand basin

Non-touch taps clinical hand-washing basin with soap dispenser and hand cream dispenser are required. It must be accessible from both the consultation and examination areas and should not be situated behind curtain rails. The glove and apron dispenser illustrated is a combined unit. Hands-free waste bins, with appropriate colour-coded waste bags, should be provided by wash-hand basin. Waste receptacles should be foot-operated only (that is, it should not be possible to open them by hand in normal use) and should be easy to clean.

(Source: HBN 00-03 Clinic and clinical support spaces/3.12-3.19)

4. Privacy

(6) Acoustic privacy

Speech privacy should be ensured, so that confidential conversations are unintelligible in adjoining rooms or spaces. Careful attention should be paid to sound attenuation of partitions in rooms where these will be held, to ensure that the privacy and dignity of patients is maintained. Sound transmission may be reduced by provision of sound-insulating or sound-attenuating partitions and doors. Noise reduction in a space can be assisted by the use of soft floor coverings, curtains and acoustic treatment of walls and ceilings.

(Source: HBN 12 Out-patients department/4.19 4.21)

Doors of consulting, examination and treatment should be sealed as far as practically possible, located as far apart as possible and not directly opposite each other. Interconnecting doors between consulting room should be discouraged on acoustic grounds because the sound insulation will be degraded and speech privacy will not be sufficient.

(Source: Health Technical Memorandum 08-01: Acoustics/2.73)

(7) Visual privacy

The examination room should ensure maximum privacy, especially when the door is open. There should be sufficient space within the curtained area for a patient to undress/dress in privacy, with assistance when required. The communication door between adjacent consulting and examination rooms should be avoided though it may facilitate the movement of staff.

(Source: HBN 12 Out-patients department/4.22)

5. Specific hospital technologies

(8) Rotated monitor computer and printer

A desk with computer facilities for accessing patient records. Possible to rotate the computer monitor to allow the patient / client to view it. Being able to see computer screens and look at images will make the patient feel more comfortable.

(Source: HBN 00-03 Clinic and clinical support spaces/3.8)

(Source: HBN 00-01 General design guidance for healthcare buildings/P38)

(9) Examination light

Ceiling-mounted examination lights should be provided where double-sided couch access is required. For single-sided-accessed couch, wall-mounted examination lights should be provided. Free-standing examination lights should also be available.

(Source: HBN 12-01 Consulting, examination and treatment facilities/4.28)

(10) Patient/staff call and staff/staff call

• Patient/staff call points should be provided in all spaces where patients may be left alone temporarily. Each call unit should comprise a push button or pull cord, reassurance lamp and reset unit. The audible alarm signal initiated by patients should operate for one second at ten-second intervals, with corresponding lamps lit continuously until cancelled.

• Staff/staff call points should be provided in all spaces where staff consult, examine and treat patients. Call units should generally comprise a switch (pull to call, push to reset) and reassurance lamp. The audible alarm signal initiated by the staff should operate intermittently at half-second intervals, with corresponding lamps flashing on and off at the same rate.

(Source: HBN 12 Out-patients department/5.87)

6. Colour

(11) Visual and Colour contrast

•Visual contrast is as important as Colour contrast, as some people with visual impairments confuse different Colours of similar tone.

• Floor Colours should contrast visually with wall Colours. Monochromatic Colour schemes should be avoided.

• Visual contrast may also be used to highlight specific features, for example lifts, stairs, doors, light switches and litter bins.

(Source: NHS Lighting and Colour for hospital design/2.1)

(12) Harmonious Colour scheme

• Form an integral part of the design process and be coordinated within the overall design scheme.

• Coordinated with the lighting design. It needs a limitation of Colour palette.

• Limitation of Colour palette. Use a lot of differing colour may lead to an environment which is too visually busy, leading to confusion and unease.

(Source: NHS Lighting and Colour for hospital design/2.1)

7. Lighting

(13) Lighting

• Avoid glare

General lighting luminance should be arranged to avoid glare on computer screens, equipment display screens and directly to the recumbent patient.

(Source: CIBSE Lighting Guide2: Lighting for healthcare premises/5.6)

• Optimum illuminance

The following table indicates typical illuminance level for different tasks.

Tasks	Illuminance (lux)
Circulation areas (corridors from night to day)	50-150
Reading (from causal to critical)	200-500
Examination/treatment (from minor to critical)	500-700

(Source: NHS Lighting and Colour for hospital design/P43)

For working plane, maintained illuminance is 500 (lux) and for examination light is 15000 to 30000(lux). Luminaire selection and positioning is important to avoid visual discomfort to patients.

(Source: CIBSE Lighting Guide2: Lighting for healthcare premises/5.6)

• Light control

Patients may sometimes feel vulnerable or faint. Being able to change lighting is important.

(Source: HBN 00-01 General design guidance for healthcare buildings/P38)

• Restful appearance

A restful appearance providing task lighting to allow patients to read or staff to carry out an examination or provide treatment.

(Source: NHS Lighting and Colour for hospital design/P66)

8. Interior environment

(14) Simple and understandable environment

A simple, calm and understand-able place is highly desirable. Use soft furnishes and lighting to help provide a calming atmosphere.

(Source: HBN 00-01 General design guidance for healthcare buildings/P39)

(15) Sufficient space and seating

A standard consulting and examination room should be large enough to enable a minimum of two clinicians to move freely around the examination couch/trolley. There should be sufficient space for an escort with children, and also a buggy or push-chair and/or wheelchair.

(Source: HBN 12 Out-patients department/4.20)

(16) Controllable window/lighting/background noise

Patients may sometimes feel vulnerable or faint. Being able to open windows, change lighting and shut out background noise are important.

(Source: HBN 00-01 General design guidance for healthcare buildings/P38)

(17) Solar shading/ blinds

Solar shading and/or a blind may be necessary to ensure the practitioner is not silhouetted from the light behind. Glare should be minimized and may be controlled by curtains and blinds. Double-glazed room vision panels with integral blinds are recommended because it is easy to clean. Window blinds are not readily amenable to cleaning.

(Source: HBN 00-03 Clinic and clinical support spaces/3.26)

(18) Views/Artwork

Views and appropriate artwork can help to create a supportive environment for counselling. Being able to see the sky and nature gives people a feeling of well-being.

It can even counteract the feeling of being temporarily cut off from the normal world.

(Source: HBN 00-01 General design guidance for healthcare buildings/P39)

9. Accessibility and security

(19) Easy cleaned, impervious, smooth， seamless and non- slip finishes

Flooring should be seamless and smooth, slip-resistant, easily cleaned and appropriately wear-resistant. Design need to ensure that surface is easily accessed. It is not physically affected by detergents and disinfectants and dries quickly. Carpets should not be used in clinical areas. This includes all areas where frequent spillage is anticipated. Smell and staining have been responsible for the removal of carpets in many clinical areas.

(Source: HBN 00-09 Infection control in the built environment/3.109)

(20) Storage

Sufficient and appropriate storage will protect equipment from damage, contamination and dust. Storage facilities for small items of equipment and small quantities of supplies are required. Hiding, disguising or designing-in the necessary medical equipment makes it less obtrusive and unfriendly and prevents a feeling of clutter and disorganization.

(Source: HBN 00-01 General design guidance for healthcare buildings/P38)

(Source: HBN 00-09 Infection control in the built environment/3.00)

10. Connection with nature

(21) Nature lighting

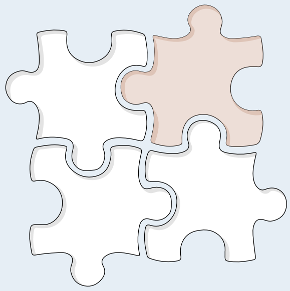
Light from the sky is particularly important in hospitals. It gives excellent Colour rendering, making many clinical tasks easier. Efforts should be made to maximize the use of natural lighting. Natural light is helpful to reduce psychological problems and improve patient outcomes. But it is necessary to ensure that the practitioner is not silhouetted from the light behind.

(Source: NHS Lighting and Colour for hospital design/3.1)

(22) Nature ventilation

The use of natural ventilation is encouraged wherever possible. Cross-ventilation which reliant on window openings on opposing sides of the building, is recommended. When natural ventilation is insufficient, mechanical ventilation needs to be provided to keep indoor air flowing and air fresh.

(Source: HBN 12 Out-patients department/5.10)



8.2 Discussion

Discussion about ambulatory space

Ambulatory care is medical care provided on an outpatient basis, including diagnosis, observation, consultation, treatment, and rehabilitation service. Take the general examination room combined with consultation as an example, there are some contradictions between the basic requirements of Health Building Note with ASD friendly environment. In order to provide a unique patient care experience for autism, it needs to discuss about the requirements of the examination room.

Sound

HBN (10) patient/staff call and staff/staff call indicates that the audible alarm signal would operate with corresponding lamps. That means it would emit noise and light during patient taking an examination. But according to the literature review, people with autism often lead to over sensitivities of external stimuli such as sounds and lighting. Patient with autism is likely to be bothered by the audible alarm signal and lamps.

There are other unnecessary noises as potential acoustic overload for autism in ambulatory. In the view of HBN (25) Nature ventilation, when natural ventilation is insufficient, mechanical ventilation needs to be provided to keep indoor air flowing and air fresh. But as the literature review mentioned, it needs to minimize the hum and continuous noise from equipment. The mechanical ventilation system would make a continuous low sound which normal people may not notice but cause pain for a patient with autism.

Likewise, HBN (8) rotated monitor computer and printer also likely to emit unnecessary noise when operating. Additionally, based on the HBN (5) clinical wash-hand basin, the sound of dripping water may also a nightmare for them. Although the HBN does not mention a lot about medical equipment in ambulatory, as we know, the “beeping” sound coming from monitor which is common in ambulatory would be annoy them.

Lighting

According to HBN and CISE (14) optimum illuminance, it indicates the illuminance of examination room is from 500 to 700 (lux) while the illuminance of examination range from 15000 to 30000 (lux). Similarly, based on HBN (8) the computer screen and other common medical equipment like X-ray display board would emit strong light. But this cannot be applied to those who have lighting sensitive. From the literature review, autism has visual processing deficits, which means they are sensitive to light. Expose them to bright light would affect their symptoms. Similarly, based on HBN (8) the computer screen and other common medical equipment like X-ray display board would emit strong light.

CIBSE (13) avoid glare notes that it should be arranged to avoid glare on computer screens, equipment display screens and directly to the recumbent patient. Glare as a negative visual stimulation would bother ASD users. In fact, there are other facilities in ambulatory could potential to cause glare due to their reflective surface. For example, the surface of the wash-hand basin and non-touch taps mentioned in HBN (5) clinical wash-hand basin.

Colour

HBN (11) visual and colour contrast suggests that use colour contrast to highlight specific features, for example, lifts, stairs, doors, light switches and litter bins in hospital. The use of different colour may contribute to not only an easy view of fittings but also help with wayfinding. But in the view of ASD-friendly requirements, the colour should be calm and simple so that minimize disturbances. Highlight colour would cause too much colour in the space, which is a visual overload for ASD users.

Views

HBN (21) views/artwork states that views can help to create a supportive environment for counselling. But it needs to pay attention to the window arrangement prevent from being distracted by movement outside.

Tactile

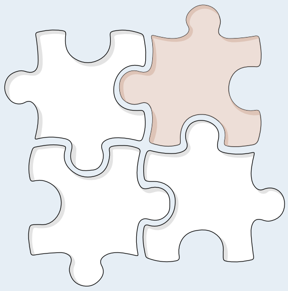
Based on HBN (3) consulting workstation and (4) examination area, patients may face different medical equipment, talk to the doctor and be touched during an examination. However, as sensory sensitive of autism mentioned before, people with autism often have unusual responses to touch stimuli which tend to occur stereotype behaviours and become irritable and anxious.

Safety

HBN (21) views/artwork states that artwork can help to create a supportive environment for counselling. However, according to the characteristic of autism, they tend to have destructive behaviour, including small items, furniture, fixtures, and fitting. Artwork and decorations and other medical equipment such as the stethoscope, needle, scissors would be a risk of security for a patient with ASD.

Sudden change of environment

According to HBN (2) location, the consultation and examination suit should be directly related to the main waiting area. But as we know the main waiting area or corridor usually crow, noisy which make a negative impact on examination room. And in the view of ASD friendly literature, people with ASD tend to fear of “different”, including spatial or environmental difference. It is difficult to cope with the sudden change for a patient with autism entering directly a closed, quiet examination room from an open and noisy waiting are.



8.3 3STI principles in hospital environments

The general environment of hospitals

Patient-friendly hospital environment

From the research of design codes from NHS documents we learned that the building of hospitals should provide a patient-friendly setting up to allow individuals to overcome medical issues. Patients in a healthcare facility are often fearful and uncertain about their health, their safety, and isolation from normal social relationships. The large, complex environment of a typical hospital further contributes to the stressful situation. Stress can dampen a person's emotional and spiritual resources, impeding recovery and healing. The architecture design for therapeutic environment play a very effective role in reducing patients stress in therapeutic environment where is potentially full of stress and the patient is stress-prone mentally. Healthcare architects and researchers have identified four key factors which, which can measurably improve patient outcomes:

• Reduce or eliminate environmental stressors
• Provide positive distractions
• Enable social support
• Give a sense of control

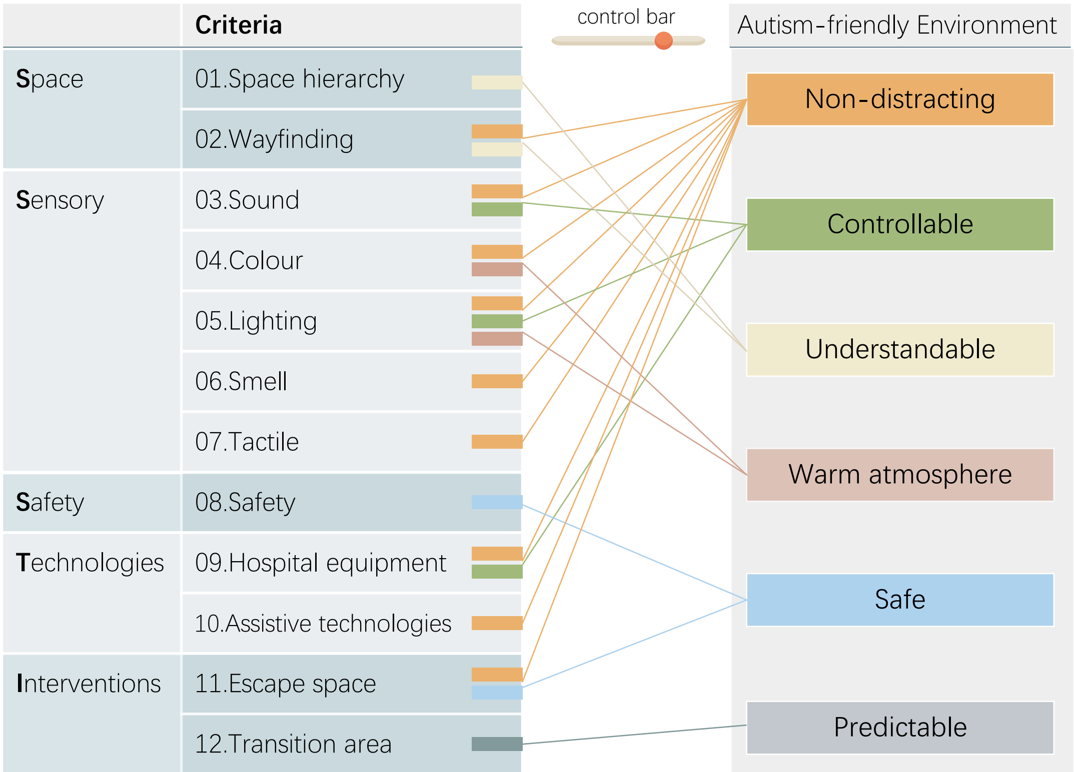
The requirements of ASD users

These key points of a patient-friendly medical environment can be achieved by architectural design solutions. But this is not enough for ASD visitors. The hospital should be designed with inclusiveness as much as possible to meet the special needs of various groups for the built environment. More strategies should be taken into consideration about their sensitivity to architectural elements, the limited ability to understanding and adapting to space and poor physical control of balance. In the following, we describe the characteristic of the hospital environment needed by ASD users according to the 3STI prototype.

The application of 3STI in hospitals

The research focuses on the built environment of hospitals, “09. Equipment” is transfered to “09. Hospital equipment”.

3STI for Hospital



The characteristic of autism-friendly environments

- **Non- distracting**

This aspect mainly considers sensory stimuli of space. Sensory distractions have negative impacts on them and may make autism users unable to use the hospital environment and hospital services. The sensory interference, including sound, colour, light, smell, and tactile need to be reduced. As the toilet and vending machine are needed near where people are waiting, but the air freshener used in the toilet, the noise sounds and blinking lights of the machine, and the crowds of people can easily cause sensory overload to them. These sensory issued need to be reduced by appropriate architectural design.

Moreover, the orderless environment is also a kind of visual disturbance. The untidy space where medical equipment and daily necessities are randomly placed and exposed to the public is not friendly to the ASD visitors. This disturbance can be eliminated or reduced by offering enough storage area. The overnumbered advertisement papers on the wall may make patients confused about wayfinding signposts. Instead of attached to the wall or everywhere, leaflets can be put together in the notification board.

Finding a balance in temperature may be challenging for individuals with ASD, the unstable and uncomfortable temperature and humidity (e.g., too warm or cold) can be alarming and painful. The overheated environment might direct increase indoor odours that make the environment unpleasant for smell sensitive people. It is necessary to offering visitors an indoor space with a comfortable and uniform temperature.

Olfactory sensitive is a challenge in the hospital environment for a patient with autism. Because of the chemicals and drugs and the heavy use of disinfectants throughout the building, people often complain about the "weird smell" when visiting hospitals. Natural ventilation and/or mechanical ventilation should keep the indoor air fresh without the unpleasant smell (e.g., institutional smell, smoke, stuffy/stale smell, irritating smell, etc).

Highlights:

√ Low-sensory stimuli (sound, colour, light, smell, and tactile)
√ The providing of enough storage space to avoid untidy and orderless environment
√ Comfortable and uniform indoor temperature
√ Fresh air without unpleasant smell.

• **Controllable**

The challenge for ASD users is the uncertainty in the space, architectural elements can be affected by many uncontrollable natural factors and it is important to make the built environment under control. Take lighting system as an example, season, weather, and time of a day can affect the indoor light level and temperature. By using of adjustable intensity lighting system can balance the change of natural lighting. It can be used to increase the lighting level and keep the room bright on cloudy days and reduce the brightness appropriately at night to create a suitable environment for rest. The audio system is the same, the level of broadcast and loudspeaker can be appropriately reduced when the general environment is quiet and the sound in the middle level can be heard clearly. The gentle and slow-in voice can reduce the frighten of ASD users within the building. When a TV screen is provided where people are waiting, instead of shutting it down, it is better to put this equipment in a cabinet with a sliding door, so that it can be removed out of sight when necessary.

On the other hand, more important, the design solution is not “one size fits all”, personal needs and preferences are important considerations when designing for sensory elements of the built environment. Especially the ability of hyper-sensitive and hypo-sensitive groups of autistic people to accept architectural elements is different, so they have different needs of the interior environment. In this case, the brightness and colour adjustable lights can adapt to the needs of individuals. It can be used in some private space to make the lighting greatly bright or keep a dim lighting environment. The controllable building elements not only increase the flexibility of environments, but is also a way to reduce the uncomfortable sensory experience and help to control the emotional stability of ASD visitors. It makes hospital environments better adapted to the needs of a different group of people, also provide ASD users with a better spatial experience.

Highlights:

√ The control of audio system

√ The control of lighting system

√ The control of hospital equipment

• Understandable

The medical environment contains a lot of information such as various text and symbol signs, colour coding departments, visual information from electronic screens, sound information from loudspeakers. Common visitor can understand the information cloud and find the target message they need quickly or ask the hospital staff for help, but this is not easy for people with autism. When ASD users enter the hospital, they have to extract effective information from various information while bearing the sensory stimuli from the built environment and the crowd of people. Their limited ability to understand and communicate skills makes them prone to collapse when they cannot handle the simultaneous input of senses and information. Therefore, a legible space hierarchy and wayfinding system are particularly important to help them quickly understand the space and navigating to the services they need. Not only ASD users, everyone prefers a building that is easy to navigate but, ASD users usually need clearer, detailed and easily understandable information.

Highlights:

√ Legible space hierarchy

√ Easy-understandable wayfinding

• Warm atmosphere

The home feeling atmosphere can allow people to relax and retain more information. But generally speaking, the atmosphere of the hospital is usually boring and institutional due to its functions, which may frighten the visitor with autism and make them nerves when searching for medical service. The change in interior design can offset this feeling. Warm colour scheme and lighting, cosy furniture, materials with interesting textures, thoughtfully placed works of art, and plants and decorations can help to convert a conventional hospital into a cosy and informal gathering place.

• Safety

People with autism tend to have unnecessary movements, weak physical balance, chew on non-food items and frequently put the hand into mouth, all these common behaviours make them have an urgent need of safe environments. Especially hypo-sensitive users, they can't feel the sensory input and lack of awareness to realize that they are or will be in danger. Safety issues include the safety of building structures, materials and furniture. Any place with potential risk should be avoided, such as the sharp corner and hard edge of wall and furniture, the slipping floors and unstable decoration objects. The clear and easy-understandable safety signs are needed when some obstruct can't be removed.

In addition, for people with autism, the challenge for the hospital is not only to provide a safe built environment but also to ensure the emotional safety of them. Although the sensory stimuli can be reduced through architecture design, there are still many unavoidable sources of stimulus in hospital, sudden crowds of people and noise, sudden alarm, outside noisy traffic, etc., which can cause them to fall into anxiety and aggression, even hurt themselves or others. Helping them to keep ASD users calm, an escape space can be implemented in the hospital environments, where is a relatively quiet and personal space can provide them with a sense of safety that can help them to calm down as soon as possible.

Highlights:

√ Safety of building structures, materials and furniture

√ Emotional safety

• Predictable

Many autistic people have a fear of "difference", including spatial or environmental difference. There are various functional spaces in the hospital, and each space has its own unique built environment. When people visit the hospital, they inevitably cross between different spaces. Ordinary users can easily and quickly adapt to changes in the surrounding environment, but ASD users are different. Changes in the built environment, especially sudden and obvious one, may cause them anxiety and fear. Making space predictable, offering them an opportunity to preview the unknow space can help ASD users adapt to change of space in advance, which can be achieved by providing a transition area between two different space or adding a visual connection of next space.

Discussion about hyper- and hypo-sensitivity

Based on the previous study, we know that people with autism can be majorly divided into 2 categories being either hyper-sensitive or being hypo-sensitive to sensory stimuli. The senses of hyper-sensitive people are too acute, they can be over-responsive to sensory stimuli. Conversely, hypo-sensitive people appear to be under-responsive, as if certain sensory information goes unnoticed or certain senses are impaired.

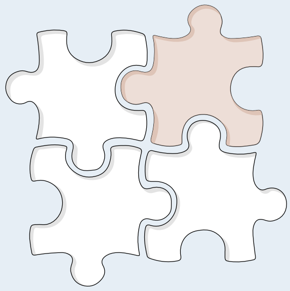
Because they have two distinct needs for the built environment, the requirements cannot be met in the same space. The healthcare environment should be an inclusive, easy-to-use and comfortable building environment for all users. So we consider reducing the sensory stimuli in the space for hyper-sensitive people and enhancing the safety level of the space for hypo-sensitive people. The reasons are as follows:

- **About sensory environment**

Loud noise, bright light, wet materials, strong odour, flicker screen and movement can make hyper-sensitive users feel distressed, uncomfortable and even painful, these sensory inputs may cause their meltdown. It is like a computer that freezes because too many processes are ongoing at once. While hypo-sensitive users don't respond to sensory information and they usually need or seek for strong sensory inputs to stimuli themselves. Sensory therapy is often used in autism medical centres to enhance sensory input and help hypo-sensitive autistic children to feel the world. But for general hospitals, it is important to reduce such stimuli barriers to help hyper-sensitive autistic people use medical services easily and comfortably.

- **About environment safety**

Considering that hypo-sensitive users can't feel the sensory input, which makes the safety issue of the environment especially important. For example, they probably don't feel pain after a hard fall, hurt by sharp corners of furniture and wall, don't scream out when touching extreme hot water, like unnecessary movements which may lead to slip down or fall down the stairs. Therefore, the selection of materials and safety of building structure and furniture (e.g., tables, chairs, doors, and windows) need to be carefully decided.



8.4 3STI principles in hospital environments: 12 criteria proposal

Introduction

01. Space hierarchy

Considering the affinity of individuals with ASD to routine and predictability, it is sensible to organize spaces in a logical order and involve sensorial compatible function. Ideally the space hierarchy is based on the typical scheduled use of spaces and allow a seamless transition from one activity to the next through one-way circulation. This can alleviate disruption and distraction throughout the day. This criterion includes the macro space layout of the building, as well as the micro space hierarchy of each sub area in the building.

1. Space design for people with autism

1.1 Macro space layout

From a macro view, the simple layout is undoubtedly friendly to people with autism, the use of a single visiting circulation is certainly recommended. It can effectively avoid patients travelling on the same route, the intersection of visiting flow and functional area. Mostafa explained that spatial sequencing requires areas to be organized in a logical order, based on the typical scheduled use of such spaces. When designing a school for children with autism, she divided the space area into high sensory stimuli zones and low sensory stimuli zones. Classrooms and therapy rooms were placed in low-stimuli zones. The cafeteria, swimming pool and playrooms all belong to high-stimuli zones. A sensory garden was introduced between the two zones to help ASD children adapt to changes in the surrounding environment in advance. In the design of the home, the autistic users' bedroom can also be arranged far away from the high sensory stimuli area such as the kitchen and bathroom. This can effectively control the negative impacts of stimuli in the space environment on people with autism. However, the functions of healthcare buildings are completely different from schools and homes. A general hospital has departments with outpatient, surgery, injection, and various examination spaces. We cannot require the hospital to change the spatial layout through the level of sensory stimulation. We can only recommend that, on the basis of meeting the requirements of medical design, simplify the visiting circulation of the space as much as possible, provide a clear and understandable wayfinding system to help ASD users understand the space.

1.2 Micro space hierarchy

(1) High-stimulus and low-stimulus area

From a micro view, considering the general examination combined with a consultation room, it should be located near the main waiting area and possible enable patients to be referred on from their initial consultation to a specialist consulting/examination room or treatment. (Figure 8.1) When in their term to treat, they could find the examination room quickly. Compare to the waiting area or corridor, the examination is more private as a low stimulus space. To minimal disruption and distraction, using transition zones, which are discussed in "12 Transition space", between public and private space. Moreover, it should be possible to enable patients to be referred on from their initial consultation to a specialist consulting and examination room or treatment room.

Inside the general examination combined with a consultation room, following the treatment flow, the consulting workstation should be positioned near the entrance then next to the examination area. Compared to the consulting area, the examination area needs more privacy. It would be better the consultation area being located on the outside wall while examination area located on the inside wall (if the window is installed in the wall opposite the door). A window with natural light and peaceful outside view is a benefit for consultation space to release the stress of the patient. Avoid the examination space immediately in front of the patient as they enter the room. (Figure 8.2)

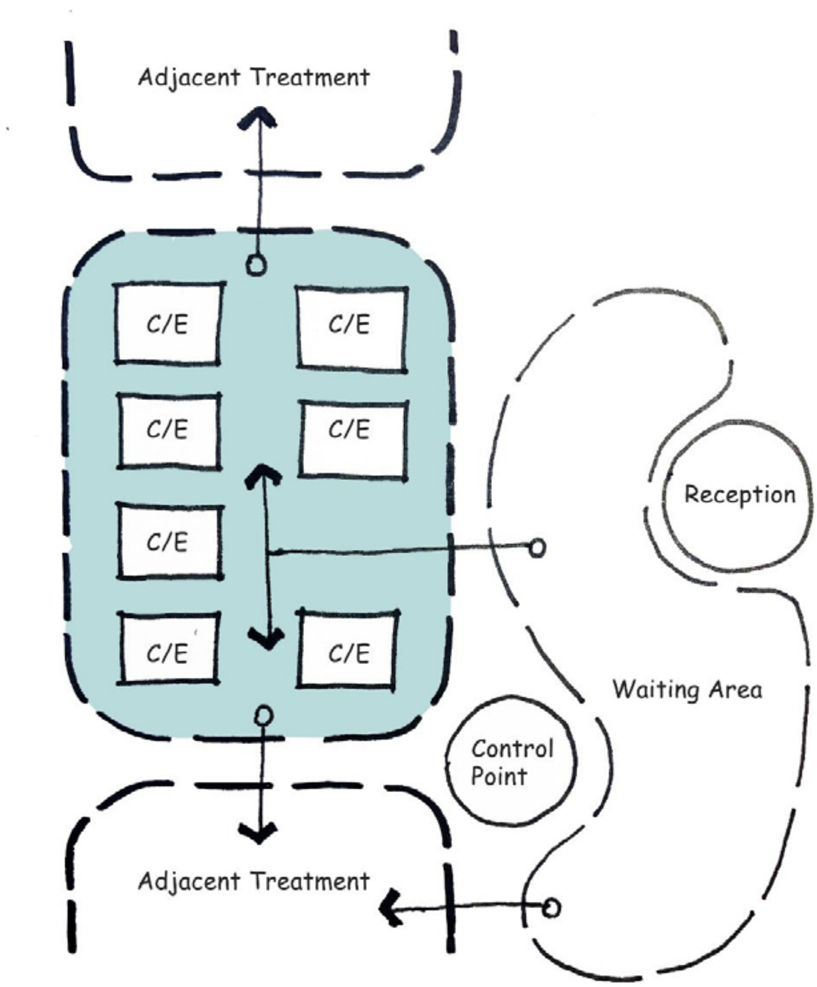


Figure 8.1 Arrangement of consulting/examination treatment

(Source: by author)

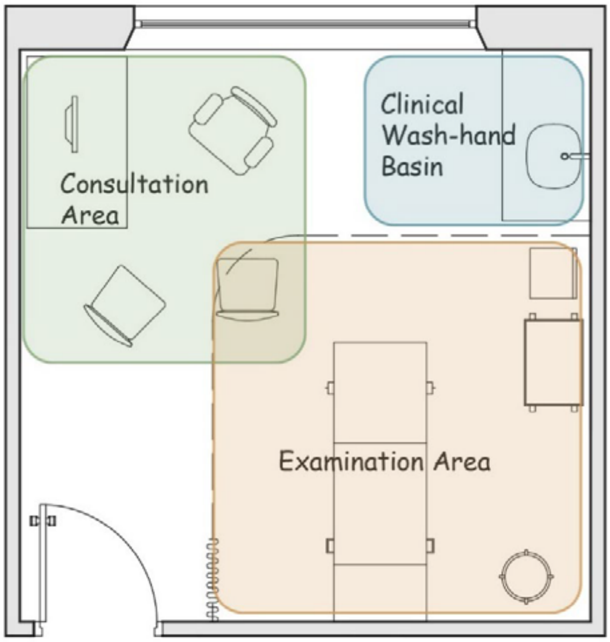


Figure 8.2 Function layout in an examination room

(Source: by author)

(2) Define each functional area

Space hierarchy will affect the ASD people. Mostafa (2014) stated that the space of the classroom can be divided into compartments, each compartment should include a single and clearly defined function and consequent sensory quality. The separation between these compartments need not be harsh but can be through furniture arrangement, different in the floor covering, the difference in the level or through variances in lighting. Clearly define the function of the various area in the space can help autistic people understand the space. The curtain around the examination couch could be regarded as a boundary, also it could use different flooring coverings and lighting to distinguish consultation and examination area.

In the case of Autism Treatment Center of San Antonio (ATC) in the United States, instead of having to paint individual spaces, Led lights can be used to the color-tune room to vibrant orange to stimulate children's minds before an activity, a soothing blue for stress relief, or easily switch back to a neutral white, creating flexible space for both students and instructors. Another case is a patient room in Pars Hospital, Iran (2016) use define the bed area by a light blue flooring covering integrating with wall and ceiling. (Figure 8.3)

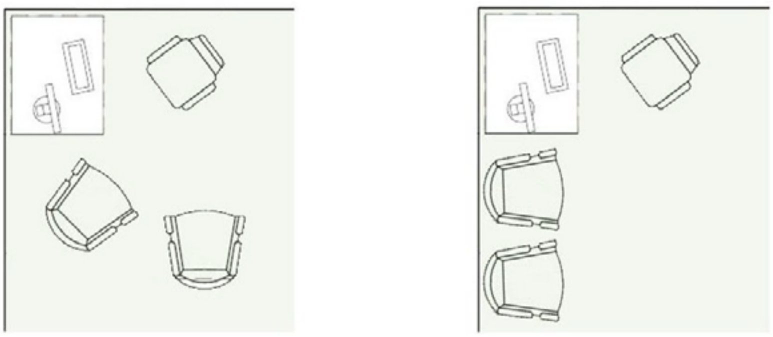
The space hierarchy is not a completely independent criterion. In fact, each criterion does not exist independently. The criteria interact and complement each other in order to provide a better-built environment. Iran Scott (2009) said that it is thus important that all visual cues, colour schemes, different qualities of light, texture changes are used to support the spatial hierarchy rather than confuse it. The Building Bulletin 77 also mentioned that the building should have a simple layout which reflects order, calm, clarity and has good signage and wayfinding.

Figure 8.3 Flooring covering define the area

(Source: Pars Hospital, Iran)

(2) The sense of closure

Mostafa also emphasized closure also plays a role in the tactile character of a space. Hypo-tactile autistic users seem to prefer small intimate spaces, particularly when conducting a clam activity. Users also seem to prefer single beds placed against a wall. Also, some articles have proved that individual with ASD would fear to others approach from behind. In addition, people diagnosed with ASD may resist being close to other people or having other people close to them. Quite frequently they choose to stand or sit in locations where they can hug the wall and/or are translucent as an act to attain privacy. Doing this sets them apart from conversations, and their acquisition of information is restricted. Standing back in the comfort of a wall to lean on also means the person with ASD is not positioned where a lot of conversation takes place. Considering the environment in the examination room, the examination couch and chairs for the patient are better placed against the wall. (Figure 8.4)



√

Figure 8.4 Chairs placed against wall for patient

(Source: by author)

(3) Visual cues/ Symbol

Labelling items can be helpful for a patient with autism to use the room and equipment. Place visual labels (symbols, photos, words, textures) on medical equipment, cabinets, bins, clinic basin. In a well-labelled environment, patient with ASD may better understand what is expected and be less likely to engage in undesirable behaviours. In addition, if the patient understands the function of an equipment (e.g., thermometer, sphygmomanometer), he/she is more likely to use it with less anxiety.

People with ASD need a clearer expressing to tell them the use and function of an area. Therefore, the visual cues about the functional area can be implemented by text and picture descriptions, colour coding, different tactile materials, etc. For example, the hands-free basin could provide a picture instruction and the step which help the patient to get the couch to need a clear sign. (Figure 8.5)

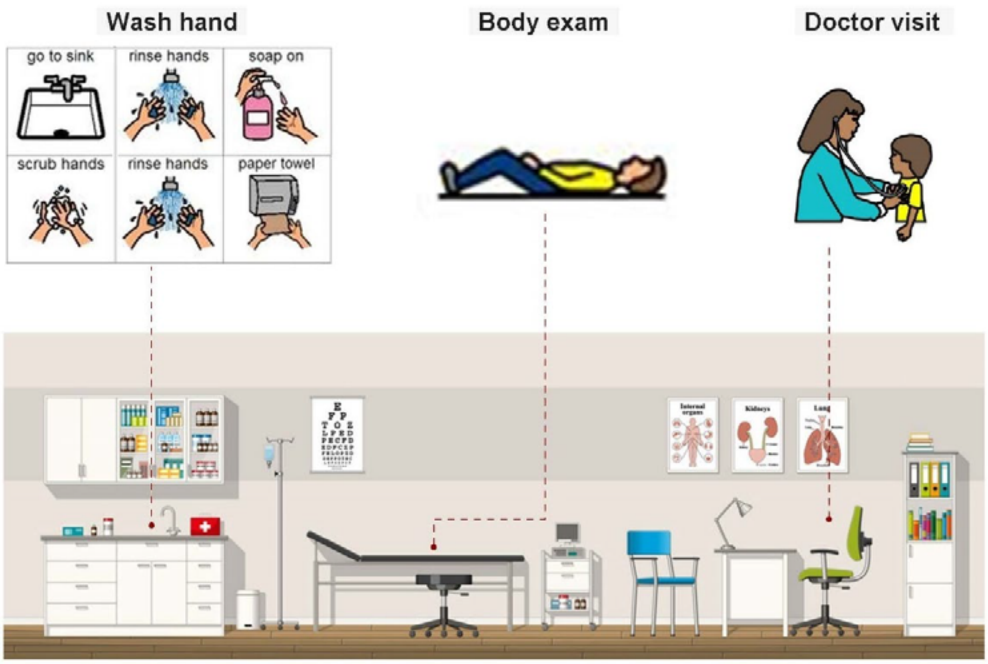
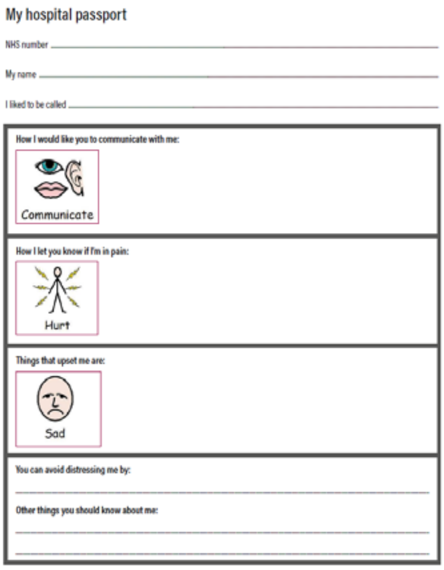


Figure 8.5 Visual cues for understandable

(Source: by author)

A case in Frankston Emergency Department uses picture and communication boards for children with autism. The pictures work really well for individuals on the autism spectrum. By using pictures, the patient can prepare and it makes them a lot co-operative with the assessment. It can also provide clipart images of medical devices and procedures. Figure XXX illustrates a doctor's office visual support package for children and adult with cognitive disabilities.

Some positive approaches have already adopted to help meet the need for the patient with autism. A hospital passport as shown in figure 8.6 is a document that provides important patient information to healthcare professionals. Hospital passports are recommended as good practize by the Department of Health (DH) (2009, 2014), and provide important information to enable positive communication between healthcare professionals and patients with ASC (Bell 2012). Hospital visual support pack enables parents and children to see what will happen next and can help reduce anxieties about the unknown. This can be combined with storyboards for routine procedures, such as 'listening to my chest' (Figure XXX).



My hospital passport

NHS number

My name

I liked to be called

How I would like you to communicate with me:

Communicate

How I let you know if I'm in pain:

Hurt

Things that upset me are:

Sad

You can avoid distressing me by:

Other things you should know about me:

Figure 8.6 Hospital passport for children with ASD

(Source: Ben Richards)

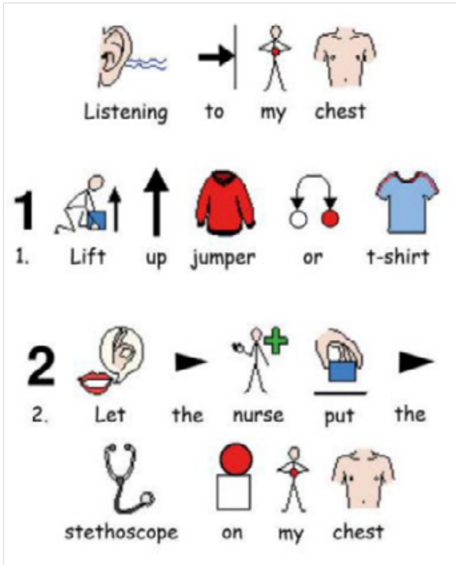


Figure 8.7 Doctor's Office Visual Support

(Source: https://www.sayitwithsymbols.com)

2. Design considerations of ASD-friendly space hierarchy in ambulatory space

- General consultation and examination room should be near the main waiting area and possibly enable patients to be referred on from their initial consultation to a specialist consulting and examination room or treatment room.

- Examination space should have a transition space for patient as they enter the room.

- The consulting workstation locates in the high-stimulus area while examination space locates in low-stimulus area. The consulting workstation is better to located in the outside wall while examination area is better to be locate in the inside wall because it needs more privacy. Also, it should provide visual barriers by curtains, window blinds to ensure the privacy.

- It should be a clear definition of the examination space, consultation workstation and clinical hand-wash basin area to help ASD user to understand the space. The curtain around the examination couch could be regarded as a boundary, also it could use different flooring coverings and lighting to distinguish consultation and examination area.

- Each functional area should have with clear signposts or visual cues to explain its function. For example, the hands-free basin could provide a picture instruction and the step which help the patient to get the couch to need a clear sign.

- Chairs for the patient and the exam couch are better to place against the wall for a sense of closure.

02. Wayfinding

All hospitals are complex environments, and for patients, staff and visitors the ability to get from one part of the facility to another quickly, efficiently and without worry is an important one. The term “wayfinding” covers everything to do with how people find their way round environments. A legible space contains distinct features that aid in wayfinding, making it easy both to find the desired location and to return to the point of origin.

1. Difficult faced by people with autism in wayfinding

HBN and NHS documents state that wayfinding systems in healthcare facilities should be available for all users. Some key considerations were listed to help people with visual impairments and people who are deaf or hearing impaired to find their way in hospital space. ASD people are also vulnerable group people who need special help, the inclusive design of wayfinding system for autism people should come up with.

Many people with autism spectrum disorder (ASD) have a hard time figuring out how to get from one place to another. This navigational challenge can be difficult, especially when a person goes somewhere for the first time. People with ASD often have a great feeling of anxiety when they are in a large and complex building like a hospital. They worry about what they will do if they get separated from parents, caregivers or escorts and have to find their way alone.

There are also data that display a number of navigational impairments in ASD: autistic groups were slower at learning spatial regularities, less efficient in their foraging behaviour, less able to learn locations based on allocentric representations, less likely to sufficiently explore an environment, and more likely to revisit locations that they have already explored. In the study by Morag et al. (2016), they mentioned individuals with learning disorders and autism raised the need for maintaining similarity in the interior spaces across multiple floors.

2. Wayfinding design for people with autism

From the previous literature we already know that people with autism are sensitive to sensory stimuli, there may be many visual stimuli in the wayfinding system. On the basis of providing clear and reasonable wayfinding, we can eliminate visual disturbance to ASD and add some aids to help them better understand the hospital space structure. Successful wayfinding depends, in part, on reading the physical environment as well as on reading and comprehending signs and other wayfinding cues. As individuals make their way, they will be helped or hindered by available cues.

McAllister et al. (2012) used architectural theory and a case study approach to consider the design of the school environment for children with ASD, their study both get the conclusion that “legibility space” can benefit children with ASD.

2.1 Colour coding

Sánchez et al. (2011), and Vázquez and Torres (2013) all advocate for the use of colour coding. In particular, Sánchez et al. (2011) suggest the use of colour coding to help people with ASD. Also, Irish (2013), in a case study approach describing a new school for children with ASD and other disabilities, used colour-coded doors to help children with ASD to navigate the school environment. McNally et al. (2013) suggest the use of colours or artworks to create "neighbourhoods" in the school, they also stated that routes should be "clear and comprehensive".

Vogel (2008) research data gathered from parents, teachers, and therapists of children with ASD, as well as adults with ASD, to create a set of interior design standards for schools. She uses examples such as making evident "paths" with coloured tape or printed footprints.

Some research pointed out that children having sensitivity to colour. Ludlow et al. (2006) conducted an experiment to test the effect of using coloured overlays on a reading exercise with children with ASD. They found that children with ASD were significantly more able to read faster with a coloured overlay than a white page (Ludlow et al. 2006), suggested that this could have implications for the design of the signage. Sum up, colour coding would be useful to help autistic navigating

Three main factors should be satisfied when using colour coding in hospital:

- **Clarity** - Use of optimum impact and legibility for communication
- **Contrast** - Ensuring all users can perceive objects and signs
- **Visual noise** - Ensuring that signs stand out from their surroundings and are not lost in or contribute to "clutter".

Royal Alexandra Children's Hospital adopted a natural world wayfinding strategy with a fun and lyrical pictorial signage system. As patients move through different floors in the hospital takes them from 'underground' at the lower ground levels through to 'sky' on the top floor. Figure 8.8 presents the entrance of the ward unit on 'Free Tops' level while figure 8.9 presents the use of colours to identify different treatment room

When using colour coding for identification, pay attention to the colour scheme for autism. As shown in figure 8.10, in some children's hospital was designed to be attractive to children by using a bright colour, which can be overstimulating to those on the autism spectrum.

Figure 8.8 Pattern identification of rooms (Source: The Royal Children's Hospital)

Figure 8.9 Colour identification of rooms (Source: KOKO Hospital, Germany)

Figure 8.10 Colour identification of rooms (Source: Internet)

2.2 Noticeable identification signage

In ambulatory spaces, it should provide identification signage for rooms. This signage announces the identity of the room and signifies the destination point of the consumers. The font type, set-out and design should be consistent to maximize their legibility. It is good wayfinding strategy to limit the number of doors/ rooms that would require identification signage to minimize cluttering and avoid information overload for consumers. Considering the visual sensitive of autism, the signage should avoid bright colours and reflective surface. (Figure 5.3.11)

2.3 Room numbering identification

A room number is a number assigned to a room within a building. Its purpose is to identify a particular room, and help building inhabitants locate that room. Logical and consistent assignment of room numbers is important for efficient everyday building usage, and to allow emergency personnel to quickly and easily find their way. In the ambulatory space of outpatient area, the room number could help patients find the treatment room quickly.

The room numbers on signs should be legible to patients and visitors (Carpman 1984a). Sometimes the room signage including the room-numbering system. Considering the visual impairments for people with autism, the room numbering identification could be emphasized for autistic easy to see. It could enlarge the size of the room numbering as figure 8.9 and figure 8.10 or integrate with the flooring as figure 8.12 that easy to read for people with autism.

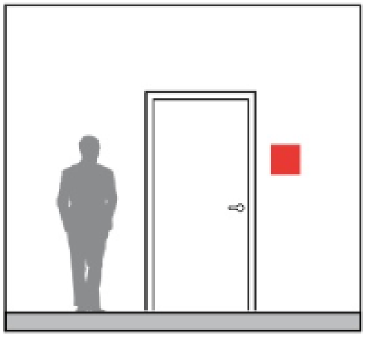


Figure 8.11 Signage of consultation room

(Source: Children's Hospital Colorado, USA)

Figure 8.12 Room numbering identification

(Source: Penn Presbyterian Hospital, USA)

2.4 Easy-understandable pictogram

Sánchez, Vázquez, and Serrano (2010) conducted a literature review of previous studies to find the design criteria that were cited as supporting adults with ASD in the built environment, noting that pictograms or photographs used as pictograms could be useful in wayfinding.

The pictograms are common to use in wayfinding system particularly in children hospital as figure 8.13 and figure 8.14 show. Children would be easy to understand the information with pictogram rather than texts. Also, the use of pictograms would benefit to create a relaxing and noninstitutional atmosphere. This children-friendly strategy is also benefit for people with autism. In the ambulatory space, easy-understand pictograms should be provided to illustrate the function of the rooms to better understand the room that reduce the anxiety.

Figure 8.13 The use of pictogram in wayfinding (Source: Emma children's hospital)

Figure 8.14 Wayfinding design

(Source: Children's Hospital Colorado, USA)

Figure 8.15 The use of pictogram for a medical office

(Source: healthcaredesignmagazine.com)

2.5 Wayfinding technology intervention

Nowadays, many technologies with mobile phone applications are designed to help people with cognitive disabilities address indoor navigation tasks. It serves to demonstrate that it is feasible and easy to implement this approach to indoor wayfinding. It could seem as Google Maps integrated directly into hospitals' own apps. A New York City-based company's MediNav system, navigational technology built into hospital apps and on-site kiosks that provide detailed indoor maps of medical facilities for patients and staff (Figure 8.16). It would show the most direct route, guiding the way with a stream of blue dots, vocal prompts, and visual landmarks. With the help of navigational technology, patients with autism could find their way easily rather than get lost.

Figure 8.16 MediNav™ for navigation in hospital

(Source: https://www.connexient.com)

3. Design considerations of ASD-friendly wayfinding in ambulatory space

- A noticeable signage should be provided in front of the door to indicate the function. The font type, set-out, colour contrast with the background and design should be consistent to maximize their legibility.

- Room number identification should be clear and noticeable to help patients find the treatment room quickly. Considering the visual difficulties for hypo-sensitive, it is better to emphasize for autistic easy to see by enlarging the size or integrate with coour coding.

- The signage should be legible without bright colour, reflective surface and information overload.

- The rooms or cluster of rooms are colour coded (e.g., door, floor, wall colour, etc.) to make wayfinding easier for the patient. At the same time, pay attention to the colour scheme for autism to avoid not too many colours overstimulating colours in wayfinding system.

- Easy-understand pictograms should be provided to illustrate the function of the rooms. Pictograms or photographs used as pictograms could be useful in wayfinding.

- With the help of navigational technology, patients with autism could find their way easily.

03. Sound

Among the sensory stimuli within the built environment, acoustics is the most influential factor on autistic behaviour (Mostafa, 2014, Beaver, 2006). Whitehurst (2012) states that good acoustics within the entire building with no or only limited reflective surfaces create a calm interior. Sound affects people both physiologically and psychologically. Patients should not be exposed to sound and noise that can cause negative feelings such as anxiety and stress. Individuals with ASD may be more prone to external stressors due to a greater sensitivity to environmental stimuli, especially within healthcare environments. For patient with autism, many of the noises other take for granted can be painful and cause unwanted instructions.

1. Acoustic stimuli to people with autism

Auditory sensitivity is experienced by a high percentage of children with ASD. Multiple studies have identified auditory processing difficulties as the most prevalent sensory trigger for individuals on the spectrum (Grandin 2006). However, Quill argues that this oversensitivity to sound is experienced at certain pitches or types of sounds. Individuals with ASD will vary in severity and presence of individual symptoms. Hyper and hypo-sensitive users have different behaviours react to sound inputs, the presence of symptoms and reactions vary in severity, according to the condition of individuals. Following Table 8.1 lists the common symptoms of autistic people when facing various sound stimuli.

Table 8.1 Acoustic stimuli
Hyper-hearing
• Easily distracted by background sounds; • Easily frightened by sudden unpredictable sounds (e.g., telephone ringing, sirens) and has unpredictable reactions to sounds as if it is a threat (e.g., scream or cry to sound); • Often covers ears when the disturbing noise is painful; • Sometimes makes repetitive noises to block out other disturbing sounds.
Hypo-hearing
• Seems oblivious to sounds of surrounding activities; • Seeks or creates for sounds to stimulate themselves (e.g., enjoy crowds, sirens, like the ‘noisiest’ places, bang doors, make loud rhythmic sounds);

(Source: by author, data from Design for Autism Spectrum Disorder)

The most individual with ASD are hyper-sensitive to sound are easily distracted by background noise even soft noise, have difficulty functioning with background noise and find some noise painful. (Nina Scarpinato 2010) There is not a clear noise level range for people with ASD because each individual with ASD will vary in sensitivity and presence of individual symptoms. Moreover, it also affected by pitch, reverberation and signal to ratio. In the hospital, the sources of interior noise are mainly from people (sound of conversation and movement), mechanical services (HAVC system, lighting system, ventilation) and medical equipment. Addressing this sensitivity to sound is necessary when creating environments that individuals with autism will utilize.

2. Noise in the hospital environment

According to the hospital design requirements from “Health Technical Memorandum: Acoustic”, noise level from mechanical and electrical services (excluding medical equipment) in a treatment room is 30-60dB. Medical equipment should be chosen so that is does not adversely affect the use of its surrounding space. Quiet medical equipment should be chosen (Nina Scarpinato 2010). Heating, ventilation, and air conditioning (HVAC) equipment is one of the most common contributors to unwanted sound within the built environment. Alarm is another common source of sound in hospital environment.

In addition to common noise, some article proved that the over-sensitivity to sound with autism is experienced at certain pitches or types of sounds. Individuals with ASD will vary in severity and presence of individual symptoms. According to Magda Mostafa (2014), a preliminary survey of 100 parents and primary caregivers of children with Autism Spectrum Disorder (ASD) ranked acoustics as the most influential feature of the sensory environment upon autistic behavior. She proposed that the acoustical environment be controlled to minimize background noise, echo and reverberation within spaces used by individual with ASD. Particularly, the fluorescent lighting, which emits a low hum, is avoided. Malfunctioning fluorescent lights can produce noise levels of 50 dB. (Manlove, Elizabeth E 2001) A research about observation of repetitive behaviors of six autistic children under two conditions with equal intensity fluorescent light and incandescent light. Subjects spent significantly more time engaged in repetitive behavior under fluorescent light (Richard S. 1976).

3. Acoustic treatment for people with autism

3.1 Sound-absorbing material

(1) Sound-absorbing wall

The structure of walls around an environment can greatly affect the sound qualities within the space. Sound insulation within a wall could be effective to keep a quiet interior environment. Magda Mostafa (2010) suggested that non-reflective sound-absorbent materials are preferable when designing autistic environments. Curtains and wall-mounted cork boards are simple ways to aid in noise reduction in existing spaces. The sound insulation is common to be used inside the wall to reduce the sound from outside. As shown in figure 8.17, on the left is a poorly insulated wall with two thin pieces of drywall. While on the right is a good insulated wall with additional insulation.

From the case of L’eveille du scarabée in Champcevrais, Yonne, France (2015), the coloured wall are lined with Sonebel type acoustic insulation. The roofs of the interior blocks are covered with 25 M1 CC type foam while the plaster ceiling absorbs the resonances. Similar, the multisensory room in the emergency department of Careggi Hospital in Florence, Italy (2016) adopts acoustic insulation inside the interior counter-wall for environment protection and sound insulation. In the ambulatory, there should be adequate acoustic insulation of walls to ensure the acoustic privacy between rooms.

Figure 8.17 Poorly insulation wall and sound insulation of wall

(Source: Design for Autism Spectrum Disorder)

(2) Sound-absorbing ceiling

Sound insulation needs to be set for rooms for a calm atmosphere and acoustic privacy. Noisy activities should not interfere with the need for quiet in adjacent rooms and private conversations should not be overheard. Absorption can take the form of acoustic-absorbing ceiling tiles. The Seniorhuset in Hinnerup adopts the White Troldteckt acoustic panels for the ceiling in the communal areas, where they promote a good sound environment and creates a feeling of closeness and calm for the senses. Nemours Children's Hospital in Wilmington, DE use lino acoustic ceiling planks to create a calm, nurturing space for preterm infants. (Figure 8.18)

Figure 8.18 Lino acoustic ceiling planks

(Source: Nemours Children's Hospital, USA)

(3) Sound-absorbing flooring

Sound interference also includes the movement of people and objects, moving and falling. These movements are inevitable. Andrew Brand (2010) advises additional sound absorption material fitted under the floor to solve these problems. The use of soft floor covering is necessary to minimize the footsteps, the sound of the cart and a loud clash of objects and so on. Christopher Beaver (2006) stated that acoustic is probably the most important aspect of the design to get right since it influences the choice of materials and so the look and warmth of the building. Carpet on the floor will reduce the impact of foot traffic and will absorb sound as well as provide opportunities for decorative treatments. However, carpets are not recommended in clinic area. In clinical area, it is better to choose soft flooring such as linoleum, rubber the false flooring, or Vinyl flooring.

As mentioned in the case study previously, the Nemours Children's Hospital in Orlando uses 3mm thick rubber flooring, which made up of a covering layer of high wear resistance. The smooth surface improves acoustic performance and cleanability. (Figure 8.19)

(4) Furniture sound protector

The protector of furniture could not only prevent the legs from the damaging floor but also reduce the sound of furniture movements. Figure (8.20) The protectors are available for every type of furniture leg imaginable, for example, the chairs, table, cabinets, medical equipment in the ambulatory environment.

Figure 8.19 Rubber flooring

(Source: Nemours Children's Hospital, USA)

Figure 8.20 Furniture floor protector

(Source: https://www.aliexpress.com)

3.2 Equipment noise reduction

Decrease the environmental stimuli from equipment is important in the healthcare setting. For a patient with ASD should use a quiet treatment room with durable furniture, hide supplies from view, remove unnecessary equipment, and keep environmental stimuli to a minimum (Souders 2002). The general equipment is common in building environment but easy to be ignored. Therefore, some strategies for general equipment need to take to fulfil the autism's acoustic sensitive.

(1) General equipment

Decrease the environmental stimuli from equipment is important in healthcare setting. For patient with ASD should use a quite treatment room with durable furniture, hide supplies from view, remove unnecessary equipment, and keep environmental stimuli to a minimum (Souders 2002). The general equipment is common in building environment but easy to be ignored. Therefore, some strategies for general equipment need to take to fulfill the autism's sensitive.

The Heating, ventilation and air conditioning (HVAC) equipment are one of the most common contributors to unwanted sound within the built environment. The heating system aims to maintain a comfortable temperature in the hospital. However, the radiator in the room may cause visual disturbances to the ASD suffers and there are security risks. Beaver (2006) pointed out that children might climb and fall off from radiators. Mechanical ventilation needs to be provided to keep indoor air flowing and air fresh when natural ventilation is insufficient. In the hospital, it is important to eliminate strong indoor odour especially for patient with autism.

Ahrentaen (2009) suggest that choose the quite systems of HVAC, ventilation, appliances to minimize ambient noise. For those with sensory sensitivities, air conditioning and heating systems should be as quiet as possible. If it not quiet, it should be sufficiently soundproofed for the HVAC. (Mostafa 2014) For the heating, Whitehurst (2007) suggests the use of underfloor heating due to without the need for radiators. Moreover, due to the different temperature requirements of different people, the temperature-adjustable heating system will provide a more comfortable indoor environment. For mechanical ventilation, Andrew brand (2010) indicates the use of specific central ventilation systems and acoustic insulation to minimize noise within the building.

Fans should be also taken into considering due to the related sound when it runs. From the case of Sweetwater Spectrum Community, it demonstrates the ceiling fans are not appropriate due to potential sensory stimulation experienced by residents.

（2） Medical equipment

Consideration should be given to reduce as much ambient noise as possible. Monitor alarms should be set to silent in the patient's room if it is safely possible. (Nina Scarpinato 2010) Also the "Health Technical Memorandum: Acoustic" indicate that the needs of people with hearing impairment should also be considered when designing alarm systems. The specific medical equipment in ambulatory and their acoustic strategies would discuss in criterion "09 Hospital equipment".

3.3 Reasonable building structure

According to the HBN 08-01: Acoustic, a reasonable organization and acoustic design of building elements such as door and window could minimize unnecessary noise in the environment. Doors should be sealed, located far apart and avoid directly opposite with each other. Door-closers minimize noise generation. Windows are located and designed to minimize sound directly reflecting into other open windows. (Figure 8.21)

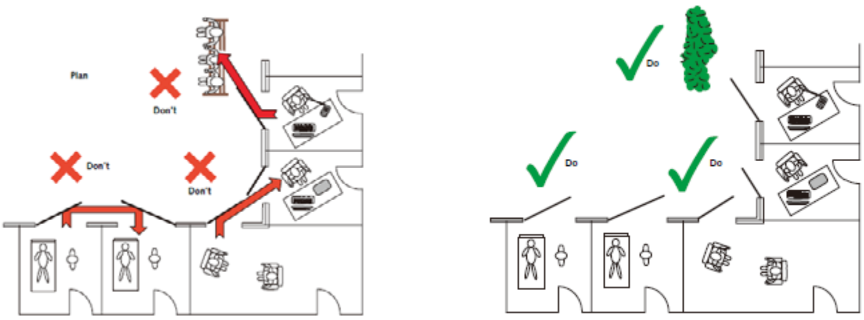


Figure 8.21 Reflected sound from openable windows

(Source: HBN 08-01: Acoustic)

4. Design considerations of ASD-friendly sound in ambulatory space

- Sound-absorbing ceiling tiles and other noise-reduction measures should be used so that the rooms and corridors in staff areas are quiet.
- The surface of floor materials is made by less noise impact materials. (e.g., carpet, rubber, Vinyl, etc.)
- Acoustically absorbent material should be chosen. Soft materials help absorb sound and reduce noise.
- The furniture is covered by sound protector. (e.g.: legs or bottom of consulting desk/chairs/revolving stool)
- There are no noise from mechanical and electrical services.
  (e.g., heating, ventilation, air condition, fans, etc.)
- Choose the quite systems of HVAC, ventilation, appliances to minimize ambient noise.
- There are no noise from external sources in the room.
  (e.g., road traffic, construction noise etc.)
- Quiet medical equipment should be chosen and ensure does not adversely affect the use of its surrounding space.
- Doors should be sealed, located far apart and avoid directly opposite with each other.
- Windows are located and designed to minimize sound directly reflecting into other open windows.
- Main waiting areas are not immediately outside consulting or examination room.

04. Colour

Nineteen percent of people on the autism spectrum experience some form of sensory difference with their vision and, in some cases, this can cause them physical pain. Colour is one of the most influential aspects of an environment with both psychological and physiological reactions. Visible colors are seen through the cones of the eye. An individual will experience emotional and psychological responses to colour.

1. Visual stimuli (colour) to people with autism

HBN and NHS documents state that colour design in the hospital needs to reflect the wide range of their users. Some key considerations were listed to help elder people, people with visual impairments, people in a wheelchair and young people have a better visiting experience in a hospital. Although the ASD population is not specifically marked in the documents, some colour design considerations, especially strategies related to visual impairment people, can be generalized. But it’s widely known that people with autism are more sensitive to colour, bright colour can be painful or distracting for the visually hypersensitive ASD people. Therefore, some additional requirements need to be discussed to create an ASD friendly hospital space. Like most sensory symptoms, colour sensitives can mostly be categorized as hyper-sensitive or hypo-sensitive.

Hyper- and hypo -vision

Hyper-sensitive means the channel between the stimulus and brain is too open as a result too much information gets in for the brain to handle. So, their brains become overloaded. Individuals on the spectrum may exhibit visual hyper-sensitivities by appearing to notice everything in the environment and intensely focusing on the most minute of visual details. Figure 8.22 shows a comparison view between neurotypical and hyper-sensitive.

Figure 8.22 A neurotypical view compared to hyper-sensitive

(Source: by author)

Hypo-sensitive is the opposite of hyper-sensitive, the channel is not open enough and as a result, not enough information gets to the brain and it is deprived. An individual's senses can become so deprived to the point that they are unable to feel their own body or clearly see the world around them. Figure 8.23 shows a comparison view between neurotypical and hypo-sensitive.

Figure 8.23 A neurotypical view compared to hypo-sensitive

(Source: by author)

People with autism have difficulty in feeling the world by using sight as a tool. Autistic people with a hyper-vision can see the stuff that normal can't feel or usually ignore while people with hypo-vision can only identify the outline of objects. Following Table 8.2 lists the common symptoms of individuals with ASD when facing various colour stimuli.

Table 8.2 Visual stimuli: colour
Hyper-vision
• Sensitive to colours, especially bright ones; • Can't bear too many colours in sight • Respond to appearance of certain objects or colours by disruptive behaviours.
Hypo-vision
• Fascinated with reflections and bright coloured objects • Has trouble in figuring out the objects, as they only see just dark and outlines; • Cannot identify a figure from the background;

(Source: by author, data from Design for Autism Spectrum Disorder)

2. Colour design for people with autism

2.1 Neutral colour scheme

The perception of colours by people with autism differs from the neurotypicals due to the defect in their sight because of chemical imbalances and neural deficiencies (Creedon, 2006). Therefore, most of the autistic people see colours with greater intensity than neurotypical people. For this group of people, red appears nearly fluorescent, vibrating with intensity. A small proportion of the children (children on the lower scale of the autism spectrum) see the colour as neurotypical children do and 5% of them see muted colours, they perceive every colour as grey (Creedon, 2006). Most studies have shown that light, warm, neutral it's the best colour scheme for autistic people.

Beaver (2006) stated colour palette should be chosen to provide a pleasant environment, but not overstimulating. Soft and cool colours can help with calm down. Other authors Humphrey (2008), Vogel (2008), Khare and Mullick (2008) all proposed that a neutral and calming colour scheme is recommended for an ASD-friendly built environment.

Mostafa (2014) suggested that autism-friendly designs generally incorporate unsaturated, light earth tones with only small, contained areas of bright colour. She proposed a colour palette in the article she published in 2018, she suggested using a neutral consistent colour palette throughout the school that her team evaluated. She also recommended that subtle, neutral colours can be used to help support navigation.

GA architects focus on projects related to people with special needs, especially for autism-friendly architecture. They have proposed several ASD-friendly design considerations, considering colour, they suggested that low arousal colour should be chosen for interior, without complicated or fussy patterns. Bright colour as red and orange should be avoided, In the meanwhile, the surface shouldn't have a high reflection. The figure 8.24 presents the neutral colour palette proposed by GA architects.

Figure 8.24 Colour palette proposed by GA architects

(Source: GA architects)

2.2 Colour temperature

Many studies have shown that an individual will experience different emotional and psychological responses between cool and warm colour. Half of the colour wheel is classified as warm and the other half as cool. Colours associated with red and yellow are considered warm. Warm colours advance in space. Cool colours are associated with blue and green and tend to recede.

Based on the result of two experiments focus on healthcare environmental sensitivity, Dijkstra suggested that the colour orange has a great impact on feelings of arousal than the colour green has on reducing the feeling of stress. Most significantly, however, the importance of individual differences has been demonstrated in the effects of environmental colour. (Figure 8.25)

Figure 8.25 Hospital room with white/orange/green wall

(Source: Dijkstra)

According to the case study mentioned in the “4 case study”, the Edgecliff Medical Center in Australia uses a fearless orange colour for the back feature wall combined with warm lighting in the reception hall. While in Royal Alexandra Children’s Hospital in Brighton, the wall of treatment room was mounted in light blue and integrated with the sea view of the window, which creates a calming and peaceful atmosphere for the healthcare setting. (Figure 8.26)

Figure 8.26 Light blue wall in the treatment room

(Source: Royal Alexandra Children’s Hospital, UK)

2.3 Colour contrast

In the view of HBN, using colour and contrast may enhance the environment considerably for people have impaired vision for a variety of short or long-term reasons. Wall colour should be different from the ceiling, floor and door colours. Fittings like switches, controls, the button of alarm, door handle in ambulatory should be highlighted in contrast colour with the background. Considering the visual sensitive for hyper-sensitive and the neutral colour scheme mentioned before, the highlighted colour need to be harmony with the environment and avoid visual overstimulate.

2.4 Limit colour quantity

Quantity of colour is another consideration in the design of the physical environment. Verghese stated that large amounts of colour overstimulate individuals no matter the colour temperature or preference. Also, in the healthcare environment, using a lot of different colours may lead to an environment which is too busy, leading to confusion and unease. (R&D Report B: Lighting and colour for hospital design)

In many children's hospital, the colour is usually bright, bold and diversity in order to create a welcoming and playful atmosphere. As shown in figure 8.27, there is three colour palette namely: green, yellow and red in an examination room. However, for the hyper-sensitive autistic they would respond physically to certain overstimulating colour. To avoid the negative effect of colour stimulate, it should limit the colour palette and select the harmony colour. (Figure 8.28)

✘

Figure 8.27 Large area over-stimulate colours (Source: Emma children's hospital, Netherlands)

√

Figure 8.28 Harmony and limited colour (Source: Columbia Memorial Health)

2.5 Minimum pattern

Patterns also should be kept to a minimum. For the hyper-visual, they are an unbearable distraction. For the hypo-visual, they create a distracting opportunity for self-stimulation by "tracking". Like other issues, such tracking can be allowed in a controlled area like an escape space or sensory room to be used when necessary (Mostafa 2010). Using geometric or repeating patterns on surfaces as these can provoke excessive focused interest or new routines. Organic, non-repeating patterns such as natural wood grain can be preferable (Andrew 2010).

3. Design considerations of ASD-friendly colour in ambulatory space

- Neutral and calming and harmony colour scheme should be used for low visual stimuli of ASD users.

- Light colour are recommended because it can reflect illuminance and make the space brighter.

- Limit the colour palette. Large amounts of colour overstimulate patient with ASD.

- Wall colour should be sufficiently different from the ceiling, floor and door colours.

- Fittings like switches, controls, the button of alarm, door handle in ambulatory should be highlighted in contrast colour with the background.

- When using colour contrast, try to avoid bright, overstimulating colours like red and orange.

- Cool colours (green, blue) are recommended in the examination/treatment environment due to the reduction of stress. But it should be light and unsaturated rather than dark and bright.

- Minimum distraction from the pattern. Organic, non-repeating patterns are recommended such as natural wood grain.

05. Lighting

Lighting is one of the most important components of design and one of the factors that most greatly influence how space will be perceived. A great of research based on the experiment has proved that lighting would affect the behaviour of people with autism and the majority of them focus on the learning environment. However, the lighting system also plays a significant role in a therapeutic environment for patient with autism because inappropriate lighting would lead to visual overload.

1. Visual stimuli (lighting) to people with autism

Hypo- and hyper-sensitivity

Sight is the sensory system that one uses to see their surroundings, such as nature, objects, and people. For individuals that exhibit visual impairments, it can be incredibly disruptive and challenging to cope with lighting in a public building.

Individuals on the spectrum with hyper-vision may notice everything in the environment and intensely focus on the most minute of visual details, often feel overwhelming by effects of surrounding environment. Contrary to them, hypo-vision people usually have difficulties with possessing visual issues. Those group of people may disregard people and objects in the environment, as if they are not there at all, or only see the outlines of objects. Some individuals may enjoy bright colours and bright lights, which would be overwhelming, even terrifying for an individual with visual hyper-sensitivity. In the hospital space, we try to balance the different needs of hypo-vision and hyper-vision people for the lighting environment to ensure that everyone can use medical services comfortably. Following Table 8.3 lists the common symptoms of individuals with ASD when facing various lighting stimuli.

Table 8.3 Visual stimuli: lighting
Hyper-vision
• Dislikes bright lights and sunlight; • May be frightened by sharp flashes of light, • Easily distracted by fluorescence lighting, can see a 60-cycle flickers of lights; • Respond to appearance of glare lighting by disruptive behaviours;
Hypo-vision
• May be fascinated with bright lights, reflections and glare; • May stares at the sun or a bright light bulb.

(Source: by author, data from Design for Autism Spectrum Disorder)

Impacts of light stimuli on ASD users In the perspective view of ASD uses, bright lighting can make environment visually-disorienting then may provoke their strong or painful responses to light. This is further compounded by the intensity of the light, the specific wavelengths and any harsh glare. As a result, the brain becomes confused, hindering one's ability to process light stimuli (Robin, 2013).

Certain types of lighting, specifically fluorescent lighting, has been shown to have a particularly negative effect on individuals with autism. Approximately half of the autistic individuals experience severe sensitivity to fluorescent lighting. One study found that the use of fluorescent lighting increased the stereotypical repetitive behaviours of children with autism, which may be attributed to hypersensitivity to fluorescent light flicker (Coulter, 2009).

Based on research on visual sensitivities of people with autism, we try to simulate the views in their eyes in order to have a more intuitive acknowledge about the research results.

Figure 8.29 The glare in common people's eyes compared to hypersensitive people
(Source: by author)

From the perspective of ASD users, the bright light leads to sight blurred, artificial lights can be seen everywhere in the hospital, therefore it is necessary to reduce glare and material reflection from architectural design.

Highlights:	Light stimuli may cause:
✘ Fluorescent lighting	• Blurred sight
✘ Bright lighting	• Painful feeling
✘ Harsh glare	• Stereotypical and repetitive behaviour

2. Lighting design for people with ASD

2.1 Natural lighting and windows

Both the hospital requirements and autism-friendly researches agree that natural light has a positive influence on people. The environment that only have artificial illumination and lack natural light increase stress and discomfort (Kuller 1998). Natural light is much more beneficial than artificial light for reducing stress and discomfort and improving attitude and performance (Edwards L. 2002). However, in some respect need to be considered. For example, it can be affected by weather and time of the day. Sometimes strong natural lighting can cause glaring, especially on a sunny day. In the other hand, natural lighting may meet the illuminance level when it is a cloud. Most people prefer ample amounts of natural light in space but a space with multiple windows that do not have any window treatments or any means to control the light would be useless and undesirable (Kristi 2017).

As mentioned in HBN, curtains, fitting blinds or external screens can be used to control the amount of sunlight, these objects can appropriately diminish visually distracting from outside views, which effectively make the space controllable. Moreover, considering some window coverings, curtains or blinds, may create what is described as "pattern glare." (Winterbottom et al. 2009). A glazed or frosted glass are recommended which can allow natural light to enter the space without creating sharp shadows or glare and will also diminish visually distracting views (Humphreys Lee, 2005). Using matte surfaces, such as matte paint, carpet, or wall coverings made of fabric, will also reduce glare.

Views when incorporating windows in a space to allow for natural light, as some views may pose a distraction. For example, in the classroom, views of the playground fro the windows can be a distraction (Tufvesson 2009). Manage sightlines to outside areas so as to eliminate views to high-activity areas or traffic. A curtain can be added to already existing windows in order to provide natural light but minimize distracting views from the window.

Having too many windows in a space is also likely to result in an overabundance of natural light that is sometimes difficult to control lighting and outside information input. Therefore, in the clinic space of the hospital, the number of windows needs to be considered carefully, it is vital to get a balance between natural lighting, outside view and visual distraction.

Windows in ambulatory space:

- Windows are recommended in ambulatory space where possible, but the arrangement should be minimize distractions.
- Ensure the practitioner is not silhouetted from the light behind during consulting.
- Windows should be with inside treatment (e.g., curtains and blinds) and outside treatment (e.g., sunshade and screens), frosted glass can be the alternative choices.

2.2 Controllable artificial light

(1) Lighting without flickering

In terms of artificial light, majority researches agree in reducing the usage of fluorescent light. Both the visual issue of flickering and the auditory issue of the low humming sound it emits, create a disturbing luminous environment for autistic users. (Mostafa 2014) (Beaver 2006) Visual sensitivity and repetitive behaviours were noted in an area with fluorescent lighting. (Boyce 2010) Fenton and Penney (1985) observed five autistic and five intellectually handicapped children under both fluorescent and incandescent lighting conditions. The study showed the autistic children engage in a significantly greater frequency of stereotypies under fluorescent as compared to incandescent lighting. Most fluorescent light sources cause flicker. Kuller and Laike (1998) said that some of this flicker is not consciously perceived by most people, it can still cause headaches and eye strain and reduce academic performance. Eye strain can eventually negatively affect sleep patterns. They concluded that children may be more sensitive to flicker than adults, so high-frequency fluorescent ballasts that do not flicker should be used.

The following figure 8.30 on the right show how Ann, who is autistic, see a medical room with flickering lighting in hospital visits. It shows the intense colours and patterns from an autism view. The lighting also flickers badly that like a strobe effect. The left picture is compared to ordinary people.

(2) Indirect light

Downward lighting should be avoided as much as possible, especially in circulation spaces, not just ASD patients, all patients will feel glaring and dizzy when they lay in bed through a corridor with direct lights.

(3) Colour temperature: a "soft warm" lighting

Winterbottom and Wilkins examined classroom lighting in UK schools (normal school), identified that lights with a colour temperature of 3500K as being preferred in classrooms for students. Teachers reportedly favour soft lighting because they observe more relaxed behaviour and better academic focus under dim lighting. Although this paper didn't research on ASD children, we thought that his findings provide us with useful information, and we will use them to discuss.

Figure 8.30 Medical room with flickering lighting for autism

(Source: https://annsautism.blogspot.com)

Li Deng and Li Li (2016) did research about interior colour brightness in a healing environment on 60 children with autism. Compare the cool colour, warm colours are more likely to be autistic children receive. When the indoor colour temperature of 5000K, illumination is between 100-200, the brightness in the room in this time most children with autism feel comfortable. Intense light would be avoided because an individual with visual-sensitivity is likely to be bothered by bright lights. Children with ASD often experience a range of sensory problems including an aversion to very bright fluorescent lighting can affect their visual field.

Angela Bourne (2013) observed that in a home for seven men with autism, the men preferred to keep the light levels very low. They also kept their blinds closed in their bedrooms and partially closed in the living areas. It appeared that they did not like brightly lit spaces. The outpatient clinic in the Burkhart Center for autism provides a button selection on the therapy door to change the warmer or cooler tones of lighting.

But this does not mean that everyone likes a warm colour and dim lighting space. Light intensity and colour temperature, just like colour, depends on the preferences of individuals. For hospital buildings, an inclusive colour temperature should be the first choice, and should not be based on the preferences of individuals or some groups. A light with a correlated colour temperature (CCT) of 4000K is recommended in HBN requirement. From the research, we know that CCT of 3000K-3500K colour can emit a "soft warm" light, which is considered can be good in both the physical environment and psychological atmosphere. In many studies on the effects of light on people with autism, they have mentioned to provide them with a non-institutional, soft and home feeling atmosphere as much as possible. We thought that correlated colour temperature between 3000-4000K, soft white light with a bit warm feeling, can create a comfortable and calm environment, which is friendly to all kinds of users in the hospital. The most important thing is to avoid glare caused by natural lighting and artificial lighting.

Application of colour temperature in ambulatory space

Very warm: CCT around 2700, such light provides an overly warm environment which is not suitable for outpatient spaces in hospitals. The strong colour of light would interference the get a good diagnosis and treatment.

Warm: CCT around 3000K, is often used in autism-friendly schools and home environments, which can create a home feeling atmosphere, has proven to be a welcome lighting colour for most autistic people. Such colour is without very strong colour aggressiveness, also suitable for using in outpatient spaces of hospitals.

Soft warm: CCT around 3500K, is a softer colour. This colour is felt towards natural light, making the overall environment relaxed. It is suitable for the hospital environment and welcomed for ASD users to relax the mood.

Natural white: CCT around 4000K, is a light colour usually used in work environment.

This natural and neutral colour create a very calm environment that helps people focus on work or study, also suitable for working environment in hospitals, but for ASD users, it may not help to reduce their stress during treatment.

Cool white: CCT around 6000K, such light creates a space environment that seems without any emotions. Few studies have proven children or adults with autism like to be involved in such cool and serious atmosphere.

Meaning of icons in light colour temperature in ambulatory:
✗ – Neither suitable for hospital space nor for ASD users.
√ – Means it's suitable for circulation space of hospital while also acceptable by ASD users.
√ √ – Means it's both suitable for circulation space of hospital and welcomed by children and adults with autism.

Light colour temperature in ambulatory space

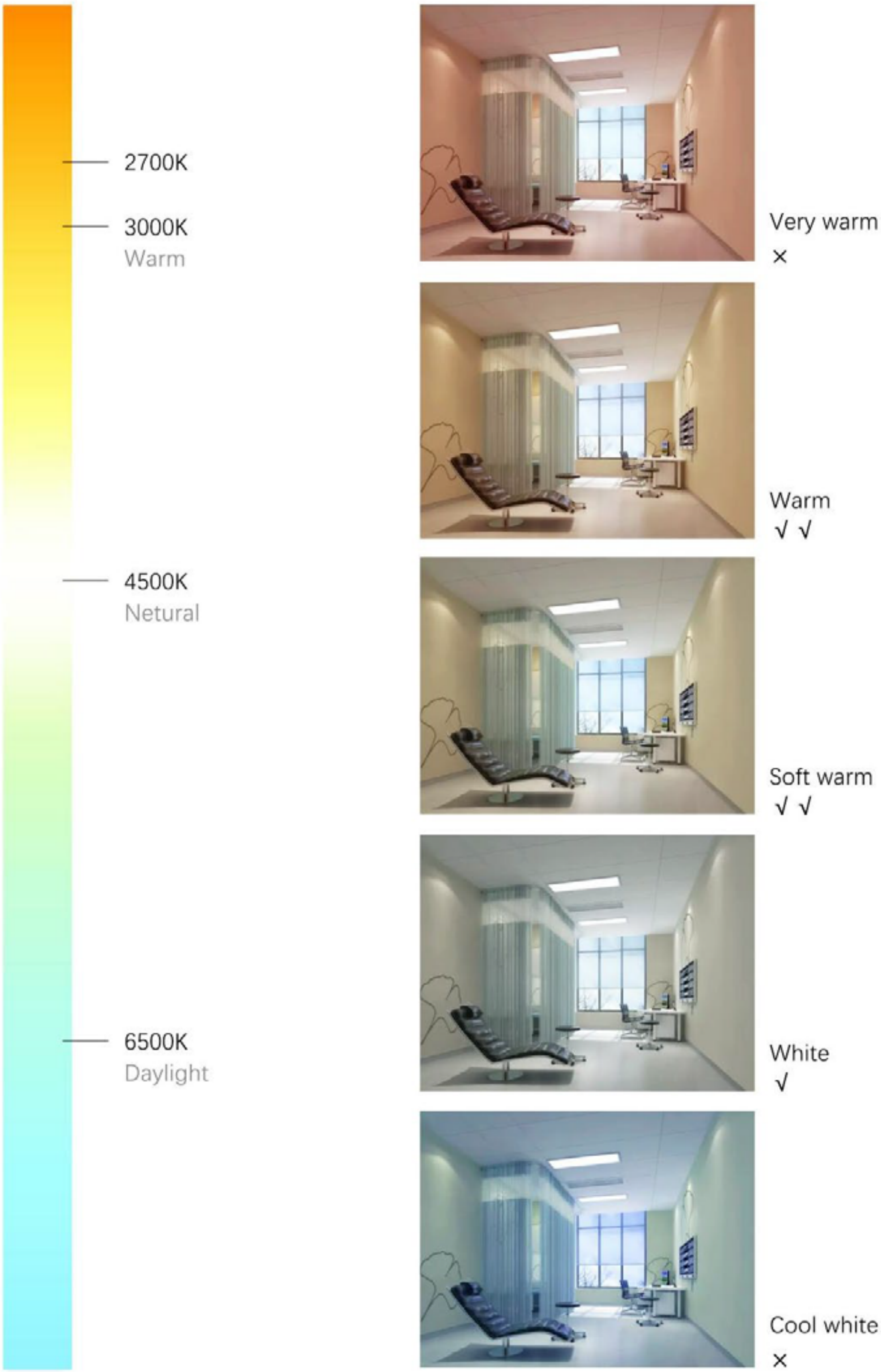


Figure 8.31 Comparison of different light colour temperature in ambulatory
(Source: by author, Image: www.haichanglight.com, edited by author)

(4) Adjustable lighting

It is necessary to consider the controllability and flexibility for lighting. A dimmer switch is also an effective means of controlling light intensity for "sensory diet" reasons, as well as to provide for varying sensitivities of users (Mostafa 2010). Dimmer switches should also be provided in classrooms to control the level of light (Winterbottom 2009). In the hospital, in addition to light-sensitivity for autism, patients may sometimes feel vulnerable or faint. Being able to change lighting is important.

As the case study mentioned before, Acland Burghley School in London adopts the changeable and indirect light in the corridor. The outpatient clinic in Burkhart Center (2012) for autism provides a button selection on the therapy door to change the warmer or cooler tones of lighting depending on individual needs. As shown in figure 8.32, the patient could choose the colour of lighting as they prefer.

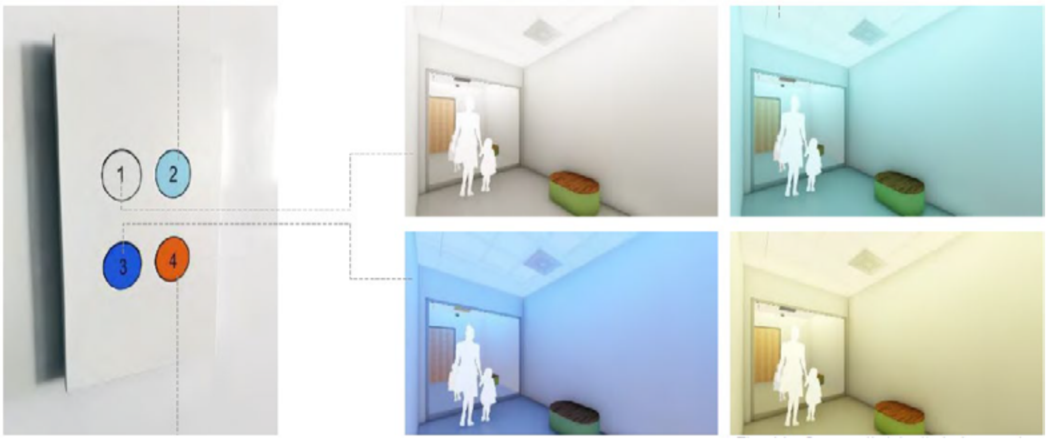


Figure 8.32 A button selection of lighting colour of therapy room
(Source: Burkhart Center for Autism)

- **Brightness adjustable lighting in ambulatory**

  HBN has emphasized the importance of lights with adjustable light intensity. Because a patient may feel vulnerable or faint. Being able to change lighting is important. Adjustable light is also very important for ASD-friendly space. Light level can be appropriately increased or decreased when some ASD users cannot accept the current light level.

- **Brightness and colour adjustable in some special space**

  More modern Snoezelen rooms and autism therapy room has a program to change the colour of lighting and can be controlled to meet the needs of the students. When in operation, the sensory room lighting emits a variety of colours and shapes that engage students' senses and enable them to manage their sensory sensitivities. The sensory space allows the entire space to be flooded with a preferred colour of light that may be changed based on individual preferences.

Considering the different needs of individuals for light and the overall hospital environment, we do not recommend the use of warm or cold light in a large area in the ambulatory space. Provide a dimmable and changeable luminaire that colour temperature and light intensity can be controlled. This controllable light can help ASD users better adapt to the hospital environment and enrich their space experience. For example, a hypersensitive ASD user can dim the brightness of light if he feels uncomfortable during treatment. Also, the working plane and examination area have different requirement of illuminance. This is like "Task illuminance" which means different illumination for different tasks is equally important in HBN. It is better to consider a combination of indirect/direct luminaires and specific task lighting. The different colour and brightness of the light can also make the spatial hierarchy clearer.

(5) Avoid lighting with visual stimulating colours

As we already discussed in “02. Colour” criterion, due to the impairment of sight, some ASD people cannot accept bright colours like red. Creedon (2006) research shows that only a small number of ASD children have the same colour perception ability with normal children, 5% ASD children perceive every colour as grey. Light and colour are complementary, so we thought that when considering the colour of light, we should also pay attention to the usage of red light that may cause visual stimuli to some ASD users.

2.3 Glare and reflection

Glare occurs when one area of the visual environment is brighter than the general brightness of the rest of the environment. (Winterbottom et al. 2009). Glare can come from artificial or natural sources, and the reflection of surfaces is also considered glare. Sensitive individuals may be distracted by sunlight coming in through the windows.

As individuals on the spectrum pass down public spaces, glare from the light reflecting off of surfaces may blur the lines of definition in the architecture and furnishings. Be aware of glare when introducing natural light into interior space, as we introduced in "1. Controllable natural lighting". In the meanwhile, we should pay attention to the selection of materials, the low-reflective and matte materials are recommended which can effectively reduce the glare caused by natural lighting and artificial lighting. In the examination room, avoid glare on a reflective surface and computer screen, equipment screens directly to the patient. (Figure 8.35)

Figure 8.33 Reflective ceramic tile (Source: www.openspace.nhs.uk)

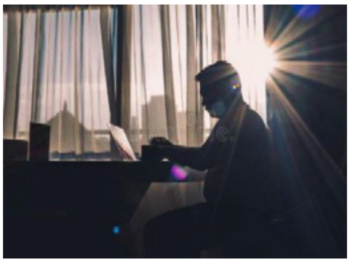


Figure 8.34 Silhouetted from the light (Source: www.canstockphoto.com)

Figure 8.35 Glare (Source: www.howtogeek.com

3. Design considerations of ASD-friendly lighting in ambulatory space

- Windows and/or skylight provide plenty of direct or indirect natural light in the room.
- Provide outside views from the window but avoid distractions. Eliminate views to high-activity areas or traffic.
- Ensure that the practitioner is not silhouetted from the light behind during consulting.
- Windows should be with inside treatment (e.g., curtains and blinds) and outside treatment (e.g., sunshade and screens), frosted glass can be the alternative choice.
- Considering a combination of recessed indirect/direct luminaires and specific task lighting.
- Non-fluorescent lighting. It is better to use LED or incandescent lighting instead.
- Indirect, soft-tone and warm colour lighting.
- Lighting should be flexible, use dimmers and multiple switches to control for vary light-sensitivity of the patient. The optimum illuminance of examination light and light of work plane would cause visual overload for a patient with autism. It is necessary to reduce the illuminance by dimmers if lighting overload.
- Computer screen, medical display screen (such as X-ray viewer) should have dimmer to control the illuminance.
- Avoid glare on a reflective surface and computer screen, equipment displayed screens directly to the patient.
- Use matter surface rather than reflective surface, such as matter paint, carpet to reduce glare. For example, carpet or rubber instead of highly polished tile.

06. Smell

Olfactory sensitivity in autism spectrum has been confirmed in researches that people with autism are highly responsive to various types of smell. (Chris Ashwin, 2014） Smell might be a hidden source of discomfort and even anxiety for some persons with ASD. It might be a faint smell to most might be very powerful smell for persons with ASD.

1. Olfactory stimuli to people with autism

Unusual behavioural responses to sensory input in autism spectrum disorders (ASD), such as hypersensitivity to auditory, visual, and tactile stimuli, have been described in numerous monographs and reports. This is also true for the sense of smell. They may even struggle to distinguish between pleasant and unpleasant smells. For autistic who are very sensitive to smells may notice smells which others do not notice. Patient with olfactory may be distracted by smells during examination.

Chemical receptors in the nose tell us about smells in our immediate environment and the sense of smell can help people to identify danger in our life, such as smoke, escape gas or food that is burnt. Compared to ordinary people, the smell sense of hyper-sensitivity individuals is enhanced and strengthened. Everyday smells, such as spicy food, scented shampoos or petrol may overwhelm people with autism, sometimes they may react in unsafe behaviours to avoid that smell. But hypo-sensitivity individuals on spectrum vice versa, they have a lack of smell and may not be able to identify things based on smell. Following Table 8.4 lists the common symptoms of individuals with ASD when facing various smell stimuli.

Table 8.4 Smell stimuli
Hyper-smell
• Cannot tolerate some smell of objects even it can't can be unaware at all by others; • May refuse to go to a place with scents products. • Dislikes people with distinctive perfumes, shampoos, etc;
Hypo-smell
• Has no sense of smell and fails to notice extreme odours; • Tends to seek out for strong smell like curry power, herbs, flowers, essential oils and perfumes for stimulation experience; • May licks or sniff things to get a better sense of what they are, as a means of exploring environment and gaining information.

(Source: by author, data from Design for Autism Spectrum Disorder)

2. Special smell in hospital

Many people will complain about the “weird smell” in the hospital. Potential sources of odours could be garbage disposal areas, food waste areas, toilets and laundries, bedpan storage and medical waste storage. Another source of the smell is the disinfectant which hospitals prefer to use to make the place clean and free from bacteria and viruses. In addition, the chemicals and drugs also emit special odour. Patients who already dread treatment may have an additional spike in anxiety on simply smelling the air where they are treated, which could affect their response to certain therapies. It also means that medical staff may be confronted by a scent which is negatively affecting them as much as patients, even when the smell can no longer be consciously perceived.

One study found that by inducing anxiety in subjects, “initially neutral odours become unpleasant,” so that even a neutral smell like disinfectant in a hospital could become tied to negative emotions (Elizabeth 2018). And hospitals - with their memories of disabling illness, painful treatments, and challenging diagnoses - certainly have a high potential to form negative associations and emotions. Likewise, in one study of patients with dental phobia, the smell of the dental office was “given high importance” in the intensity their fear (Lehrner 2018).

3. Smell protection for people with autism

The cause of “hospital smell” is multiple such as disinfectant, various medicament, etc. It is inevitable but some solutions could help to reduce the olfactory stimulus for a patient with ASD.

3.1 Hospital cleanliness

Cleaning plays an essential part in helping to reduce the risk of infection in the hospital and providing a clean and safe environment for our patients. Sufficient cleanliness could reduce the smell of garbage and infection. Considering the smell of disinfectant when cleaning, it could allow time for the chemical smell of cleaning agents to dissipate after disinfecting an examination room between patients.

3.2 Good ventilation

Keep rooms well ventilated for fresh air quality. First, it should maximize the use of natural ventilation. Adequate ventilation is essential to reduce unwanted smells that can negatively affect individuals with hyperreactive (extremely sensitive) sensory processing (Sherry Ahrentzen and Kim Steele 2009). Extra artificial ventilation and/or air-conditioning are required in a specific type of room, such as plaster room, wash hand basin, WC, internal waiting areas. Plants and fresh flowers could be helpful in distracting from odours. It could improve indoor air quality by reducing the number of mould spores and airborne microorganisms. (Seong-Hyun Park, 2009) However, it should also take the security risk for a patient with autism especially for children due to their destructive behaviour.

3.3 Nontoxic products

People with autism often have underlying health issues that are exacerbated by environmental chemicals. Many studies that implicate the tendency of ASD to have immune problems. People with autism might not be able to cough up or hold breathing for an unpleasant smell from coming into their system. There is a large number of publications addressing environmental chemical exposures and autism. A study about some volatile organic compounds (VOC) associate with autism. VOC include a large group of chemicals that become gaseous close to room temperature and are released from products or processes. (Amy E. 2014) It is suggested that select specifying low or no VOC finish products and coating. (Sherry Ahrentzen 2009)

3.4 Away from strong smelling area

It is better to avoid places which are strong smelling. Toilet/washroom would tend to emit peculiar smell which have a negative impact on patient with autism. In order to reduce the peculiar smell from toilet, plants and fresh flowers may be helpful in distracting. Avoid using air fresheners or perfumes with a strong odour which cause sensory overload for patient with autism. If possible, the location of toilet could keep a distance from main waiting area and consulting room.

3.5 Fragrance-free environment

Ari Ne'eman, co-founder of the Autistic Self-Advocacy Network in the United State, states the rise of fragrance-free policies at many public institutions. A common source of indoor air pollutants is fragranced consumer products, such as air fresheners, cleaning supplies, and personal care product. Air fresheners can add more confusion to autistic's sensory input. It is suggested that people refrain from wearing scents such as perfumes, colognes when in hospital. Avoid using air fresheners or perfumes with a strong odour which cause sensory overload for a patient with autism in toilet/washroom.

In the examination and treatment room, apart from medicament, also take attention to the odour of soap, hand cream and waste bin. Avoid unnecessary olfactory stimulus for a patient with autism, fragrance-free soap and hand cream are recommended.

4. Design considerations of ASD-friendly smell in ambulatory space

- There is no unpleasant smell, including institutional smell, smoke, stuffy/stale smell, irritating smell, etc.
- Air quality should be fresh by maximizing natural ventilation and extra mechanical ventilation would be required for clinic and functional reason.
- Avoidance of strongly scented products (perfumes, air fresheners, soaps, etc), fragrance-Free soap and hand cream are recommended.
- Eliminating smells, including those from cleaning materials and air fresheners.
- Select specifying low or no VOC finish products and coating.
- Provide smell distraction such as plants and fresh flower.
- Toilet/washroom keep a distance from the waiting area and consulting room.

07. Tactile

After emphasized acoustic before, touch is the most prevalent sensory characteristic observed by autism with sensory sensitivities (Feed, 1998). The tactile sense tells a person what an object feels like. For people with ASD, engagement of the tactile sense is especially important, as they learn by engaging physically with materials.

1. Tactile stimuli to people with autism

Hypo- and hyper- sensitivity

Tactile impairment is the most prevalent sensory characteristic observed by children with sensory dysfunction (Freed et al. 1998). For people with ASD, engagement of the tactile sense is especially important, as they learn by engaging physically with materials. Autistic people may experience difficulty with processing tactile information and fail to get a 'feel' on daily stuff. Hypo-sensitive autistic people usually can't feel things by touching while hyper-sensitive group refuses to tactile experiences. Individuals may resist being touched or hugged, wearing certain types of clothing, and complain about having their hair or face washed. This may cause the brain to be overly stimulated and lead to excessive brain activity, making it difficult to concentrate or organize behavior, leading to developmental delays, learning problems, and other sensory problems (Hatch-Rasmusse 1995). Following Table 8.5 shows the common symptoms that hyposensitive and hypersensitive autistic people exhibit when facing various touch stimuli.

Table 8.5 Tactile stimuli
Hyper-tactile
• Does not like to be touched or hugged, even the slightest touch can send them into a panic attack; • Dislikes to have anything on hands or feet; • Avoids tasks with strong tactile element (glue, clay, water, paint, sand and etc.); • Only likes certain types of clothing or textures.
Hypo-tactile
• Does not seem to notice touch of others; • Tends to seek out tactile experience to stimuli themselves (e.g., physical touch and different textures); • Holds others tightly for pressure sensations and enjoys heavy objects (e.g., weighted blankets) on top of them; • Has high pain threshold, unaware of danger because of low response to pain.

(Source: by author, data from Design for Autism Spectrum Disorder)

For clinic space of hospital, we main consider reduce the uncomfortable tactile stimuli that may threat the sensory of hyper-sensitive users. For hypo-sensitive users it should consider the safety issue because they would be unaware of danger and frequently put things into mouth.

2. Tactile sensitives in therapeutic environment

Tactile defensiveness is a condition in which the tactile system is immature or working improperly. Individuals may resist being touched or hugged, wearing certain types of clothing, and complain about having their hair or face washed. Sensitivity to scratchy clothing or textiles may create additional tactile issues for individuals on the spectrum.

The body touch during examination is another difficult for patient with autism. Children often have unusual responses to touch stimuli. Some individuals with autism have described the perception of routine stimuli such as a casual touch (Michael Seid, 1997). It is helpful to reduce exposure to tactile stimuli that the patient finds annoying or agitating, limit the amount of physical contact, and inform the patient before getting close or touching (Vaz, 2010).

3. Tactile protection for people with autism

3.1 Soft and smooth material

Mostafa mentioned the tactile environment in housing adaptation for adults with ASD. With the hyper-sensitive user, smooth, soft materials should be used while the hypo-sensitive user needs stimulation through rough textures. Natural materials provide a positive balance. Childers and peck revealed soft textures/surfaces are more pleasant and preferred to hard ones. It is similar with the consulting and examination environment, in order to calm down and reduce the anxiety for patient with ASD during curing, smooth and soft materials are recommended.

Soft textures/ surfaces are generally seen as more pleasant and preferred to hard ones for people with autism. Zuo (2014) studied human responses to metal surfaces: "Smooth metallic surfaces evoke positive emotional responses such as lively/cheerful, modern, elegant, and comfortable. In contrast, rough metallic surfaces evoke negative emotional responses such as dull/depressing, traditional, ugly, and uncomfortable." Results were obtained after blindfolded touching. In Bourne's (2013) interviews with adults with ASD, several of the men commented on liking images of residential interiors that had smooth, shiny surfaces.

In ambulatory space, smooth and soft material are recommended for chair, bedding, curtains and cushions. For patients, the materials immediately next to their skin, forming their bed surroundings, are the most important in creating a feeling of comfort. Individual with autism may be particularly sensitive to new sensory stimuli such as rough bedding (Souders 2002). Disposable paper are usually used for examination bed coverings.

Considering the tactile sensitive of autism, cloth gowns and soft exam couch coverings can replace paper. (Figure 8.36)

3.2 Sufficient personal space

The concept of personal space is associated with the sense of touch. People diagnosed with ASD may resist being close to other people or having other people close to them. Quite frequently they choose to stand or sit in locations where they can hug the wall and/or are translucent as an act to attain privacy. Doing this sets them apart from conversations, and their acquisition of information is restricted. Standing back in the comfort of a wall to lean on also means the person with ASD is not positioned where a lot of conversation takes place. In order to help a person with ASD to feel more comfortable in public spaces, a variety of design interventions need to be implemented. Providing opportunities for a person with ASD to ease into a space and acclimatize to their surroundings is one way.

In the ambulatory environment, the chairs for the patient could be located against the wall to help the person with autism to feel more comfortable and protected. The seating with high backs and the upholstered seat would provide a cocooning effect. Cocooning makes the vulnerable person feel more protected, hence more likely to feel less stress in serious situations. (Figure 8.37)

Figure 8.36 Paper covering replaced by cloth covering

Figure 8.37 A sense of protected of high back and upholstered seat

3.3 Soft-touch intervention

In terms of tactile positive intervention, soft-touch objects such as pillows, stuffed animals and heavy blanket could be provided for people with autism. Observations of young adult residents in research conducted by Dr. Angela Bourne (2013) revealed that this group either prefers their personal space such as their bedroom to be heavily adorned with stuffed animals, pillows, and blankets or, in contrast, minimally decorated with tailored bedding. Whatever their preference, evidence suggests that preferences are important to these individuals and that they covet their belongings in unique ways that bring meaning through the tactile sense.

4. Design considerations of ASD-friendly tactile in ambulatory space

- Smooth and soft material are recommended for chair, bedding, curtains and cushions while rough metallic surfaces should be avoided.

- The surfaces of furniture which get in contact with skin such as chair and exam couch should be comfortable and soft. Cloth gowns and exam couch coverings can replace paper.

- The chairs for the patient could be located against the wall to help the person with autism to feel more comfortable and protected. The seating with high backs and the upholstered seat would provide a cocooning effect.

- It is better to inform the patient before getting close or touching.

- Soft-touch objects such as pillows, stuffed animals and heavy blanket could be provided for people with autism.

08. Safety

Safety may be the biggest concern for children with autism who may have an altered sense of their environment and little or no awareness of danger. As autistic children often have the tendency to escape and run away, mechanisms and warning systems that make unobserved leaving of spaces or facilities difficult to exit unseen need to be developed. Therefore, a safe environment plays an important role in individuals with autism. In order to create a safe environment, it should pay attention to choose the building material and furniture, especially for autism.

1. Safety issue faced by autism

Children with ASD would have self-injury (hitting head, pulling hair, pica, biting, pinching), aggression (hitting, pinching, scratching), and destructive behavior (personal property, others' property, small items, furniture, fixtures, and fittings). (Lowe 2007) The first challenge facing some people with autism, especially the hypo-sensitive group and children, is lack of awareness to realize that they are or will be in danger. Less fear may explain why children with autism often run into traffic or deep bodies of water. Here we list a set of behaviours that may lead them more susceptible and exposed to danger.

Table 8.6 Some symptoms and behaviours with potential risks

Hyper-sensitive autistic people may:
• Easily overreacts to various sensory input. • Has poor balance ability.
Hypo-sensitive autistic people may:
• Does not react to sounds indicating potential danger. • Frequently puts things into mouth; • Chews on inedible and non-food items (e.g., soil, grass); • May licks things to get a better sense of what they are. • Has high pain threshold and unaware of danger, even may tend to self-harm; • Does not response to pain after being hurt or touch extreme temperatures. • Tends to move around unnecessarily and enjoys spinning in circles.

(Source: by author, data from Design for Autism Spectrum Disorder)

In general, the layout and organization of the facilities and the intent of the design should be to allow the greatest possible freedom and independence for all users while minimizing hazards, security risks or behavioural triggers for those with ASD. Elements present in the built environment must be designed and chosen bearing in mind the possibility of eventual abuses.

2. Safety design for people with autism

2.1 Material

(1) Durable material

A large amount of study agrees that materials and finishes should be selected to maximize durability and be compatible with their intended function. One reason for that is the repetitive behaviours of autistic, closing the same door over and over, walking the same path repeatedly. Beaver claimed that carpets, wall surfaces and ceilings have to be durable and easily cleaned. Shiny vinyl floors are to be avoided. Also, Richer and Nicoll (1971) suggest that the use of elements and materials that are durable. As the case study of Sweetwater Spectrum Community (2013) in the USA, a new national model for supportive housing for an adult with autism, suggests the use of durable materials, such as impact-resistant drywall, commercial grade doors, and cement board exterior cladding.

(2) Soft material

The soft material does not only help to noise reduction and a comfortable tactile but also be used to cover the edge of the corner to prevent patient with ASD from hurting. Vogel (2008) stated that the soft surface can reduce the potential for injury. For example, a fabric chair is better than a metal one in the view of potential danger.

(3) Harmless material

Beware of chemicals, odors and off-gassing in surfaces such as foam and carpeting. In the view of Ahrenten and Steele (2009), it needs to pay particular attention to specifying products and materials that reduce exposure to toxic chemicals. As the case study of Sweetwater Spectrum Community (2013) in USA, a new national model for supportive housing for adult with autism, highlight the use of harmless materials, such as no VOC paints, adhesives and sealers, formaldehyde-free insulation and wood products, and non-toxic, vinyl-free flooring.

(4) Non-slip and easy cleaned material

Flooring should be seamless and smooth, slip-resistant, easily cleaned and appropriately wear-resistant. For soft flooring to reduce the movement noise, it could choose linoleum, rubber the false flooring, PVC or Vinyl flooring.

Material selection:

√ Soft material
√ Durable material
√ Easy-cleaned material
√ Non-slip material

✘ Hard material
✘ Toxic material

* Carpet should not be used in clinical area.

2.2 Furniture

(1) Soft edge or corner protection

It suggests that all objects in the room, including furniture, have softened edges. Because it would add protection when an autistic is experiencing violent movements during a meltdown. Mostafa (2014) states that the avoidance of sharp edges and corners. In the case of Edgecliff Medical Center in Australia, the furniture, tables and chair have a soft edge. (Figure 8.38) If there is a sharp edge, the protector is needed to prevent the patient from hurt. (Figure 8.39)

Figure 8.38 Soft edge of table and chair

(Source: Mitford Hospital Autism Inpatient Unit, UK)

Figure 8.39 Corner protector

(Source: https://www.stlfinder.com)

(2) Sufficient storage

Provide sufficient storage for patients' possessions and for all supplies to discourage clutter. And considering individual with autism tend to have self- injuring behaviours and destructive behaviours, exposing things would be a potential risk for them. Art furnishing and plants should be protected in glass display cabinets or fixed in building structures. In a medical environment, the medical supplies needed to be hidden from patient to reduce their nervous and avoid the potential risk for injury due to their destructive behaviour. The cabinets and drawers should be keep closed and locked when is not use. (Figure 8.40) At the same time, it should keep dangerous items and medication out of reach, such as sharp objects (scissors, knives, needle).

✘

Figure 8.40 Medical supplies are exposed

(Source: internet)

(3) Well fixed

Due to autistic often have the tendency of destructiveness, furniture and decorative objects should be well fixed and unmovable. Falling furniture is actual a risk to all people, but because of the way autistic interact with the world around them, it can be a great risk to them. Chairs, tables, cabinets and fittings should be fixed to the floor or to each other to ensure the furniture cannot be used as potential weapons or footholds for the climb (Beaver 2003). Structures and fixtures were robust and firmly anchored so that there was no need to interrupt the children's games with safety warnings or instruction

(Richer & Nicoll 1971). Beaver (2006) state that fittings must be firmly fixed, otherwise they could be pulled out of their place.

Safety considerations of furniture:

- Objects in the room, including furniture, are recommended have softened edges. If there is a sharp edge/corner, protector should be needed.
- Sufficient storage for medical supplies and remove unnecessary equipment.
- Chairs, tables, cabinets, fittings and art furnishings are fixed to the floor/wall or each other.

2.3 Building structure

(1) Curved wall

Curved wall it not only liked by children with autism because they would walk in contact it, but also for safety consideration. According to case study of Edgecliff Medical Center in Australia (2012), the form of interior space is geometry circulates and unfolds. It not only promotes an atmosphere of calm, rest and relaxation but also prevents children from harming themselves on corner in severe circumstances.

(2) Window

Windows can be opened to building exterior and restrict locked from the interior. Glazing should be made out of safety glass-both on the exterior and the interior sides. Blinds could be inside double glazings (Beaver 2003). There should be no support in front of the window that can be climbed or used as footholds to prevent ASD users from looking through the window and falling.

2.4 Warming signal

Clear warmings signals or physical barriers should be provided to inform risks of protruding obstacles, slippery area, untouched objects, unclimbable area and etc. Use dividers, tape boundaries, and signs for setting expectations and limits. For example, the use of STOP on windowsill would help patient with ASD understand that these items/areas are off-limits. As shown in figure 8.41, it adds stop signs to every exit of the house to remind autistic not to go further.

Figure 8.41 STOP sign on exit

(Source: http://angelsandautism.blogspot.com)

3. Design considerations of ASD-friendly safety in ambulatory space

- The building materials and finishes including furniture, wall, flooring, ceiling should be durable and easy-cleanable in the environment.

- In the clinical area, the finishes of flooring should be seamless, smooth, slip-resistant, easily cleaned and appropriate wear-resistant. Carpet should not be used in clinical area.

- Use harmless, nontoxic, zero-or low-VOC material including paints, carpets, particle board, plywood and wood production.

- Furniture with a soft edge are recommended. If there are sharp edges and corners, it should be protected.

- Sufficient storage should be provided for medical supplies, equipment, daily necessaries. Unnecessary equipment is removed.

- Art furnishing and plants should be protected in glass display cabinets or fixed in building structures.

- Cabinets and drawers should be keep closed with restricted locker when it is not used.

- The decorative objects are inaccessible. For example, potted plants, artworks need be put in the cabinet with glass windows or fixed in a building structure.

- Windows can be restricted locked from the interior and open to exterior. Use of safety glazing both on the exterior and interior.

- Clear warmings signals or physical barriers should be provided to inform risks of protruding obstacles, slippery area, untouched objects, unclimbable area and etc. Use dividers, tape boundaries, and signs for setting expectations and limits.

- There are no high temperature objects in the room, such as heating radiators and hot water of the handwash basin.

09. Hospital equipment

Youth with ASD are hospitalized at higher rates in comparison to their typically developing peers (Mandell 2008). Frequent hospitalizations and medical appointments are due to the high rate of comorbidities among individuals with ASD. However, in hospital individuals with autism may display an abnormal sensitivity to specific sensory stimuli from the hospital equipment. In order to have a pleasure hospital visit for autism, the influence of equipment should be taken into consideration.

1. Reduce the impacts of hospital equipment

The technologies used in hospital not only bring convenience to people's lives but also increase the sensory burden of sensitive autism people. The medical devices in ambulatory space of outpatient area that would affect autism as following:

- Computer and printer
- Examination light
- X-ray viewer/ Medical display screen
- Beep machine (eg: electrocardiography monitor)
- Alarms

In the environment, the various sensory stimuli generated by electronic equipment should be minimized. The main problem of these equipment and the suggestions would discuss below.

(1) Computer and printer

A rotated monitor computer and printer should be placed on the consulting desk. As mentioned before, the computer screen would be possible to cause glare which is a visual overload for patient. It should consider the brightness level of the monitor for people with visual sensitive. In addition, the sound of printer and of computer keyboard would disturb patient with autism during treatment.

Suggestion: Proper placement of consulting desk, window and the artificial lighting to avoid glare on the screen. It suggests that select matte screen monitor and have a dimmer to adjust the brightness and contrast. For individual with autism, the colour contract and brightness is more dim and soft so it is less painful to look at. Although elimination of all noise is not feasible, it is best to use quiet keyboard and well quality printer. The printer could be placed far from the patient's seat.

(2) Examination light

Ceiling-mounted examination lights should be provided where double-sided couch access is required. For single-sided-accessed couch, wall-mounted examination lights should be provided. According to CISE, the optimum illuminance of examination ranges from 15000 to 30000 (lux). In the perspective view of ASD users, bright lighting can make environment visually-disorienting then may provoke their strong or painful responses to light.

Suggestion: Fulfilling the need of examination, minimize the bright light in the patient's sight as possible. An experimental study in a dental clinic of Children's Hospital Los Angeles make modification for autism sensory-adapted environment. It turned off overhead fluorescent and dental lamps, the dentist wore a headlamp to direct light directly into child's mouth and minimize light in the child's eyes (Sharon 2015).

(3) X-ray viewer

An X-ray viewer includes a photosensor within the housing proximate to the fluorescent lamps for detecting the intensity of the light prior to transmission through the X-rays or other transparencies to be viewed. The problem of X-ray viewer is similar with computer screen. The fluorescent lamp, as mentioned before, would bother their eye and make them feel painful. Again, avoid the glare on the screen

Suggestion: It is better to choose glare-free X-ray viewer with switch for adjustable brightness for patient with autism.

(4) Beeping machine

The electrocardiography monitor (ECG or EKG), which records the heart's rhythm and activity on a line on a screen, would emit beep, beep, beep noise. The noise is uncomfortable for patients and staff. Individual with autism may be particularly sensitive to new sensory stimuli such as beeping monitor. (Souders 2002)

Suggestion: The monitor could be set to silent. A 'sensory friendly' room in Nashville Hospital in USA for kids on autism spectrum aim to minimized sounds as much as possible, like beeping cardiac monitors. Perlin says" We've actually made it so that those monitors no longer ring in the room. They only ring at the nursing station so the child not bothered by it." Monitor alarms should be set to silent in the patient's room if it is safety possible. (Scarpinato 2010)

(5) Alarms

In view of characteristic of autism, they may be very sensitive to loud alarm sounds. The alarm in hospital would be especially stressful for patient with autism during a hospital visit. Fire alarm is common in hospital, but it creates a problem for people with autism. Autism will have an unusual sensitivity to sounds, especially high-pitched intermittent sounds such as fire alarms. They disrupt routine, increase anxiety, and can even be painful (Collins 2010).

The fire alarms are also equipped with strobes, for those who may be hard of hearing. When an alarm goes off, or testing of the alarms happens, these things flash for a while.

Patient/staff call points should be provided in all spaces where patients may be left alone temporarily. The audible alarm signal should operate for one second at ten-second intervals continuously until canceled. It would be terrible for individual with autism.

Solution: For the fire alarm, some literature recommends use a woman's voice or music in place of fire alarm in school. (Jackson, 2011) On the safety condition that reduce the volume of alarm appropriately. Another solution is the placement of fire alarm could far away from the examination room. For the patient/staff call it could replace music with beeping sound.

Medical equipment suggestion:

- Computer and printer should be as quite as possible.
- A switch is needed for screen to change the colour contrast and brightness.
- Beeping machine could be set to silent mode.
- The loud sound of alarm could be turn down or replaced to music.
- The blink lighting of equipment could be covered or shut down when necessary.

2. Design considerations of ASD-friendly safety in ambulatory space

- Under floor heating is recommended due to hide the radiators. The exposing radiators would be a risk of safety for because of the high temperature and able to be climbed.
- Remove unnecessary equipment to reduce clutter in the environment.
- Computer and printer should be quiet. It will be best to choose quite keyboards so that avoid unnecessary sound during consulting. The printer should keep away from patient with autism and choose the good quality printer with less noise.
- The printer could be placed far from the patient's seat.
- Minimize the bright light in the patient's sight as possible during examination.
- Glare-free/ Matte surface is recommended to avoid glare on computer screens, X-ray viewer monitor and other equipment display screens.
- Computer monitor and illuminated display screen (e.g.: X-ray viewer) should have a switch to adjust brightness and colour contrast.
- Examination lights should be non-fluorescent and minimize the bright light in the patient's sight as possible.
- Beeping machine (e.g.: electrocardiography monitor) could be set to silent mode.
- The blink lighting of equipment could be covered or shut down when necessary.
- The loud sound of alarm could be turned down or replaced with music. (e.g.: patient/staff call and staff/staff call)

10. Assistive technologies

A growing number of studies have investigated diverse applications of technology-based interventions with people with ASD. There is a need to provide appropriate technology assistant to help children with autism to integrate their senses and have more pleasurable interactions with people and their environment.

1. Assist technology as a tool in autism education and treatment

Today, technologies are widely used to work on areas affected by the Autism Spectrum Disorder (ASD). Technologies can focus on the strengths and weakness of this disorder as they make it possible to create controlled environments, reducing in the anxiety produced by real social situations. Based on some literature and case study, technologies could be summary in four type: virtual reality applications, dedicated applications, social robots and multisensory intervention.

The following division was used:

- Virtual reality applications
- Dedicated applications
- Robots
- Multisensory intervention (Snoezelen room)

1.1 Virtual reality application

Virtual reality makes it possible to create and develop worlds in which real and computer-created elements are merged. In ASD, it can help us to understand how children with autism are challenged by a sensory overload and aversion to a variety of visual and tactile stimuli. Ehrlich et al. developed a 3D virtual world called Animated Visual Supports for Social Skills (AViSSS) at the University of Kansas in 2008. This system enabled people with Asperger syndrome to work on social skills using different environments and situations shown on the platform. The figure XXX shows a virtual classroom environment for students with ASD.

1.2 Dedicated application

Technological tools targeting people with autism are called dedicated applications (virtual reality is not used). They are designed to be used on computers, iPad or mobile telephones. Applications dedicated to people with autism are mostly support tools to facilitate or assess their skills when communicating, with a focus on social skills. There are a lot of applications and those adapt in hospital such as Vi.co Hospital and Proloquo2Go™ will discuss in the assist technology in healthcare environment.

1.3 Robots

A wide range of studies prove that robot is a useful tool to treat ASD. It shows predictable behaviour, produce controlled social situations and interact with persons in a simple manner. This makes people with ASD feel less anxious by making social situations less complex. Goodrich (2012) included a robot managed by the Wii control in 16 treatment sessions. The children interacted with it. They found that the children were very motivated to interact with the robot and after the treatment with the robots, they interacted more with the clinicians than at the beginning of the study.

Figure 8.42 Virtual classroom environment

(Source: AViSSS)

Figure 8.43 Interact with robot

(Source: Wii)

1.4 Multisensory intervention

In addition to the technologies described, there are rooms with multisensory intervention designed to help an individual with sensory issues learn to regulate their brain's negative reactions to external stimuli by developing coping skills for these experiences. There are various multisensory rooms designed for autism such Snoezelen, RDE, MEIDATE etc. The most common is Snoezelen, which have been used in the therapy of patients with autism since 1970s. The room is specially designed to deliver stimuli to various sense, using lighting effects, colour, sounds, music and so on, to address some of the issues caused by sensory problems.

An autism-friendly multisensory waiting room located in the Emergency Department of Careggi Hospital in Florence, Italy (2016). Design concept of the healthcare environment aimed at reducing distress in hospital and answering to particular needs of people with ASD. The figure 8.44 shows a specific technological system support sensory stimulation including light cones, video screenings, vibrating platform, aromatherapy as well as interactive iPad.

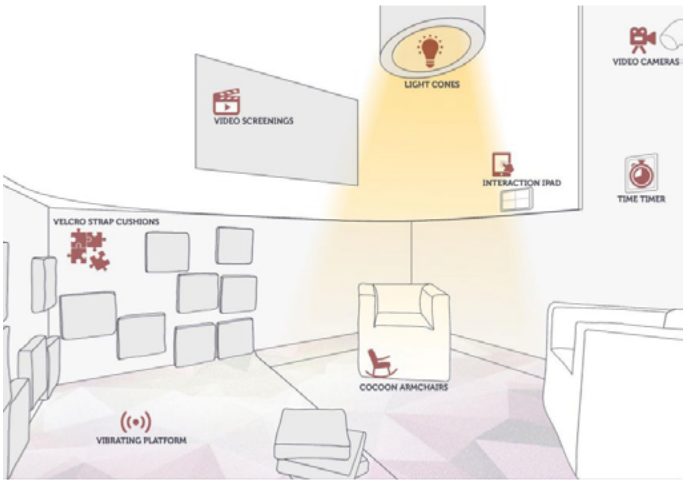


Figure 8.44 Technologies in multisensory waiting room

(Source: Careggi Hospital, Italy)

2. Assist technology in healthcare environment

The hospital experience for ASD patients, their caregivers, and the healthcare provider are multifaceted and complex. Because children with ASD have more anxiety and behavioural conduct problems than children without ASD. Many patients with ASD dislike and/or avoid physical contact and resist being touched by unknown medical instruments, which can be frightening or make them uncomfortable (Gurney 2006). Doctors, nurses, and hospitals are associated with an unpleasant or painful procedure, instigating a heightened level of anxiety.

Nowadays, many technologies were invented for a patient with autism to reduce the stress and sensory overload in the healthcare setting. According to the difficult for autism in the healthcare setting discuss before, the positive technology interventions are mainly solved the anxiety and communication problem of autism during treatment.

2.1 Technology assisting stress reduction

Distraction would be needed in therapy spaced under such a stressful situation for a patient with autism. Based on case studies and related article, most of them focus on the visual and acoustic sensory area.

- **Colour light**

Gentle changes in light patterns and colours are relaxing and interesting. Besides that, the light also provides visual stimulation to address the children's visual hypersensitivity issues by desensitizing (See C. 2015). In 2015, Sharon A. Cermak and his colleagues of the University of Southern California in the USA gained a positive result of a sensory-adapted dental environment (SADE) for children with ASD in a dental clinic in an urban hospital. Their approach is shining slow-moving visual colour effects (Snoezelen) on the ceiling in the patient's visual field. A similar technology application, Securing projectors that project different patterns of light on the ceiling that are soothing, w ▪ as applied in a sensory-friendly emergency room at the Children's Hospital at TriStar Centennial for patients with autism or sensory sensitivity. (Figure 8.45)

- **Video / Illuminated picture**

A calming video and picture such as under-water world, countryside could make the room comfortable and relaxing. An autism-friendly waiting room in the Emergency Department of Careggi Hospital in Florence provides video screenings to project images and videos. A dental clinic in Germany creates the illusion of being in nature by an illuminated picture of treetops" above the treatment chair. (Figure 8.46)

- **Bubble column**

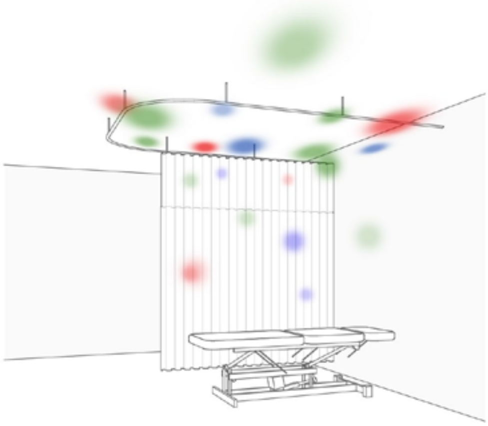
The bubble column is bubbles of air propel multi-coloured balls upwards inside an illuminated column of water. The bubbles float gently to the top giving a great visual effect. The plastic tube gently vibrates and hums for added stimulation (See C. 2015). At Nemours Children's Hospital in Orlando, Florida introduced a special sensory-friendly exam room with various types of distraction objects including an interactive “bubble column”. (Figure 8.47) Autism would want to go in and actually interact with it, as opposed to just being asked to go in a room with a normal bed and machines, which can be frightening to them. Apart from a bubble column, the room includes stimulation disks, a light dome, and a projector with design slides.

- **Music**

Previous research in the fields of music therapy indicates that music can be an effective means of decreasing pain among hospitalized children (Cheetta 1981). Beneficial effects of music listening on health are mediated by a psychophysiological stress reduction (Thoma and Nater 2011).

Certain types of music induce relaxation and positive responses, which reduce activity in the neuroendocrine and sympathetic nervous systems, resulting in decreased anxiety, heart rate, respiratory rate, and increased temperature (Lai et al. 2006). Generally, sedative music that is suitable for music intervention tends to have no accented beats, no percussive characteristics, a slow tempo, and a smooth melody (Chlan 2000). The music could cooperate with projector screen. For example, people with autism look at the “Under Water World” while listening to “Sound of dolphins”. Sum up, music should ideally be selected by autistic patients based on their preferences.

The background music should possible to turn it off. An experimental study in a dental clinic of Children’s Hospital Los Angeles makes a modification for autism sensory-adapted environment. It played calming, rhythmic music in the treatment room. One child with ASD stated that he did not like the music and requested to turn it off (Sharon 2015).



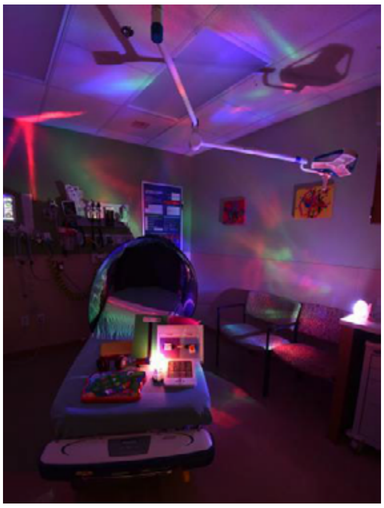
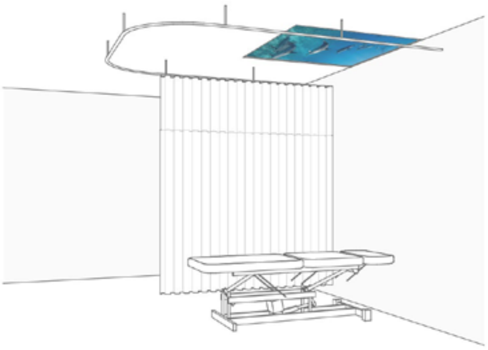


Figure 8.45 Moving colour light

(Source: Children's Hospital at TriStar, USA)



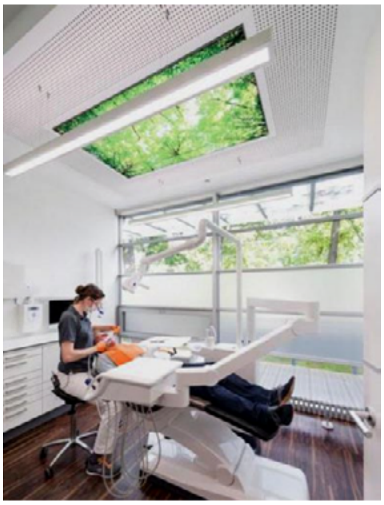


Figure 8.46 Tree picture above patient visual

(Source: http://kriesche-plan.de)

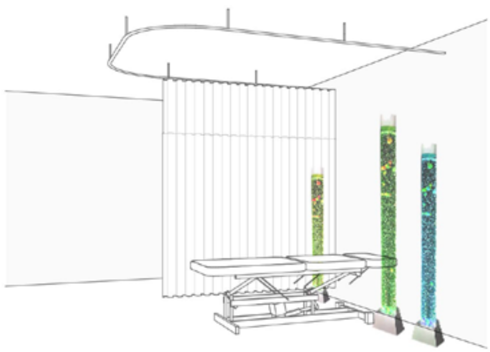


Figure 8.47 Illuminated bubble column

(Source: Nemours Children's Hospital, USA)

2.2 Technology assisting nonverbal communication

Children and adults with autism have difficulty with verbal and nonverbal communication. Apart from the help with visual cues, iPads would allow patients to communicate with staff and providers to assess a patient's pain and discomfort level. An “autism-friendly “pediatric emergency department of Capital Health- Hopewell Hospital in the USA have applied the technology to help medical providers learn why the patient arrived, their pain levels and communication preferences. Some specific applications are designed as a communication solution for people who have difficulty speaking like autism.

• Vi.co Hospital

"Vi.co" stands for Visual Communication. People with communication disorders and in particular people suffering from ASD are assisted in understanding messages if they are conveyed using visual languages. It intended for the interaction between individuals affected by ASD and medical and nursing staff, therapeutic operators, families and care-giver.

Depending on the individual level of understanding, it is possible to select between the use of an iconic code, a photographic code or video, for showing and demonstrating in detail and step by step, to those affected by difficulties, the way visits, physical examinations, medical tests, etc. are carried out. (Figure 8.48)

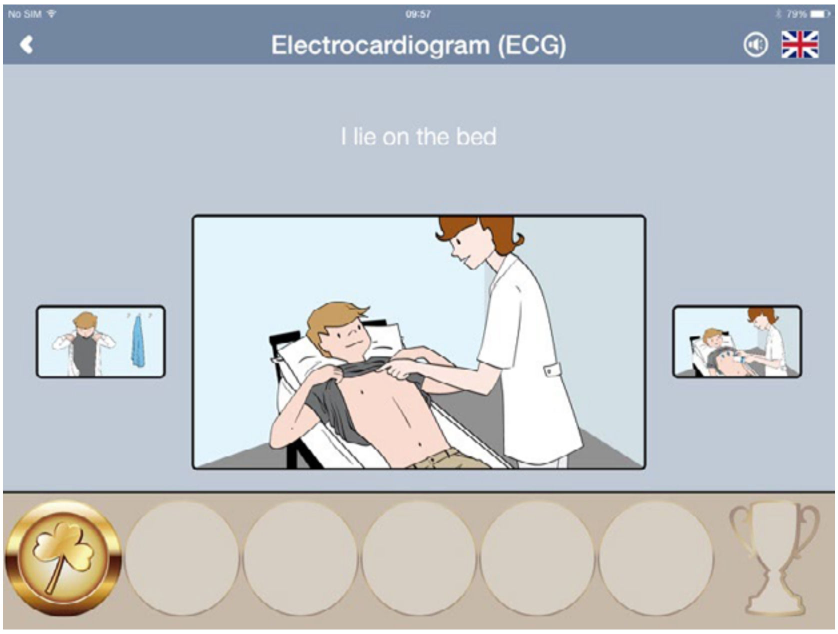


Figure 8.48 The Vi.co Hospital software

(Source: http://www.vicoapp.it)

• **Proloquo2Go**™

From Norah L. and Dana (2013), it introduces the Proloquo2GoTM communication software for the iPad [http://www.proloquo2go.com] to allow an individual with autism's voice to be heard through pictures (Figure 8.49), which can be a useful solution in hospital and rehabilitation settings. The application was tested by Taylor (2015) for enhancing communication in children with autism during therapy in the USA. The study proves that using Proloquo2GoTM with children with ASD is useful as an accessible form of communication.

An interactive iPad is not only used for therapy communication but also benefit for autism to change the physical environment as they prefer. An autism-friendly waiting room in the Emergency Department of Careggi Hospital in Florence use iPad for autism adapt the space to their needs by changing the colours, music, pictures, videos and anything else wanted. Communicates through a system of images showing primary needs and one's own physical and psychological comfort necessities. (Figure 8.50)

Figure 8.49 Proloquo2Go™ software

(Source: http://www.proloquo2go.com)

Figure 8.50 Change the environment by iPad

(Source: Careggi Hospital, Italy)

2.3 Technology assisting noise blocking

If the surrounding noise overstimulate the sound sensory, the simplest way of doing that is to give the affected person a way to block it. Organizations like the UK's National Autism Society recommend using headphones or earplugs to block distracting sounds, and many people have found it effective. By wearing noise-canceling headphone individual with ASD can eliminate most of the background noise and reduce what remains to a manageable level. It has already applied in many autism-friendly sensory rooms. The sensory-friendly room at Tristar Centennial Hospital provides noise-canceling headphones or earplugs to decrease sensory overload. This makes it possible to concentrate on other tasks, relax, play games with others and many more activities that are normally difficult or impossible.

3.Design considerations of ASD-friendly assist technology in ambulatory space

- It is suggested to provide distracting objects for the patient with autism to reduce their stress during examination. For example, gentle changes in light patterns and colours are relaxing and interesting. A calming video and picture such as under-water world, countryside could make the room comfortable and relaxing.,

- Calming, rhythmic, smooth melody, slow tempo background music could be reduced the stress. The music induce relaxation and positive responses would resulting in decreased anxiety

- It is possible for patient with autism to turn off the background music.

- There are means for non-verbal communication to help the patient with autism communicate with staff. For example, iPad with dedicated application like Vi.co Hospital.

- Noise-cancelling headphones or earplugs should be provided for patient with autism.

11. Escape space

Secluded retreats are important features in educational facilities to provide relief for the autistic user in case of overstimulation through their environment. (Mostafa, 2008, 2014; Whitehurst, 2006, 2012). Individuals with ASD may benefit from escape space to retreat to when feeling overwhelmed with sensory overload from the environment. It is important to design for people with ASD although would be easy to ignore in reality.

1. Importance of escape space for people with autism

An individual with hyper-sensitive symptoms can be easily overwhelmed when too much stimulation is present in the environment and each case of ASD comes with its own opportunities and challenges. Therefore, a neutral sensory space should be offered for them respite from overwhelming. As early as 1971, in the pioneering work of autism and the built environment, Richer and Nicoll mentioned the importance of escape space. They called this space "retreat space". In 2008 when Mostafa does the intervention experiment to test impacts of architectural elements on children with autism, she found that it is important to establish an escape space in the classroom, which should be in the lowest stimulation area of the classroom. Beaver (2007) recommends providing “quiet rooms” where a child having a tantrum - or simply experiencing too much stress, due to sensory overload, for example - can calm.

2. Characteristic of escape space

Escape space should provide a neutral sensory environment with minimal stimulation that can be customized by the user to provide the necessary sensory input (Mostafa 2014). Normally it located in the lowest stimulation part of building or room that is not prone to a lot of noise or interruptions. Their rooms should provide only minimal stimulation to provide respite but can be equipped with adaptable and flexible equipment that can be changed to be either stimulating or calming to meet the needs of individual users.

Also, it should provide adequate privacy. Individuals need to live and learn in spaces that provide personal privacy. Mostafa (2018) recommends the escape space need to be at least partially separated from the remainder of the room. Generally, the escape space has to be kept neutral in colour, texture and other forms of stimulation, as well as be located in the quietest part of the room whenever possible.

Escape space feature:

- Minimal stimulation
- Soft furniture
- Adequate privacy

3. Application of escape space

3.1 Application in learning environment

In the learning environment, it is necessary to create an escape space, which located in the lowest stimulus area of the classroom. This area can be used at the beginning and end of classes to help children calm down and prepare to be more receptive to the upcoming tasks (Mostafa 2014). Escape spaces are helpful to children that tend to be hyper-sensitive, as the environment is particularly stressful for them.

When Mostafa(2018) adapt the ASPECTSS for post-occupancy evaluation in a school, she describes the escape space in the classroom as: a carpeted area with soft furnishings such as cushions and/or beanbags, typically located in the corner of the room opposite the wet area sink counter along the exterior wall.

3.2 Application in living environment

It suggests that separating the "loud" spaces and "quiet" spaces within the home for people with autism. Space like the kitchen, TV room and dining room that typically create a lot of noise are located on the side of the home, while bedrooms are on the other side. An escape is located on the "quiet" side of the house to reduce the number of auditory stimuli. The escape space could be a room located on the quiet side of the house or a quiet reading room as long as any books and materials can be stored in a way they are completely hidden from view. If space in homes is not luxury, an escape can be a spare closet that has been emptied of its contents or a screened-off corner of a quiet room (Kristi 2017).

Though most of the study focus on learning space, an escape space in therapeutic environment can have equal benefits for a people on the spectrum. In the hospital individuals with autism, particularly children, would desire to escape from a stressful medical situation.

3.3 Space form

The form of escape space is diverse. Mostafa (2014) states the escape space include a small particularly area or crawl space in a quite section of room, or throughout a building in the form of quite corners.

(1) Quiet room

A quiet room particularly for people with autism is already applied in learning, living and therapeutic environment and other public space like airport and park. Judy Toth worked with Autism Speaks to design a space appropriate for helping kids recover from sensory overload in Florida. The room features lowing lighting, a tent for privacy, bean bag chairs, stuffed animals and even items used in treatment. (Figure 8.51)

An escape room could be "snoezelen" room for autistic to choose their level of privacy and control the amount of interaction with others. It is designed as a sensory neutral space with various items close at hand, much lik 发 e a small Snoezelen sensory curriculum room (Hulsegge, & Verhal, 1987) so that people with ASD can have the space customized according to his or her sensory needs. As mentioned in the "10 assist technology", a multisensory waiting room for special need of people with ASD in emergency department of Careggi Hospital (2016) to reduce stress in hospital.

Figure 8.51 Calming room for children with autism

(Source: Tennessee park, USA)

(2) Small quite area

When no separate room are available, small particularly quite area or corner within a room is the most common in existence designed for autism. Creating an area or corner of the room designated as a quite space, give autistic a space to relax and regulate their emotion. An escape space could be used for reading, listening to music to calm down. The Children's Hospital of Philadephia (CHOP) create a small quite space with lower ceiling height, carpet and tree wallpaper for reading as figure 8.52.

Figure 8.52 Quite space

(Source: Children's Hospital of Philadephia)

Figure 8.53 Quite space

(Source: https://sites.google.com)

For a whole hospital and a department, it could provide quite rooms particularly for patient with autism. For an examination room, it is suggested that create a quiet area in the lowest stimulus area with carpet, soft cloth as well as some books for read to reduce stress during therapy. Essentially it is a small partitioned area where a child may seek refuge whenever over-stimulated or overwhelmed. (Figure 8.54)

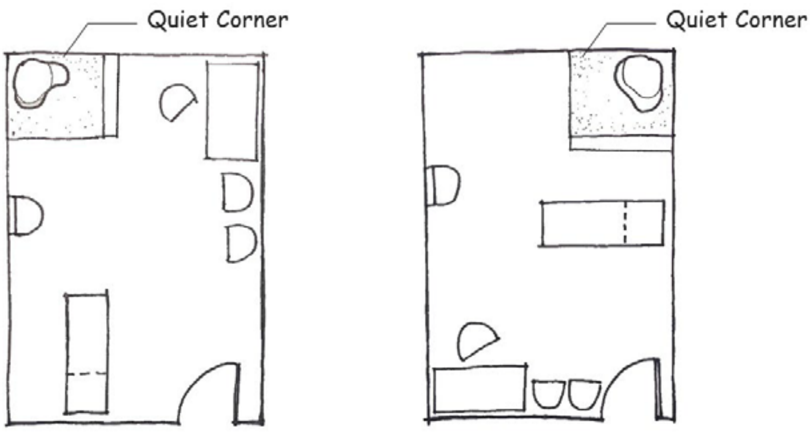


Figure 8.54 A quiet corner in an exam room

(Source: by author)

(3) Built-in space

Compared to the escape space mentioned above, the "built-in" space is more flexible. It is common built in a wall or integrated with windowsill, which provide a small, private seating for sensory restoration.

A case in the Garden School in London Borough of Hackney provides built-in hexagonal seating for learner with autism to relax and restore their physical and mental energy. (Figure 8.55) It could improve students' concentration, attention and perception of safety. Another case in Levine Autism Clinic, which provide evaluation and treatment services for children and youth with ASD, create "holes" on the wall along the corridor for people with autism for seat and retreat their sensory.

Figure 8.55 Escape in hexagonal seating

(Source: The Garden School, UK)

Figure 8.56 Escape in built-in seating

(Source: Levine Autism Clinic, USA)

4. Design considerations of ASD-friendly escape space in ambulatory space

- A quiet waiting room like the “snoezelen” room could be provided particularly for people with ASD in the hospital.

- A quiet corner in the room lowest stimulation area could help ASD patients escape away from sensory overload and hide themselves for relaxing or calming down during examination.

- The escape space is better to be equipped with soft furnishings (carpet/ beanbag), neutral colour as well as books for reading.

12. Transition space

The transition between environments can be an important moment for people with autism. The presence of transition space helps the user recalibrate their senses as they move from one level of stimulus to the next. It could help people with ASD adapt to the environment change in advance.

1. Importance of escape space for people with autism

A lot of literature state that individual with ASD would difficult to move from one place to another or one activity to another. They may have greater difficulty in shifting attention from one task to another or in changes of routine. This may be due to a greater need for predictability (Flannery & Horner,1994), challenges in understanding what activity will be coming next, or difficulty when a pattern of behavior is disrupted.

"Many autistic children have a fear of "difference", including spatial or environmental difference." (Andrew Lester, Aitken Turnbull Architecture) People with autism are bombarded with sensory stimuli. They perceive everything without filtration and selection. This leads to the perception of the whole scene as one single entity with all the details perceived but not processed simultaneously (Bogdashina 2011).

Known from the literature review, the autistic individuals feel more comfortable and in control when they have a transition zone between private and public space (Vogel 2008).Mostafa (2014) indicates that the presence of transition zones helps the user recalibrate their senses as they move from one level of stimulus to the next. It can be used in the separation of different functional spaces in the room, or in the junction of indoor and outdoor spaces. It can be in many forms, such as using a threshold instead of a door to divide the space, providing not only a visual transitional area, but also reduce the visual pressure of a large number of doors.

In general, transition area and threshold help the user adjust their senses as they move from one level of stimulus to the next and are especially important as users transition from high-stimulus to low-stimulus.

2. Transition space design for people with autism

2.1 Transition space between public and private

The threshold space is often considered to be a transition space between public and private. The definition of threshold is the floor of an entrance to a building or room according to the Cambridge Dictionary. In the architecture filed, it is common refer to spatial conditions that create openings in boundary allowing for movement and transition in space.

A case of using threshold space is in New Struan design by Aitken Turn Architecture (2005). In the education center, the classrooms are integrated with the atrium space by threshold spaces or ‘lay-bys’, which are personalized and allow the children to assimilate the environmental and spatial change from the atrium space to the classroom. (Figure 8.57) Andrew Lester, who is the architect of the center, states the threshold space can make children with autism feel threatening. The anterooms smooth the transition between the play space represented by the street and the teaching zone found in the classroom.

Another case is Seniorhuset in Hinnerup project (2014), a housing for elderly people with autism. It designs a safe transition zone in the entrance to each flat with a niche with a bench and a plant. (Figure 8.58) The residents can choose to sit on the bench outside their own apartment before perhaps summoning up the courage to move on into the communal area.

Figure 8.57 Classroom threshold space
(Source: New Struan School, UK)

Figure 8.58 Flat threshold space
(Source: Senior House, Denmark)

Based on the cases, thresholds can be formed through altering ceiling heights, switching floor coverings, changing the colour of interface and lighting or arranging furniture to indicate separate functional areas. It has been found helpful to clearly distinguish the sensory qualities of each space. This will help provide sensory cues as to what is expected of the user in each space, with minimal ambiguity.

Thresholds are needed in front of the treatment room to help patients with ASD recalibrate their senses in advance. As mentioned in the critical thinking before, both the main waiting area and corridor are usually crowed, noisy. It is difficult for them to cope with the sudden change of environment when entering directly a closed, quite examination room. Therefore, threshold with dimming light, lower ceiling height, calming colour scheme could benefit to calm them before taking an examination. (Figure 8.59)

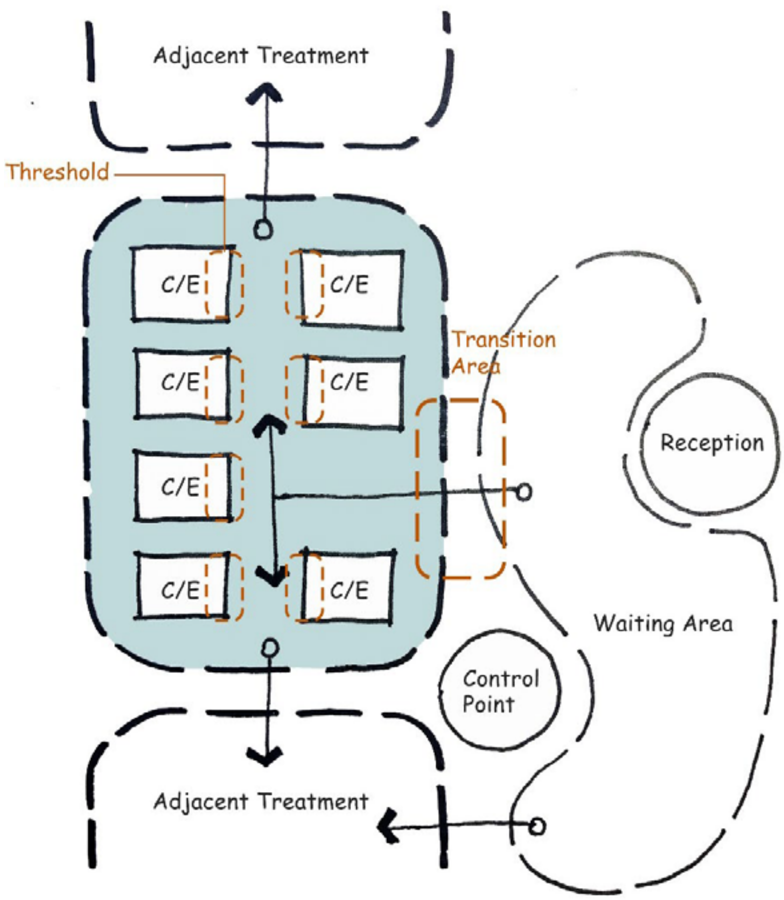


Figure 8.59 Transition space in ambulatory space

(Source: by author)

2.2 Visual connection

The visual transparency from space to space allows the vulnerable population they serve to scan the environment and establish their bearings as they adjust to a new setting. View connection should be considered.

Visual connection by window could be one of the transition space between interior and exterior. According to the Mitford Hospital Autism Inpatient Unit located in UK (2017) as the case study mentioned before, a well-positioned window or window seat would be a transition space from inside to the outside.(Figure 8.60) Additional when glass is used as the division of space, the frame or corner should be marked with visual contrast in case the autistic uses have collisions with it.

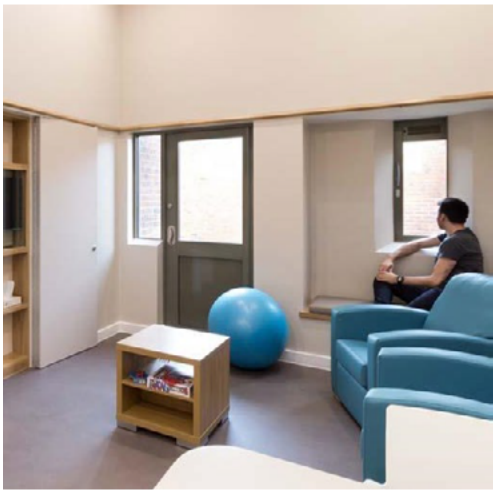


Figure 8.60 Window seat as transition space between inside and outside

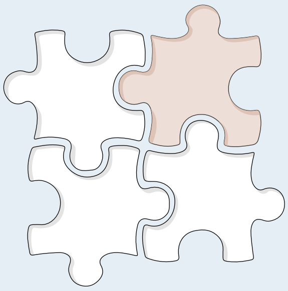
(Source: Mitford Hospital Autism Inpatient Unit, UK)

For the visual transparency, a window or window seat could be a transition between inside and outside. The position of window should take the privacy requirement into consideration.

3. Design considerations of ASD-friendly transition area in ambulatory space

- It is better to have a transition area to allow ASD users to preview the physical, sensory environment and human activities of adjacent space in advance. Thresholds should be provided in front of the treatment room to help patients with ASD recalibrate their senses in advance.

- A window or window seat could be a transition between inside and outside. But the window used for visual connection does not expose patient's privacy to public.



8.5 Evaluation tool construction:

Evaluation of hospital environments for ASD users

1. Autism-friendly tool : 3STI for Hospital

Introduction

Based on previous research, we develop an evaluation tool to measure the accessibility and comfort of the hospital environment to ASD visitors when they are using the different functional areas of the hospital. The tool is divided into two parts, Part A is used to measure the general environment, and Part B is about 12 important autism-friendly built environment criteria we have proposed.

Scoring system

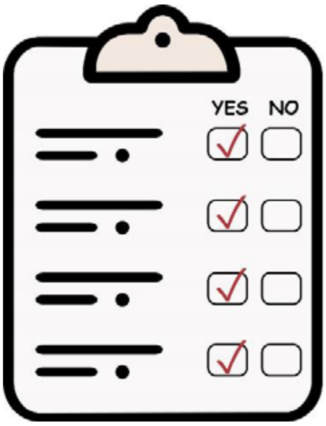
According to the symptoms and common behaviours of autistic users, we propose the requirements and audit checklist of each criterion, the performance of the built environment is measured by a ranked score. The audit checklist consists of a series of needs of the autism-friendly environment, was designed to assist rate the score. At this stage, we suppose that every evaluation criterion is the same importance and score equally. Inside each criterion would have a different number of indicators depend on the complexity of the criterion but not the weight. If the indicator is implemented in the space, select the "Yes" box next to the indicator, otherwise, select the "No" box. All the indicators of the same criteria are divided equally and the score of the criterion depends on how much indicators the space implemented. In order to calculate easily, each criterion would multiply by 10 that means the maximum of each criterion is 10 points. For example, if there are 4 indicators in the "03 sound" criterion, each indicator would be deserved 0.25 points. When all the 4 indicators are implemented in the space, it would get 10 points which means the optimal performance for the criterion. If there are only 3 indicators are implemented the score would be 7.5 points (o.25*3*10 = 7.5). In general, the score of the criterion could be formulated as "Score of each criterion=x/n * 10" ("x" means the number of indicators the space implemented, "n" means the number of indicators inside the criterion).

It is common that the number of indicators inside the criterion can not be capable of being divided by 1 exactly. In this case, the score would be rounding-off to one decimal. For example, there are 3 indicators of one criterion but just two of them are implemented in the space, the score of the criterion should be 2/3 * 10= 6.7 according to the formula.

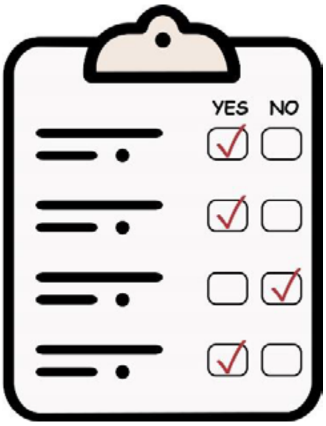
Score of each criterion = x/n * 10

"X" means the number of indicators answer "Yes"
"n" means the number of indicators inside the criterion
the result is rounding-off to one decimal

For example, there are 4 indicators inside the criterion and on the left, all the indicators are met while on the right, 3 of them are met. Therefore, the score would be 10 and 7.5 respectively.



Score : 4/4 * 10 = 10



Score : 3/4 * 10 = 7.5

Final score and evaluation standard

The maximum score of the evaluation tool is 130 points, including 10 points for the general environment and 120 points of 12 criteria (10 points of each). According to our research on the autism-friendly hospital environment, we give the following evaluation standard:

Each criterion is rated from 0 to 10 points and is divided into 5 ranks. When it is rated from 7.5 to 10 points, this indicator represents the top quality of the autism-friendly environment. Similarly, rated from 5 to 7.4 represents medium-high quality, 2.5 to 4.9 represents medium-low quality, 0 to 2.4 points represents low quality. There are 13 criteria in the 3STI tool, thereby the hospital environment with an overall score between 97.5 and 130 has a high level of friendliness to autism users , corresponding to 65 to 97.4 points is medium-high, 32.5 to 64.9 points is medium-low, below 32.5 points is a low level of autism friendliness, the evaluation standard is shown in the table below.

Rank		Score of each criterion	Total score
A	Top quality	7.5-10	97.5-130
B	Medium-high quality	5-7.4	65-97.4
C	Medium-low quality	2.5-4.9	32.5-64.9
D	Low quality	0-2.4	<32.5

2. The Evaluation tool for Ambulatory Space

PART A: General Environment

Requirements:

The autism-friendly hospital environment should keep clean and everything arranged in order. Temperature and humidity should be constant and comfortable. Individuals with autism would easy to be anxiety, particularly in the hospital environment. Therefore, a non-institutional atmosphere would be beneficial to reduce nervously. Sufficient space should be available because the most patient with autism would accompany with their families or caregivers.

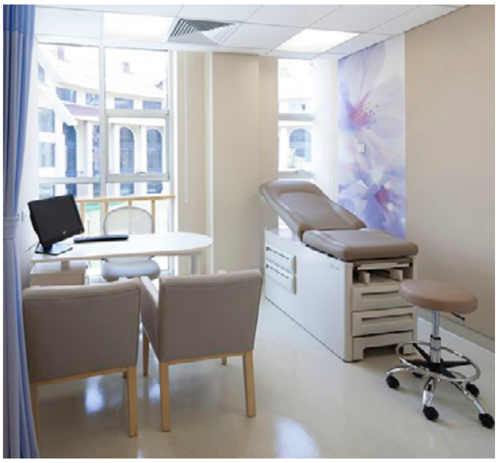
Auditing checklist:

(1) Furniture, daily necessaries, medical equipments are arranged in order and clean.	Yes ▢	No ▢
(2) Air temperature and relative humidity are maintained at a comfort level without dramatic difference between nearby spaces. There are no heating radiators with high temperature exposed to the air.	Yes ▢	No ▢
(3) Warm light and hight-quality home-like or natural materials were used, creating a non-institutional atmosphere for patients and families.	Yes ▢	No ▢
(4) Sufficient seating is available for individuals (including families, caregivers) who accompany the patient with autism.	Yes ▢	No ▢

Score of general environment: ___ /4 * 10 = _____

Example:

✓ Clean and order



✗ Messy

PART B: 12 Criteria of Autism-friendly Built Environment

01. Space hierarchy

Requirements:

It is sensible to organize space in a logical order and involve sensorial compatible function. The examination area needs more privacy than the consulting area. The overall environment should be simple and easy to understand. Different colour of flooring/wall would help to define function area. Also, visual cues would benefit to inform the ASD users the location and functions. Considering the autistic are likely to have a sense of closure, chairs for the patient and the exam couch are better to place against the wall.

Auditing checklist:

(1) The consulting workstation locates in the high-stimulus area while examination space locates in low-stimulus area. Yes ▢ No ▢
(e.g., the distance from the entrance, location of inside or outside wall, visual barriers by a curtain)

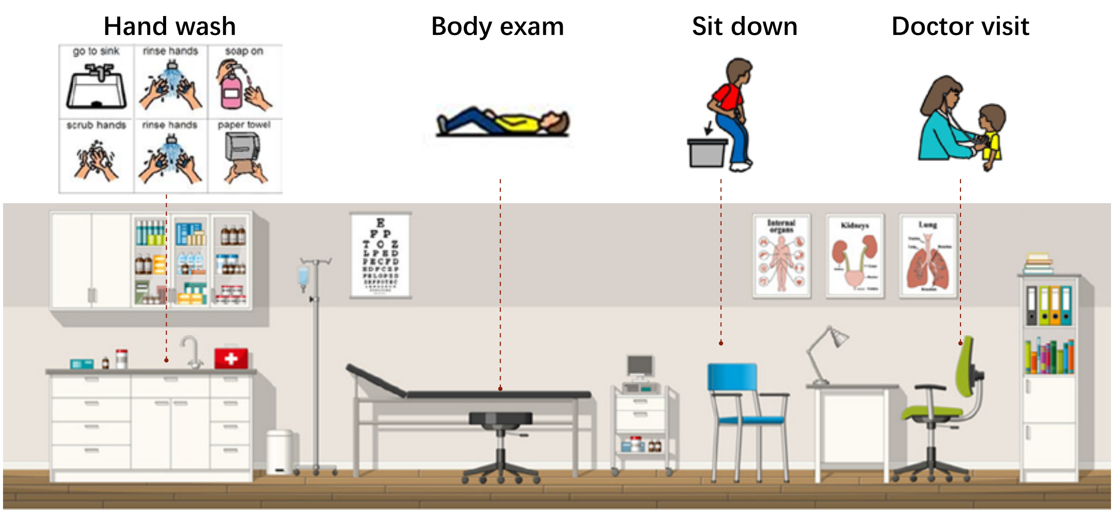
(2) A clear definition of the examination space, consultation workstation and basin space by different flooring covering/lighting/curtain. Yes ▢ No ▢

(3) Each functional area is with clear signposts or visual cues to explain its function. Yes ▢ No ▢
(e.g., "water" text and symbol to indicate the water dispenser)

(4) Chairs for the patient and the exam couch are placed against the wall. Yes ▢ No ▢

Score of space hierarchy: ___ /4 * 10 = _____

Example:



02. Wayfinding

Requirements:

The wayfinding system should be simple and easy to understand, with clear text, symbols and the use of colours. The colour coding is an effective tool for a patient with autism to find their way and distinguish different therapy space. Pictogram can clearly inform the patient about the function of the room. In addition, the visual overload issue should be considered in the wayfinding system.

Auditing checklist:

(1) There is noticeable signage to indicate the function, condition of exam rooms. (including the font type, set-out, contrast with the background)	Yes ▢	No ▢
(2) Room number identification is clear and noticeable.	Yes ▢	No ▢
(3) The rooms or cluster of rooms are colour coded (e.g., door, floor, wall colour, etc.) to make wayfinding easier for the patient.	Yes ▢	No ▢
(4) There are not too many colours and overstimulate colours in wayfinding system.	Yes ▢	No ▢
(5) There is easy-understand pictogram to illustrate the function of the rooms.	Yes ▢	No ▢

Score of wayfinding: ___/5 * 10 = _____

Example:

Point (3)(4)

✓ Colour coding of doors

Point (3)(6)

✓ Pictogram

03. Sound

Requirements:

Acoustic is the most influential factor in autistic behaviour among the sensory stimuli within the built environment. The noise in the hospital could be classified as external sources and internal sources. Soft surfaces are recommended on walls, floors, and ceiling to reduce noise and reverberation. Selecting sound-absorbing materials during construction or renovation could reduce the noise level within the room.

Auditing checklist:

(1) The walls of room are sound insulated.	Yes ☐	No ☐
(2) The ceiling of room is with sound-absorbing materials.	Yes ☐	No ☐
(3) The surface of floor materials is made by less noise impact materials. (e.g., rubber, Vinyl, linoleum, etc.)	Yes ☐	No ☐
(4) The furniture in the room are with sound protection. (e.g., legs or bottom of consulting desk/chairs/revolving stool with soft protection)	Yes ☐	No ☐
(5) There are no noise from mechanical and electrical services. (e.g., heating, ventilation, air condition, fans, etc.)	Yes ☐	No ☐
(6) There are no noise from external sources in the room. (e.g., road traffic, construction noise etc.)	Yes ☐	No ☐

Score of sound: ___ /6 * 10 = _____

Example:

Point (3)

✓ Rubber flooring

Point (4)

✓ Furniture leg protector

04. Colour

Requirements:

Neutral and calming colours and the use of natural materials are suited for autism-friendly therapeutic environments. The pattern is better simple and organic to avoid visual overstimulate. The colour contrast for hospital design should be fulfilled but try to avoid disturbing and over-stimulate colour.

Auditing checklist:

(1) Space is decorated with neutral, calming and harmony colour scheme.	Yes ▢	No ▢
(2) The floor and wall of the room are coloured in a different and not similar colour.	Yes ▢	No ▢
(3) The handrails, doors, fittings and other furniture are coloured in contrast colour with its background.	Yes ▢	No ▢
(4) The bright colours are avoided in the interior environment. (e.g., bright red, bright yellow, etc.)	Yes ▢	No ▢
(5) There are not overnumbered colours in the interior environment.	Yes ▢	No ▢
(6) The patterns of surface are organic, non-repeating, non-overly.	Yes ▢	No ▢

Score of Colour: ___ /6 * 10 = ______

Example:

Point (1)

✓ Neutral colour and organic pattern

Point (5)

✗ Overnumbered colour

05. Lighting

Requirements:

Both natural and artificial lighting needs to be well-orchestrated throughout clinical facilities. The indoor lighting should be soft and uniform and the intensity should be moderate. Negative visual stimulus including flickering lights, glare, and reflective surface should be avoided in the built environment. Artificial lighting should be equipped with dimming controls to allow for adjustments.

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(1) Windows or skylight provide plenty of direct or indirect natural light. Yes ▢ No ▢

(2) Windows have glare protections to control the shining sunlight. (e.g., curtain, window blinds or frosted glass, external screen, etc.) Yes ▢ No ▢

(3) The lighting is soft and uniform, without shadows produced by uneven lighting. Yes ▢ No ▢

(4) Artificial lighting in the room is with diffuser and without flicker. Yes ▢ No ▢

(5) Proper placement of lightings to avoid glare. (e.g., computer monitor, display screen, reflective surface, etc.) Yes ▢ No ▢

(6) Artificial lighting is equipped with dimming controls to allow for both brightness and colour adjustments. Yes ▢ No ▢

(7) Combination of recessed direct/indirect lighting and specific task lighting for consulting, examination and clinical wash-hand basin area. Yes ▢ No ▢

Score of sound: ___ /7 * 10 = ______

Example:

Point (5)

✓ Adjustable lighting

Point (1) (6)

✓ Specific task lighting for areas

06. Smell

Requirements:

The indoor environment should be clean with fresh air by natural ventilation and mechanical ventilation. No unpleasant smell, including institutional smell, smoke, stuffy/ stale smell, irritating smell. A fragrance-free environment is recommended for the olfactory sensory of autistic.

Auditing checklist:

(1) There is no unpleasant smell, including institutional smell, smoke, stuffy/stale smell, irritating smell, etc. Yes ▢ No ▢

(2) The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through good ventilation, both natural and mechanical. Yes ▢ No ▢

(3) Products used in hospitals are fragrance-free. Yes ▢ No ▢
(e.g., fragrane-free hand santizier,soap, air purifiers, etc.)

Score of smell: ___ /3 * 10 = _____

Example:

Point (1)

✗ Smell from trash

Point (3)

✓ Fragrance-free space

07. Tactile

Requirements:

The tactile sense is especially important in the ambulatory environment because the patient trend to contact with furniture and medical equipment during therapy. The surface of building structure and furniture should be smooth and clean. For the surface which contacts with their skin should be comfortable and soft enough to reduce their stress.

Auditing checklist:

(1) The surfaces of the building structure, fitting, furniture have a smooth and clean surface. (e.g. wall, table, chair, curtain, couch, instrument) Yes ▢ No ▢

(2) The surfaces which get in contact with the skin such as chair and exam couch are comfortable and soft. (e.g., cloth exam couch coverings rather than paper) Yes ▢ No ▢

(3) There are no objects with a rough surface that have the potential risk of scratching the skins. Yes ▢ No ▢

(4) There are some positive tactile interventions. (e.g. soft-touch toy or pillow in exam couch or seating for the patient) Yes ▢ No ▢

Score of tactile: ___ /4 * 10 = _____

Example:

Point (2)

✗ Paper bedsheet

Point (2)(4)

✓ Soft covering and toys

08. Safety

Requirements:

A safe built environment is very important for ASD users, especially some of them who have high pain thresholds that cannot respond to body injuries in time. Any potential risk factors in the environment should be avoided or with a protector. Sufficient storage is needed to keep a simple and safe environment. Warning signals should be provided to inform risks.

Auditing checklist:

(1) The building materials and finishes including furniture, wall, flooring, ceiling are durable and easy-cleanable.	Yes ▢	No ▢
(2) In the clinical area, the finishes of flooring are seamless, smooth, slip-resistant, easily cleaned and appropriate wear-resistant.	Yes ▢	No ▢
(3) The materials are harmless, non-toxic. (e.g.,including paints, furniture, wood production, etc.)	Yes ▢	No ▢
(4) There is not falling risk when patient goes in and out wet area such as clinic washbasin area.	Yes ▢	No ▢
(5) Objects in the room are designed with a soft edge or have a corner protector.	Yes ▢	No ▢
(6) Sufficient storage is provided for medical supplies, equipment, daily necessaries. Unnecessary equipment is removed.	Yes ▢	No ▢
(7) Cabinets and drawers are keep closed with restricted locker.	Yes ▢	No ▢
(8) The decorative objects are inaccessible. (e.g., potted plants, artworks and etc. can be put in the cabinet with glass windows or fixed in a building structure)	Yes ▢	No ▢
(9) The opening of windows is with restricted locker.	Yes ▢	No ▢
(10)There are clear warning signals or physical barriers to inform risks of protruding obstacles, slippery area, untouched objects, unclimbable area and etc.	Yes ▢	No ▢

Score of safety: ___/10 * 10 = _____

09. Hospital equipment

Requirements:

In the ambulatory, the various sensory stimuli generated by electronic equipment should be minimized, such as beeping machine, bright and colourful screen, blink lighting or sudden loud alarm sound.

Auditing checklist:

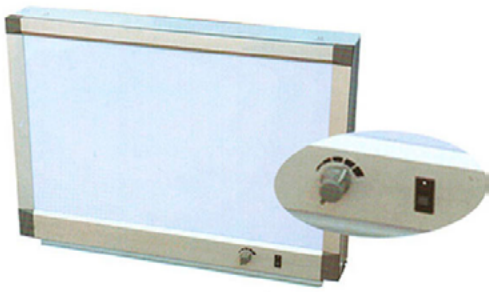
(1) Computer and printer are quiet. (e.g., choose quiet keyboard, good quality printer)	Yes ▢	No ▢
(2) Computer monitor and illuminated display screen (e.g.: X-ray viewer) are glare-free and have a switch to adjust brightness and colour contrast.	Yes ▢	No ▢
(3) Beeping machine (e.g., electrocardiography monitor) could be set to silent mode.	Yes ▢	No ▢
(4) Examination lights are non-fluorescent and minimize the bright light in the patient's sight as possible.	Yes ▢	No ▢
(5) The blink lighting of equipment could be covered or shut down when necessary.	Yes ▢	No ▢
(6) The loud sound of alarm are replaced with music. (e.g., patient/staff call and staff/staff call)	Yes ▢	No ▢

Score of hospital equipment: ___ /6 * 10 = ______

Example:

Point (2)

✓ Brightness adjustment



Point (3)

✓ Silent beeping machine

10. Assistive technologies

Requirements:

In a therapeutic environment, assist technology products could be implemented to help autistic especially difficult of speaking to communicate with the staff effectively and use the medical equipment properly. Apart from the medical instruction, some technologies are used to reduce the anxiety for ASD patient during an examination

Auditing checklist:

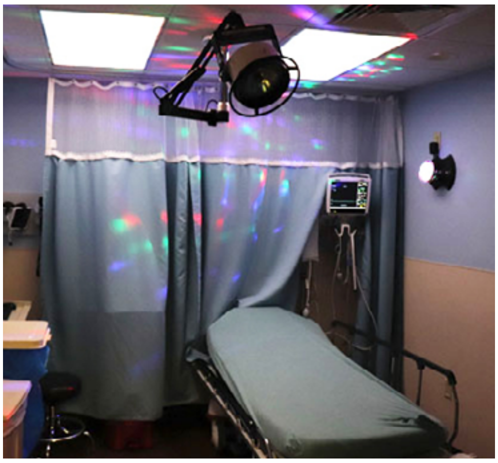
(1) There are distracting objects for the patient with autism to reduce their stress during examination. (e.g., calming video/picture, moving colour light, bubble column, music, etc.)	Yes ▢	No ▢
(2) There are means for non-verbal communication to help the patient with autism communicate with staff. (e.g., iPad with dedicated application like Vi.co Hospital)	Yes ▢	No ▢
(3) Noise-cancelling headphones or earplugs are provided for patient with autism.	Yes ▢	No ▢

Score of assistive technologies: ___ /3 * 10 = _____

Example:

Point (1)

✓ Colour lights on ceiling



Point (2)

✓ iPad with dedicated application

11. Escape space

Requirements:

There should be an escape space where allow a patient with autism to retreat and hide into, which can help them calm down and release anxiety in the therapeutic environment. The escape space should be situated in the lowest stimulation area within the room. The characteristics of this space are relatively quiet and private with minimal stimulation.

Auditing checklist:

(1) There is a quiet and safe space in the lowest stimulation area that can help ASD users escape away from sensory overload and hide for relaxing or calming down during therapy. Yes ▢ No ▢

Score of escape space:___ /1 * 10 = _____

Example:

✓ Quiet corner

✓ Quite room

12. Transition space

Requirements:

The presence of transition space helps the user recalibrate their senses as they move from one level of stimulus to the next. In the ambulatory, a threshold should be provided between an examination room (low stimulus) with related waiting area/corridor (high stimulus) to help them calm down in advance.

Auditing checklist:

(1) There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance. (e.g., the transition area in ambulatory space can be a threshold between the examination room entrance and the waiting area/ corridor)	Yes ▢	No ▢

Score of transition space: ___ /1 * 10 = _____

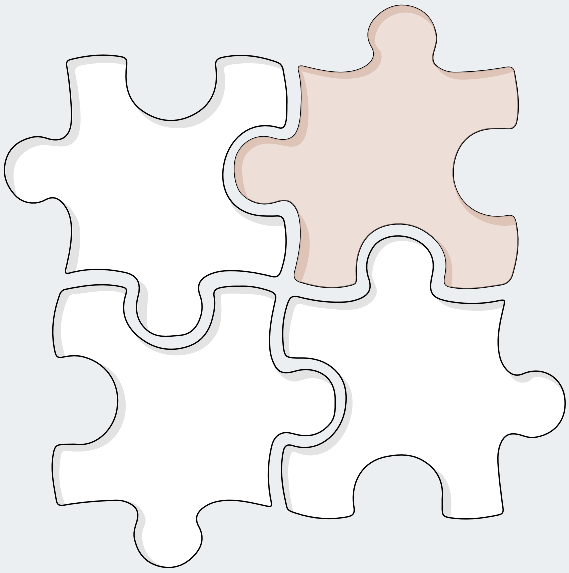
Example:

✓ Tansition space

✓ Tansition space

Score statistics

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: <u>Ambulatory Spaces- Outpatient Area</u>		Score (0-10)
PART A: **General Environment**		
PART B: **12 Criteria of Autism-friendly Built Environment**	01. Space hierarchy	
	02. Wayfinding	
	03. Sound	
	04. Colour	
	05. Lighting	
	06. Smell	
	07. Tactile	
	08. Safety	
	09. Hospital equipment	
	10. Assistive technologies	
	11. Escape space	
	12. Transition area	
Final Evaluation Score (total score 130)		
Rank		



9. Application of '3STI for Hospital'

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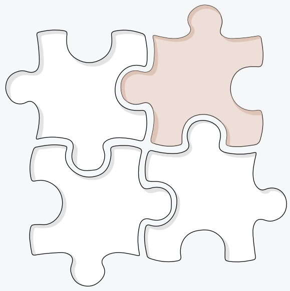


9.1 Applying “3STI for Hospital” in Texas Children’s Hospital

9.1.1 An Introduction before talking about Texas Children's Hospital

In order to validate and test the 3STI tool, one of the desired outcomes of the thesis was to apply it on a real case study. Thanks to previous contacts, the opportunity was provided by a specialized autism center in Milan, with on-site visits for meetings with staff, layout mapping and then tool application to the selected spaces. However, due to the spread of the COVID-19 epidemic disease in the whole world, schools and other gathering places have to be temporarily closed to prevent the spread of the virus (until now, the closure date is from March 8 to April 13). Therefore, we cannot go to the autism centre to visit the site and complete the application of the evaluation tool. This is a great regret for this research, we sincerely hope that people all over the world can overcome this sudden disaster as soon as possible and restore the social environment in order. If there is a chance later, we will complete the blank of this chapter in future research.

Since it is not possible to apply the 3STI tool to hospitals through on-site visits, we decided to evaluate Texas Children's Hospital which mentioned in Chapter 4 Case Study. In addition to the information on its hospital space already introduced, some additional text descriptions and images will be collected from the Internet. We will use all the collected information to complete the assessment of the friendliness of hospital spaces for ASD users.

9.1.2 Methodology

Due to the impossibility to conduct on-site investigations, we collected various information about the built environment and hospital equipment of the hospital through the Internet, including text descriptions, videos, photos, and visitor experience and their comments. From the images, we can get basic understanding about architectural elements inside hospital environment, such as the ambient atmosphere, the used colour scheme, and the lighting system, etc., The information can be used to answer the questions raised in the auditing checklist. But some sensory information about odours, smells, indoor temperature and humidity, background music cannot be obtained from images or the Internet. About such indicators, we regard it as unknow and mark it with N.A. and assign half of the score of the indicator.

9.1.3 Overview of Texas Children's Hospital

Architects: FKP Architects
Location: 17580 Interstate, The Woodlands, Texas, USA
Project year: 2017
User: Children

Texas Children's Hospital Woodlands campus is a free-standing children's hospital designed specifically to provide comprehensive patient care to children and their families, including a five-story inpatient hospital and a six-story medical office building with outpatient clinics, offices and ancillary support spaces, opened in 2017.

The overall built environment of the hospital is a child-friendly park-like environment, offering children an easy, pleasant, and welcoming experience during treatment and hospital visits. The colour coding system is applied here. Cylindrical beacons with different colour which looks like colourful lanterns, define the function of each floor of the building and signify the important work happening inside. Both two buildings are connected on the first and second floors. The central reception hall serves as a transportation hub, connecting different departments of the hospital. The overall layout of the building is simple and clear, with signposts to assist navigation within the building.

The interior design building draws inspiration from the natural elements and play areas are surrounded by wood materials. The "nature" theme of decoration features informal paths, organic shapes and textures, diffused daylighting, and bright, playful colours. Coordination of these architectural elements creates a warm environment that can appeal attention of young patients and their parents and release them from pressure.

Image information

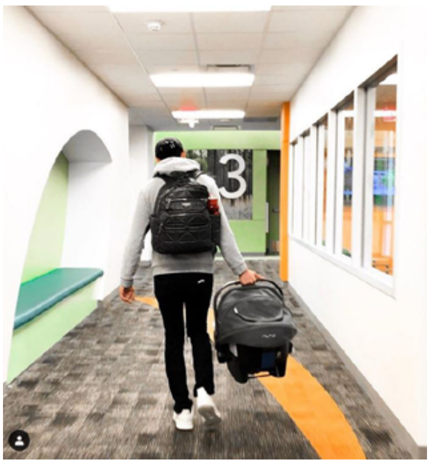
Outside and inside overview

Outside view

Refreshment area

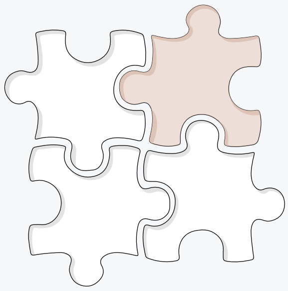
Evaluation area: Reception hall

Evaluation area: Circulation space --- Corridor



Evaluation area: Circulation space ---Waiting area

Evaluation area --- Ambulatory space-Outpatient Area



9.2 The evaluation of reception hall

3STI tool is used to evaluate the built environment of Texas Children's Hospital. Through the collected information of text descriptions, videos, photos, and visitor experience, we will answer 'Yes' or 'No' to each indicator proposed in the auditing checklist, mark the unknown information as N.A.. The results are listed below.

Position: Reception hall

PART A: General Environment

		Yes	No
1	There are enough storage areas to put medical equipment, daily necessaries and non-patient stuff to keep the general environmentclean and in order.	√	
2	The indoor space doesn't have a peculiar odour, especially the toilet,storage room and public trash.	√	
3	By the use of warm lighting, cosy colour scheme and furniture, the overall indoor atmosphere is homey, welcoming and informal.	√	
4	The indoor environment is pleasant and comfortable, with stable and uniform temperature and humidity, there are not heating radiators with high temperature exposed to the air.	√	
	Score	4/4*10=10	

PART B: 12 Criteria of Autism-friendly Built Environment

01. Space hierarchy

		Yes	No
1	Layout is optimized as simple as possible.	√	
2	Space zoning means to divide reception hall into different zones, with each zone having only one function or activity		√
3	Each functional area is with clear signposts or visual cues to explainits function (e.g., the text, symbol can indicate the function and boundaries,furniture placement,flooring, finishes serve as a means of communicating information)		√
4	Space continuity should be enhanced. (e.g., the repetition of the architectural forms)	√	
	Score	2/4*10=5	

02. Wayfinding

		Yes	No
1	The use of colour coding is applied in wayfinding system.(e.g. colour coding means doors, different departments or functional area are represented by different colour)	√	
2	There are landmarks to help ASD users remember space. (e.g., distinguish coloured wall, different floor materials, artworks,sculpture, murals, special decoration, etc. can be used as landmarks)	√	
3	There are easy-understandable symbols in wayfinding signposts.		√
	Score	2/3*10=6.7	

03. Sound

		Yes	No
1	The walls and windows of reception hall are sound insulated.	N.A	
2	The ceiling is with sound-absorbing materials or structure.	N.A	
3	The surface of floor materials is made by less noise impact materials or carpeted.		√
4	Soft furnishings or furniture with sound protection is used in reception hall.	√	
5	The background music or natural sound (e.g., water or fountain) is provided for covering various noises.	N.A.	
6	The machinery of the HVAC system doesn't produce noisy sounds.	√	
7	The sound of hospital communication devices, such as loudspeakers, is gentle, and the voice does not occur suddenly and harshly.	√	
	Score	4.5/7*10=6.4	

04. Colour

		Yes	No
1	The indoor space is decorated by neutral and nature colour scheme.	√	
2	There are not overnumbered colours in interior environment.	√	
3	The handrails, doors, fittings and other furniture are coloured in contrast colour with its background so that they can be clearly noticed.	√	
4	The bright colours are avoided in interior environment. (e.g., bright red, bright yellow and etc.)	√	
	Score	4/4*10=10	

05. Lighting

		Yes	No
1	The natural lighting is provided wherever possible.	√	

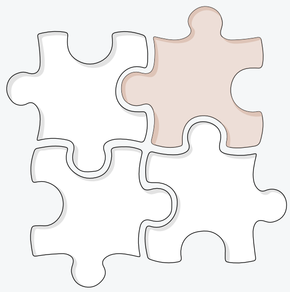
2	Windows have glare protections to control the shining sunlight.(e.g., curtain, window blinds or frosted glass, external screen, etc.)	✓	
3	All artificial lightings are soft, warm and uniform with diffuser and without flicker.	✓	
4	There are no glaring and reflection from various materials.		✓
5	The intensity of lighting can be adjusted according to the time of day.	N.A.	
6	The reception area has a higher level of vertical illuminance and the waiting areas have a calming illuminance.	✓	
	Score	4.5/6*10=7.5	
06. Smell			
1	There are no strong odours near toilets, washrooms, coffee machines, vending machines, public trash can and other frequently used public facilities.	✓	
2	The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through good ventilation, both natural and mechanical.	✓	
3	Low or no VOC finish products and coating are selected.	✓	
4	Products such as cleaning supplies and air purifiers used in hospitals are fragrance-free.	N.A.	
	Score	3.5/4*10=8.8	
07. Tactile			
1	There is enough space for people to go in and out or seat individually without touching other people.	✓	
2	The surfaces of building structure, fittings and furniture have a smooth and clean surface, without the existence of dust, water stain or other dirt.(e.g., walls, floors, tables, chairs, handrails and etc.)	✓	
3	There are no objects with a rough surface that have the potential risk of scratching the skins.	✓	
4	There are some positive tactile interventions.(e.g., offer a soft touch toy or a pillow in the seating area, or tactile walls)	N.A.	
	Score	3.5/4*10=8.8	
08. Safety			
1	The building materials are durable, harmless and easy-cleanable and the floor materials are anti-slippery.	✓	
2	There are clear warning signals or physical barriers or visual contrast to inform risks of protruding obstacles, slippery area, untouched objects, unclimbed area, steps and etc.		✓
3	The opening of windows is with restricted locker and doors are open inwards with restricted locker.	✓	
4	The furniture is unmovable, chairs can be fixed to each other or fixed on the floor.	N.A.	
5	The corners of structure, furniture and equipment are rounded or with corner protections.	✓	
	Score	3.5/5*10=7	
09. Hospital equipment			
1	The non-patients-necessary electronic device such as TV screens can be removed out of sight(e.g., these devices can be put in cabinet with sliding door or recessed space)	✓	
2	There are not too many electronic screens for notifying information.	✓	
3	The emergency alarm is away from reception desk and waiting chairs.	N.A.	
	Score	2.5/3*10=8.3	
10. Assistive technologies			
1	There is a navigation application to assist wayfinding.		✓
2	There is an interactive game device, or interactive robotics, or virtual reality application for distracting ASD patient's attention away from sensory stimuli.		✓
3	Modern auditory equipment such as smart phone and MP4 players is provided which can create a pleasant auditory environment.		✓
4	A sensory room is placed near the entrance,such as Snoezelen room.		✓
5	The interactive device does not cause sensory stimuli to ASD users.		✓
	Score	0/5*10=0	
11. Escape space			
1	There is a quiet and safe space that can help ASD users escape away from sensory overload and hide themselves for relaxing or calming down.	✓	
	Score	1/1*10=10	
12. Transition area			

1	There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance.(e.g. the transition area of the corridor can be a recessed threshold in the entrance for temporary staying and previewing)	✓
2	There are sensory gardens, playing areas incorporated in the entrance hall as a buffer zone between inside and outside.	✓
	Score	2/2*10=10

Score statistics

Table 9.1 The evaluation results of reception hall of Texas Children's Hospital

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: Hospital Reception Hall		Score (0-10)
PART A: General Environment		10
PART B: 12 Criteria for Autism-friendly Built Environment	01. Space hierarchy	5
	02. Wayfinding	6.7
	03. Sound	6.4
	04. Colour	10
	05. Lighting	7.5
	06. Smell	8.8
	07. Tactile	8.8
	08. Safety	7
	09. Hospital equipment	8.3
	10. Assistive technologies	0
	11. Escape space	10
	12. Transition area	10
Final Evaluation Score *(total score 130)*		98.5
Rank		A



9.3 The evaluation of corridor

3STI tool is used to evaluate the built environment of Texas Children's Hospital. Through the collected information of text descriptions, videos, photos, and visitor experience, we will answer 'Yes' or 'No' to each indicator proposed in the auditing checklist, mark the unknown information as N.A.. The results are listed below.

Position: Corridor

PART A: General Environment

		Yes	No
1	The materials and products used in the hospital are easy-cleanable in order to keep the overall environment clean.	✓	
2	There are enough storage areas to put medical equipment, daily necessaries and non-patient stuff to keep the general environment in order.	✓	
3	The indoor space doesn't have a peculiar odour, especially the toilet, storage room and public trash near the waiting area and other facilities commonly used by the public.	N.A.	
4	By the use of warm lighting, cosy colour scheme and furniture, the overall indoor atmosphere is homey, welcoming and informal.	✓	
5	The indoor environment is pleasant and comfortable, with stable and uniform temperature and humidity, there are not heating radiators with high temperature exposed to the air.	✓	
	Score	4.5/5*10=9	

PART B: 12 Criteria of Autism-friendly Built Environment

01. Space hierarchy

		Yes	No
1	The overall layout of the hospital is simple and clear.	✓	
2	Each functional area is equipped with clear signposts or visual cues to explain its function. (e.g., "water" text and symbol to indicate the water dispenser; "information" text and symbol to indicate the notification board)		✓
	Score	1/2*10=5	

02. Wayfinding

		Yes	No
1	The use of colour coding is applied in wayfinding system. (e.g. colour coding means doors, different departments or functional area are represented by different colour)	✓	
2	There are landmarks to help ASD users find and identify each space. (e.g., distinguish coloured wall, different floor materials, artworks, sculpture, murals, special decoration can be used as landmarks)	✓	
3	There are easy-understandable symbols in wayfinding signposts.		✓
4	The bright colours and large coloured areas are avoided in wayfinding solution. There are not too many colours and similar colours in wayfinding solution.	✓	
5	There are not too many disorder advertisements and notification leaflets attached to the wall which make patients confused about wayfinding signposts.	✓	
	Score	4/5*10=8	

03. Sound

		Yes	No
1	The walls of corridor are sound insulated.	N.A.	
2	The ceiling of corridor is with sound-absorbing materials.	N.A.	
3	The surface of floor materials is made by less noise impact materials. (e.g., rubbers)	✓	
4	The furniture in corridor are with sound protection. (e.g., legs or bottom of chairs in corridor are with soft materials)		✓
5	The background music is provided for releasing the tension and covering various noises, such as the sounds of movements and conversations.	N.A.	
6	The machinery of the HVAC system oesn't produce noisy sounds, including heating system, ventilation, air conditioning, and fans are avoided.	✓	
7	The sound of hospital communication devices, such as loudspeakers, audio calling and the next patient "call" system does not occur suddenly and harshly, the voice is slow-in, gentle, clear and noise-free.	N.A.	
8	There is a simple electronic screen, with easy-understandable text and numbers showing the medical communication message to replace the next patient audio "call" when necessary.	✓	
	Score	5/8*10=6.3	

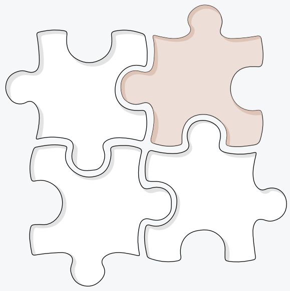
04. Colour			
1	The indoor space is decorated by neutral and nature colour scheme.	√	
2	The floor and wall of corridor are coloured in different and not similar colour.	√	
3	The handrails, doors, fittings and other furniture are coloured in contrast colour with its background so that they can be clearly noticed.		√
4	The bright colours are avoided in interior environment. (e.g., bright red, bright yellow and etc.)		√
5	There are not overnumbered colours in interior environment.	√	
6	The decoration materials with dense pattern are avoided.	√	
	Score	4/6*10=6.7	
05. Lighting			
1	The natural lighting is provided wherever possible	√	
2	Windows have glare protections to control the shining sunlight. (e.g., curtain, window blinds or frosted glass, external screen, etc.)	√	
3	The lighting is soft and uniform, without shadows produced by uneven lighting.	√	
4	All lightings are with diffuser and without flicker.	√	
5	The artificial lightings are glare-free, especially when people look into typical viewing directions. (e.g., looking towards a central desk or illuminated displays)		√
6	There are no glaring and reflection from various materials.	N.A.	
7	The intensity of lighting can be adjusted according to the time of day.	N.A.	
8	The artificial lighting can create a warm, welcoming and informal interior environment.	√	
9	The corridor doesn't have a "tunnel effect". (e.g., the dim lighting or uneven lighting can make long corridors looks like a tunnel.)	√	
	Score	7/9*10=7.8	
06. Smell			
1	The overall hygienic environment of corridors is neat, clean and in order.	√	
2	There are no strong odours near toilets, washrooms, coffee machines, vending machines, public trash can and other frequently used public facilities.	N.A.	
3	The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through good ventilation, both natural and mechanical.	√	
4	Products such as cleaning supplies and air purifiers used in hospitals are fragrance-free.	N.A.	
	Score	3/4*10=7.5	
07. Tactile			
1	There is enough space for people to go in and out or seat individually without touching other people.	√	
2	The surfaces of building structure, fittings and furniture have a smooth and clean surface, without the touch feeling of rough. (e.g., walls, floors, tables, chairs, handrails and etc.)	√	
3	There are not objects with a rough surface that have the potential risk of scratching the skins.	√	
4	There are some positive tactile interventions. (e.g., offer a soft touch toy or a pillow in the seating area, or a pressure ball when they are waiting for medical service.)		√
	Score	3/4*10=7.5	
08.Safety			
1	The floor materials are anti-slippery.	√	
2	There are not obstacles that could trip people on floor. (e.g., bare wires, easy-knocked down vase and etc.)	√	
3	There isn't falling risk when patient go in and out wet area such as toilets, washroom and water dispenser area.	√	
4	There are clear warning signals or physical barriers to inform risks of protruding obstacles, slippery area, untouched objects, unclimbed area, steps and etc. in corridor space. (if there are not dangerous area, answers "Yes".)	√	
5	There are not protruding obstacles with the risk of patients may bump into. (e.g., fire extinguishers, wall fixed cabinets, windowsill, etc.)	√	

6	The opening of windows is inaccessible or within the restricted distance, there is no potential risk of falling down from windows.	√
7	Doors are open inwards with restricted locker, there is no potential risk of bumping into the opening doors.	√
8	The furniture is unmovable, chairs can be fixed to each other or fixed on the floor.	√
9	The decorative objects are inaccessible, these stuffs can be put in cabinet with glass windows or fixed in building structure	√
10	The building materials are durable and easy-cleanable.	√
11	There are ward guards to protect surface of the wall and reduce the crashing noises.	√
12	The corners of walls are rounded or with corner protections.	√
	Score	12/12*10=10
09. Hospital equipment		
1	The non-patients-necessary electronic device such as clocks or TV screens can be removed out of sight. (e.g., these devices can be put in cabinet with sliding door or recessed space)	√
2	There are not too many electronic screens for notifying information.	√
3	The emergency alarm is away from reception desk and waiting chairs in corridor.	√
4	The illuminance signposts and handrails are with suitable brightness and glare free.	√
5	Machines do not have repeated blinking lights while running, or there is a covering provided to block the visual connection between autism users and the blinking lights.	√
	Score	4/5*10=8
10. Assistive technologies		
1	There is a navigation application to assist wayfinding.	N.A.
2	There is an interactive game device for distracting ASD patient's attention away from sensory stimuli.	√
3	The interactive device does not cause sensory stimuli to ASD users.	√
	Score	0.5/3*10=1.7
11. Escape space		
1	There is a quiet and safe space that can help ASD users escape away from sensory overload and hide themselves for relaxing or calming down.	√
	Score	1/1*10=10
12. Transition area		
1	There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance. (e.g. the transition area of the corridor can be a recessed threshold in the entrance for temporary staying and previewing)	√
	Score	1/1*10=10

Score statistics

Table 9.2 The evaluation results of corridor of Texas Children's Hospital

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: Hospital Corridor		Score (0-10)
PART A: **General Environment**		9
PART B: **12 Criteria for Autism-friendly Built Environment**	01. Space hierarchy	5
	02. Wayfinding	8
	03. Sound	6.3
	04. Colour	6.7
	05. Lighting	7.8
	06. Smell	7.5
	07. Tactile	7.5
	08. Safety	10
	09. Hospital equipment	8
	10. Assistive technologies	1.7
	11. Escape space	10
	12. Transition area	10
Final Evaluation Score *(total score 130)*		97.5
Rank		A



9.4 The evaluation of waiting area

3STI tool is used to evaluate the built environment of Texas Children's Hospital. Through the collected information of text descriptions, videos, photos, and visitor experience, we will answer 'Yes' or 'No' to each indicator proposed in the auditing checklist, mark the unknown information as N.A.. The results are listed below.

Position: Waiting area

PART A: General Environment

		Yes	No
1	The materials and products used in the hospital are easy-cleanable in order to keep the overall environment clean.	✓	
2	There are enough storage areas to put medical equipment, daily necessaries and non-patient stuff to keep the general environment in order.	✓	
3	The indoor space doesn't have a peculiar odour, especially the toilet, storage room and public trash near the waiting area and other facilities commonly used by the public.	N.A.	
4	By the use of warm lighting, cosy colour scheme and furniture, the overall indoor atmosphere is homey, welcoming and informal.	✓	
5	The indoor environment is pleasant and comfortable, with stable and uniform temperature and humidity, there are not heating radiators with high temperature exposed to the air.	✓	
6	Both individual seating and group seating are provided.	✓	
	Score	5/6*10=8.3	

PART B: 12 Criteria of Autism-friendly Built Environment

01. Space hierarchy

		Yes	No
1	Common facilities such as toilets and vending machines that accompanied by noises and the crowd of people are placed away from the quiet waiting area.	✓	
2	Clear visual cues are provided to assist wayfinding for these facilities.		✓
3	Each functional area has clear definition or visual cues to explain its function. (e.g., use a different floor colour or materials to identify the boundary of waiting area; use "book" text and symbol to indicate the place of magazine or reading materials, and other function area as well)	✓	
4	There are relaxing or entertainment facilities in the waiting area, such as reading materials, games.	✓	
	Score	3/4*10=7.5	

02. Wayfinding

		Yes	No
1	There is a clear signpost to tell the entrance of waiting area.		✓
2	The signpost of waiting area have easy-understandable symbol.		✓
3	There are landmarks that help ASD users to find, identify and remember this waiting area. (e.g., distinguish coloured wall, artworks, sculpture, murals, special decoration can be used as landmarks)	✓	
4	The bright colours, similar colours and large coloured area are avoided when waiting area is involved in colour coding wayfinding.	✓	
5	There are not too many disorder advertisements and notification leaflets attached to the wall which make patients confused about wayfinding signposts.	✓	
	Score	3/5*10=6	

03. Sound

		Yes	No
1	The wall of waiting area is sound insulated.	N.A.	
2	The surfaces of wall in waiting area are with sound insulated panels, or the ceiling of waiting area are with sound-absorbing material or additional sound absorbing ceiling hanging.	N.A.	
3	The reception desk close to waiting area have an additional sound absorbing ceiling hanging.	✓	
4	There is a soft covering on the floor, or the surface of floor materials is made by less noise impact materials (e.g., rubbers).		✓
5	If the floor is made of hard and firm materials, furniture in the waiting area should have sound protection. (e.g., legs or bottom of chairs with soft materials)	✓	

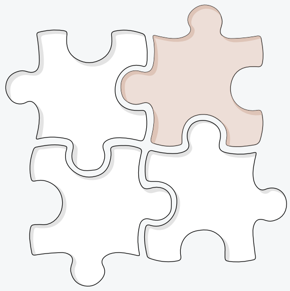
6	There is background music to cover inevitable noise, such as the sounds of movements and conversations.		√
7	The machinery of the HVAC system, including heating system, ventilation, air conditioning, doesn't produce noisy sounds, and fans should be avoided as much as possible.	√	
8	The sound of hospital communication devices, such as loudspeakers, audio calling and the next patient "call" system does not occur suddenly and harshly, the voice is slow-in, gentle, clear and noise-free.	√	
9	There is a simple electronic screen, with easy-understandable text and numbers showing the medical communication message to replace the next patient audio "call" when necessary.	√	
	Score	6/9*10=6.7	
04. Colour			
1	The interior environments are decorated by neutral and nature colour scheme.	√	
2	Tables, chairs, windows, fittings and other furniture can be clearly noticed, coloured in contrast colour with its background.	√	
3	There are not overnumbered colours in interior environment.	✓	
4	The bright colours are avoided in built environment.		√
5	The decoration materials with dense pattern are avoided.	√	
	Score	4/5*10=8	
05. Lighting			
1	The natural lighting is provided wherever possible	√	
2	Windows have glare protections to control the shining sunlight. (e.g., curtain, window blinds or frosted glass, external screen, etc.)		√
3	The lighting is soft and uniform, without shadows produced by uneven lighting.	√	
4	All lightings are with diffuser and without flicker.	√	
5	The artificial lightings are glare-free, especially when people look into typical viewing directions. (e.g., looking towards a central desk or illuminated displays)	√	
6	There are no glaring and reflection from various materials.		√
7	The intensity of lighting can be adjusted according to time of a day.		√
8	The artificial lighting can create a warm, welcoming and informal interior environment.	√	
9	There is a brightness and colour adjustable lighting provided in some special space. (e.g., reading area, interactive games area or escape space)		√
	Score	5/9*10=5.6	
06. Smell			
1	The overall hygienic environment of corridors is neat, clean and in order.	√	
2	There are no strong odours near toilets, washrooms, coffee machines, vending machines, public trash can and other frequently used public facilities.	N.A.	
3	The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through good ventilation, both natural and mechanical.	√	
4	Products such as cleaning supplies and air purifiers used in hospitals are fragrance-free.	N.A.	
	Score	3/4*10=7.5	
07. Tactile			
1	There is enough space for people to go in and out or seat individually without touching other people.	√	
2	The surfaces of building structure, fittings and furniture have a smooth and clean surface, without the touch feeling of rough. (e.g., walls, floors, tables, chairs, handrails and etc.)	√	
3	There are not objects with a rough surface that have the potential risk of scratching the skins.	√	
4	There are some positive tactile interventions. (e.g., offer a soft touch toy or a pillow in the seating area, or a pressure ball when they are waiting for medical service.)		√
	Score	3/4*10=7.5	
08.Safety			
1	The floor materials are anti-slippery.	√	

2	There are no obstacles on the floor that may cause stumble down. (e.g., bare wires, torn surfaces of carpet, etc.)	√	
3	There is no falling risk when patient go in and out wet area such as toilets, washroom and water dispenser area.	√	
4	The warning signals or physical barriers are provided to inform risks of protruding obstacles, slippery area, untouched objects, unclimbed area, steps and etc. in waiting area. (if there are not dangerous area, answers "Yes")	√	
5	The protruding obstacles with the risk of patients may bump into are avoided or with soft protection. (e.g., fire extinguishers, wall fixed cabinets, windowsill, etc.)	√	
6	The opening of windows is inaccessible or within the restricted distance, there is no potential risk of falling down from windows.	√	
7	Doors are open inwards with restricted locker, there is no potential risk of bumping into the opening doors.	√	
8	The furniture is unmovable, chairs can be fixed to each other or fixed on the floor.		√
9	The decorative objects are inaccessible, these stuffs can be put in cabinet with glass windows or fixed in building structure (e.g., potted plants, artworks and etc.)		√
10	The building materials are durable and easy-cleanable.	√	
11	The hard edges and sharp corners of furniture and building structure that may hurt ASD users are avoided.		√
12	The corners of walls are rounded or with corner protections.		√
	Score	8/12*10=6.7	
09. Hospital equipment			
1	The non-patients-necessary electronic device such as clocks or TV screens can be removed out of sight. (e.g., these devices can be put in cabinet with sliding door or recessed space)		√
2	There are not too many electronic screens for notifying information.	√	
3	The emergency alarm is away from reception desk and waiting area.	√	
4	The illuminance signposts and handrails are with suitable brightness and glare free.	√	
5	Machines do not have repeated blinking lights while running, or there is a covering provided to block the visual connection between autism users and the blinking lights.	N.A.	
6	There is no visual connection between the waiting area and the vending machine.	√	
	Score	4.5/6*10=7.5	
10. Assistive technologies			
1	There is a navigation application to assist wayfinding.		√
2	There is an interactive game device for distracting ASD patient's attention away from sensory stimuli.		√
3	The interactive device does not cause sensory stimuli to ASD users.		√
	Score	0/3*10=0	
11. Escape space			
1	There is a quiet and safe space that can help ASD users escape away from sensory overload and hide themselves for relaxing or calming down.	√	
	Score	1/1*10=10	
12. Transition area			
1	There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance. (e.g. the transition area of the waiting area can be a recessed threshold in the entrance or a well-positioned window that visually connect two different spaces)		√
2	The window used for visual connection does not expose patient's privacy to public.		√
	Score	0/2*10=0	

Score statistics

Table 9.3 The evaluation results of waiting area of Texas Children's Hospital

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: Hospital Waiting Area		Score (0-10)
PART A: General Environment		8.3
PART B: 12 Criteria for Autism-friendly Built Environment	01. Space hierarchy	7.5
	02. Wayfinding	6
	03. Sound	5.6
	04. Colour	8
	05. Lighting	5.6
	06. Smell	7.5
	07. Tactile	7.5
	08. Safety	6.7
	09. Hospital equipment	7.5
	10. Assistive technologies	0
	11. Escape space	10
	12. Transition area	0
Final Evaluation Score *(total score 130)*		80.2
Rank		B



9.5 The evaluation of ambulatory space

3STI tool is used to evaluate the built environment of Texas Children's Hospital. Through the collected information of text descriptions, videos, photos, and visitor experience, we will answer 'Yes' or 'No' to each indicator proposed in the auditing checklist, mark the unknown information as N.A.. The results are listed below.

Position: Ambulatory space-outpatient area

PART A: General Environment

		Yes	No
1	Furniture, daily necessaries, medical equipments are arranged in order and clean.		✓
2	Air temperature and relative humidity are maintained at comfort level without dramatic difference between nearby spaces. There are no heating radiators with high temperature exposed to the air.	✓	
3	Warm light and hight-quality home-like or natural materials were used, creating a non-institutional atmosphere for patients and families.	✓	
4	Sufficient seating is available for individuals (including families,caregivers) who accompany the patient with autism.	✓	
	Score:	3/4*10=7.5	

PART B: 12 Criteria of Autism-friendly Built Environment

01 Space hierarchy

		Yes	No
1	The consulting workstation is located in the high-stimulus area while examination space is located in low-stimulus area. (e.g., the distance from the entrance, location of inside or outside wall, visual barriers by a curtain)	✓	
2	A clear definition of the examination space, consultation workstation and basin space by different flooring covering/lighting/curtain.		✓
3	Each functional area is with clear signposts or visual cues to explain its function. (e.g., "water" text and symbol to indicate the water dispenser		✓
4	Chairs for the patient and the exam couch are placed against the wall.	✓	
	Score	2/4*10=5	

02 Wayfinding

		Yes	No
1	There is noticeable signage to indicate the function, condition of exam rooms. (including the font type, set-out, contrast with the background)	✓	
2	Room number identification is clear and noticeable.	✓	
3	The rooms or cluster of rooms are colour coded (e.g., door, floor, wall colour, etc.) to make wayfinding easier for the patient.	✓	
4	There are not too many colours and overstimulate colours in wayfinding system.	✓	
5	There is easy-understand pictogram to illustrate the function of the rooms.		✓
	Score	4/5*10=8	

03 Sound

		Yes	No
1	The walls of room are sound insulated.	✓	
2	The ceiling of room is with sound-absorbing materials.	✓	
3	The surface of floor materials is made by less noise impact materials. (e.g., rubber, Vinyl, linoleum, etc.)	✓	
4	The furniture in the room are with sound protection. (e.g., legs or bottom of consulting desk/chairs/revolving stoolwith soft protection)		✓
5	There are no noise from mechanical and electrical services. (e.g., heating, ventilation, air condition, fans, etc.)	N.A.	
6	There are no noise from external sources in the room. (e.g., road traffic, construction noise etc.)	N.A.	
	Score:	4/6*10=6.7	

04 Colour

		Yes	No
1	Space is decorated with neutral, calming and harmony colour scheme.	✓	
2	The floor and wall of the room are coloured in a different and not similar colour.	✓	
3	The handrails, doors, fittings and other furniture are coloured in contrast colour with its background.		✓
4	The bright colours are avoided in the interior environment. (e.g., bright red, bright yellow, etc.)	✓	
5	There are not overnumbered colours in the interior environment.	✓	
6	The patterns of surface are organic, non-repeating, non-overly.		✓
	Score	4/6*10=6.7	

05 Lighting

		Yes	No
1	Windows or skylight provide plenty of direct or indirect natural light.	✓	

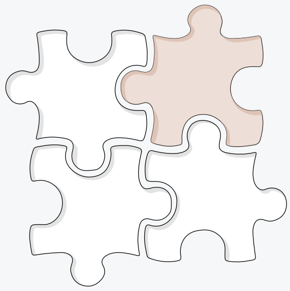
2	Windows have glare protections to control the shining sunlight. (e.g., curtain, window blinds or frosted glass, external screen, etc.)	✓	
3	The lighting is soft and uniform, without shadows produced by uneven lighting.	✓	
4	Artificial lighting in the room is with diffuser and without flicker.	✓	
5	Proper placement of lightings to avoid glare. (e.g., computer monitor, display screen, reflective surface, etc.)	✓	
6	Artificial lighting is equipped with dimming controls to allow for both brightness and colour adjustments.		✓
7	Combination of recessed direct/indirect lighting and specific task lighting for consulting, examination and clinical wash-hand basin area.		✓
	Score	5/7*10=7.1	
06 Smell			
1	There is no unpleasant smell, including institutional smell, smoke, stuffy/stale smell, irritating smell, etc.	N.A.	
2	The indoor air is fresh and free of odours, the quality and circulation of air can be guaranteed through good ventilation, both natural and mechanical.	✓	
3	Products used in hospitals are fragrance-free. (e.g., fragrane-free hand santizier,soap, air purifiers, etc.)	N.A.	
	Score	2/3*10=6.7	
07 Tactile			
1	The surfaces of the building structure, fitting, furniture have a smooth and clean surface. (e.g. wall, table, chair, curtain, couch, instrument)	✓	
2	The surfaces which get in contact with the skin such as chair and exam couch are comfortable and soft. (e.g., cloth exam couch coverings rather than paper)	✓	
3	There are no objects with a rough surface that have the potential risk of scratching the skins.	✓	
4	There are some positive tactile interventions. (e.g. soft-touch toy or pillow in exam couch or seating for the patient)		✓
	Score	3/4*10=7.5	
08 Safety			
1	The building materials and finishes including furniture, wall, flooring, ceiling are durable and easy-cleanable.	✓	
2	In the clinical area, the finishes of flooring are seamless, smooth, slip-resistant, easily cleaned and appropriate wear-resistant.	✓	
3	The materials are harmless, non-toxic. (e.g.,including paints, furniture, wood production, etc.)	✓	
4	There is not falling risk when patient goes in and out wet area such as clinic washbasin area.		✓
5	Objects in the room are designed with a soft edge or have a corner protector.	✓	
6	Sufficient storage is provided for medical supplies, equipment, daily necessaries. Unnecessary equipment is removed.		✓
7	Cabinets and drawers are keep closed with restricted locker.		✓
8	The decorative objects are inaccessible.(e.g., potted plants, artworks and etc. can be put in the cabinet with glass windows or fixed in a building structure)	✓	
9	The opening of windows is with restricted locker.	✓	
10	There are clear warning signals or physical barriers to inform risks of protruding obstacles, slippery area, untouched objects, unclimbable area and etc.		✓
	Score	6/10*10=6	
09 Hospital equipment			
1	Computer and printer are quiet.(e.g., choose quiet keyboard, good quality printer)	✓	
2	Computer monitor and illuminated display screen (e.g.: X-ray viewer) are glare-free and have a switch to adjust brightness and colour contrast.	✓	
3	Beeping machine (e.g., electrocardiography monitor) could be set to silent mode.	N.A.	
4	Examination lights are non-fluorescent and minimize the bright light in the patient's sight as possible.	✓	
5	The blink lighting of equipment could be covered or shut down when necessary.	N.A.	
6	The loud sound of alarm are replaced with music. (e.g., patient/staff call and staff/staff call)	N.A.	
	Score	4.5/6*10=7.5	
10 Assitive technologies			
1	There are distracting objects for the patient with autism to reduce their stress during examination. (e.g., calming video/picture, moving colour light, bubble column, music, etc.)		✓
2	There are means for non-verbal communication to help the patient with autism communicate with staff. (e.g., iPad with dedicated application like Vi.co Hospital)		✓
3	Noise-cancelling headphones or earplugs are provided for patient with autism.		✓

	Score	0/3*10=0
11 Escape space		
1 There is a quiet and safe space in the lowest stimulation area that can help ASD users escape away from sensory overload and hide for relaxing or calming down during therapy.		✓
	Score	0/1*10=0
12 Transition area		
1 There is a transition area where allows ASD users to preview the physical, sensory environment and human activities of adjacent space in advance. (e.g., the transition area in ambulatory space can be a threshold between the examination room entrance and the waiting area/corridor)		✓
	Score	0/1*10=0

Score statistics

Table 9.4 The evaluation results of ambulatory spaces of Texas Children's Hospital

The Evaluation of Autism Accessibility of Hospital Built Environment		
Position: Ambulatory Spaces- Outpatient Area		Score (0-10)
PART A: General Environment		7.5
PART B: 12 Criteria of Autism-friendly Built Environment	01. Space hierarchy	5
	02. Wayfinding	8
	03. Sound	5
	04. Colour	6.7
	05. Lighting	7.1
	06. Smell	6.7
	07. Tactile	7.5
	08. Safety	6
	09. Hospital equipment	7.5
	10. Assistive technologies	0
	11. Escape space	0
	12. Transition area	0
Final Evaluation Score (total score 130)		67
Rank		B



9.6 Discussion on the evaluation

9.6.1 Evaluation results

The evaluation results of the autism friendliness of the built environment in Texas Children's Hospital are shown in the following table. The reception hall and corridor in the hospital have a high degree of autism friendliness, rated as class “A”. While the evaluation score of waiting area and ambulatory space (take the examination room as an example) are relatively low and both are rated as class “B”.

Table 9.5 The evaluation results of the autism friendliness of Texas Children’s Hospital

	Reception hall	**Corridor**	**Waiting area**	**Ambulatory**
General environment	10	9	8.3	7.5
01. Space hierarchy	5	5	7.5	5
02. Wayfinding	6.7	8	6	8
03. Sound	6.4	6.3	5.6	5
04. Colour	10	6.7	8	6.7
05. Lighting	7.5	7.8	5.6	7.1
06. Smell	8.8	7.5	7.5	6.7
07. Tactile	8.8	7.5	7.5	7.5
08. Safety	7	10	6.7	6
09. Hospital equipment	8.3	8	7.5	7.5
10. Assistive technologies	0	1.7	0	0
11. Escape space	10	10	10	0
12. Transition area	10	10	0	0
Final evaluation score	**98.5**	**97.5**	**80.2**	**67**
Rank	**A**	**A**	**B**	**B**

9.6.2 Discussions

Overall, ASD users can benefit from the children-friendly interior environment design strategy of Texas Children 's Hospital. The combination of natural elements colour scheme and decorations, the diffused lights with warm temperature, soft furniture, carpets, and textures of ground materials create a warm and non-institution atmosphere are beneficial for people with autism feel comfortable and relieve tension when visiting the hospital. The built environment is clean and tidy, medical equipment and daily necessities are stored in non-public spaces without causing visual interference for people with autism. Air temperature and relative humidity are maintained at a comfort level. Both individual seats and group seats are provided to meet the needs of different groups of people.

In terms of the overall environment, the four functional spaces in Texas Children 's Hospital are all evaluated as relatively high scores. The score of ambulatory space is lower because there is not enough storage space for medical equipment in the examination room and the random arrangement cause clutter in the environment. In particular, the blinking light from the medical instruments would cause visual stimulus for people with autism.

The overall layout of Texas Children 's Hospital is simple with a central reception hall serves as a transportation hub which connects various departments in the hospital. It is very helpful for visitors to understand the space and find their destination. In the reception hall and ambulatory, different floor materials are used to distinguish the function of space. The wall which fixed with the electronic display fixed is emphasized with colours that the display monitor is obvious to find. The visual cues used to define functions and divide the space is very important for autistic patients because it could inform them of the activities in the space. However, the strategy of using visual cues and symbols is not implemented in micro space, for example, there are no visual cues to indicate the seating area, game area and tea snack area.

Colour coding and number coding are used in wayfinding system. The decoration with natural elements can be used as landmarks to help people memory space. These design strategies can help people with autism navigate without asking the staff for help. But for the wayfinding system, there are not clear and easy-to-understand road signs and symbols. The reception desks in the reception hall and the corridor have no text signs and no way signs to indicate arrival at the waiting area. Colour coding is used to divide the space of the elevator, emphasize the position of the reception desk and divide the space with different floorings in waiting area, but signs with text instructions should be provided.

The sound insulation effect of the building structure is good, using sound absorption materials in the ceiling, and providing an additional building structure at the reception desk to prevent the transmission of sound. The use of carpet can effectively reduce the noise caused by people movements and falling objects. The legs of the chair are with sound protector to prevent it from rubbing against the ground and noise. The application of these strategies can provide a quiet environment in hospital. However, many waiting area in hospitals are open.

Although the external noise is effectively isolated, the open space leads to the noise generated by indoor medical activities and conversations affecting the waiting and rest of autistic patients.

The use of natural colour schemes creates a relaxing indoor atmosphere and there are no bright colours such as red and yellow in the decoration and wayfinding system. These strategies avoid the visual interference of colours on autistic users. Colour contrast is used properly to emphasize important information including the front rails of the corridor and the firmware on the wall which clearly distinguished from the background. However, some materials with a dense pattern are used in chairs, curtains and furniture in the waiting area and ambulatory. These materials should be avoided because they may cause visual overstimulation.

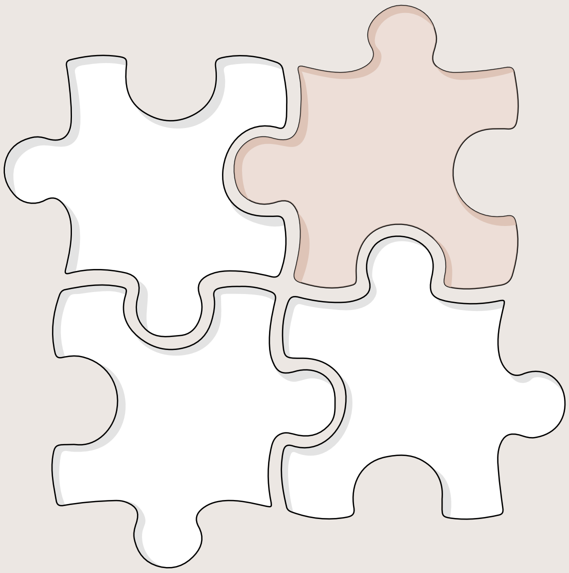
Glass curtain walls and large-size windows are widely used in building structures. On one hand, they provide sufficient natural light. On the other hand, they bring the possibility of excessive light input which causes glare. The window blind is configured on the glass curtain wall of the reception hall, but the performance is poor. Since the amount of light cannot be controlled, the reception hall will have glare. In the waiting room, the same problem exists. A structure with large-area glass is used, but there are no blinds or curtains. Extremely bright and uncontrollable natural lighting is not recommended in the building environments. The artificial lighting system in the hospital provides a uniform and bright lighting environment. The lamps used have no flicker and emit low noises. The artificial lighting used in the reception hall and the waiting room is an indirect light source, and the light is diffused to avoid glare. However, the lights in the corridors and ambulatory rooms generate substantial glare. Especially when people are lying on the bed in the ambulatory room for physical examination, the glare generated by the downward light source above the head can cause physical discomfort. In the reception hall, floor materials with high reflectivity are used, which reflect natural light and artificial lighting and form a light spot on the ground, leading to visual interference for autistic patients.

Since hospital buildings use large-sized windows and glass curtain walls, many windows cannot be opened, indoor ventilation is mainly performed by mechanical ventilation systems. The mechanical ventilation system can operate efficiently to ensure that the indoor air is fresh. The structure and furniture used in Texas Children 's Hospital have clean and smooth surfaces, without rough materials in the space that will give autistic users tactile discomfort. Moreover, we do not observe any positive tactile intervention. It is beneficial to ASD users if tactile intervention is introduced into the space.

Safety is critical for autistic users, especially hypo-sensitive people. There is a high degree of safety in the reception hall and corridors. The sharp corners and hard edges of furniture and corners are avoided or chamfered, preventing people with autism from harming themselves. There are no potential risks with extruded obstacles and the furniture is also fixed on the ground in case of being easily moved. However, the tables and chairs in the waiting room can be movable. Although such furniture increases the flexibility of the space, it brings hidden safety risks. It is recommended to fix the furniture in the building structure. Small square table with hard edges in the waiting room should be avoided. Decorations placed on the table are likely to be broken because of users' aggressive behaviours, so they should also be avoided. These safety risks contribute to a lower score of the waiting room in the safety criterion. The main risk in the ambulatory room is that there is no anti-slip mat on the floor under the sink, where it is wet and easy to slip. Medical equipment with wheels placed randomly can be easily moved by autistic patients, which may cause danger.

In the reception hall, corridors and waiting rooms, there is not much electronic equipment used. Each reception desk is equipped with an electronic screen to inform patients of the latest medical news, showing the easy-understanding information. Some TVs are provided in some waiting rooms and some are placed in the recessed spaces. The building structure can be used to block the visual connection between autistic users and TV screens. The clock is placed in an obvious position in the reception desk and the ambulatory room. Although it is proven that a clock can reassure the patients, the presence of the clock may produce discomfort to some visually sensitive people.

Assistive technologies have been proven to enable to help people with autism, but such positive intervention has not been introduced into Texas Children 's Hospital. The hospital's built environment adopts some positive spatial intervention design strategies. Although these spaces may not be specifically designed for autistic users, they can benefit from the design of spaces. The relatively quiet and private space under the stairs in the reception hall can be used as an escape space for autistic users. When they can't bear the sensory stimuli in their surroundings, they can retreat to calm down. Many spaces have the characteristics of the escape space required by autistic users, such as the recessed space in the corridor and the seats near the window corners in the waiting room. Another positive spatial intervention is the transition area, where it provides opportunities for autistic users to preview the built environment of the following space. There are some seats near the window in the reception hall, allowing them to view the outside environment and prepare themselves. The platform in the middle of the stairs provides a temporary stop, allowing them to preview the building environment and activities on the upper floors. At the entrance of the corridor, there is a glass door, which provides a visual connection between the two architectural spaces and can also be used as a transition space.



10. Discussion

10.1 Discussion of the 3STI

This is an evaluation tool based on observing the built environment. The advantage of it is that it can review the architectural elements one by one according to the items listed in the checklist to get more objective results, excluding some accidental cases. For example, when the built environment is evaluated in the period that hospitals and streets are not busy, there are not many noises from medical activities and vehicles on the streets, which will make people think that the acoustic environment is quiet and comfortable. However, in fact, the sound insulation solution of this space cannot meet the requirements of providing a quiet environment for users when there is a lot of external noise.

On the other hand, the auditing checklist represents all the indicators that we proposed for the autism-friendly built environment in each criterion. But in fact, it is possible to obtain a high-quality autism-friendly space without meeting all the indicators. For example, the "sound" indicator in the space, although we proposed in the auditing checklist that insulting solutions such as sound-proof walls, sound-absorbing ceiling materials and carpets are required to ensure the sound insulation of the interior space and reduce noise interference to ASD users. It can be rated as 10 points when the listed items are satisfied. But considering that when the space is arranged in a relatively quiet area, the use of carpet is enough to eliminate the noises from internal and external. The evaluation of this building environment in "Sound" according to the auditing checklist may just deserve a low score, because other indicators are not satisfied. Therefore, the evaluation score in "Sound" criterion cannot represent accurately the acoustic friendliness in the environment for autistic. In general, the 3TSI evaluation tool exists the deviation of assessing the actual performance in different conditions of different medical environments.

Using the 3STI tool can get a score for the overall performance of the built environment, but due to the limitations of the study, we cannot get a conclusion about how to make each indicator weighted reasonably in the assessment. Therefore, when it is used to evaluate and compare the friendliness for ASD users of different hospitals, it is necessary to not only look at the final score of each hospital vertically but also look at the score of each criterion horizontally.

For example, the three hospitals in the below figure, we only list indicators of "01. Sound" and "02. Colour" as an example for discussion. The overall score of Hospital 1 is higher, and the score is evenly distributed which means each indicator can reach the A level (top quality) of autism-friendly environment. However, when it comes to Hospital 2 and 3, the overall evaluation of the two hospitals in two indicators is 13 points totally, but the meanings represented are different. The performance of Hospital 2 in sound insulation and colour scheme is relatively stable, while Hospital 3 has a very good sound insulation solution and a very chaotic colour scheme. Since we cannot find that the relative importance of impact of sound and colour on autistic people through research, our suggestion is that to use the score form both vertically and horizontally. Especially when it is used to compare different hospital building environments, when the overall scores obtained by the hospitals are similar, the scores of each indicator can be compared horizontally for more detailed comparison and discussion.

We think that a medical environment with evenly distributed scores is more friendly to autism users because it can avoid the item with a low evaluation score having a significant negative impact on users with autism. But this is only the inference we propose here through this thesis, its feasibility still needs to be verified by future research.

	Evenly distributed	Evenly	Unevenly
Projects / Evaluation	Hospital 1	Hospital 2	Hospital 3
......	...	...	...
01. Sound	10	6	10
02. Colour	8	7	3
......	...	...	...
Total score	102	89	73

Vertical

Horizontal

Considering the weight assignment of the 12 criteria in the 3STI, we suppose to be done with stakeholders (such as caregivers, architects, therapists, medical doctors) but COVID propagation stopped also this phase. In future research or in the next version, we hope that 3STI can be improved so that each criterion can be weighted reasonably. This can be done based on a survey of parents, teachers, caregivers, therapists, and individuals with autism themselves, determining the relative importance of each criterion with the respect to the user with autism. Not only that, but the content of the survey can also include the 6 characteristics of the autism-friendly built environment, a series of design considerations and items listed in auditing for their suggestions. Some additional criterion and expanded items that is not presented here may be found and added in future iterations of 3STI, thereby gradually improving it.

10.2 Conclusion

The research results of this thesis include the definition of the autism-friendly tool prototype called 3STI, its application in the hospital called 3STI for hospital, which includes a range of autism-friendly design considerations and strategies for reception hall, circulation spaces (corridors and waiting areas) and ambulatory spaces in hospitals, and it can be used to assess the accessibility of the three medical spaces for autistic users.

The results of the thesis are mainly obtained by summarizing the design concepts and experiences from both studies and cases for the autism-friendly built environment, which also leads to certain limitations. The limitation is that some of the literature referenced in this thesis was for educational buildings, residences, and autism centres rather than researched on the guideline that can be used in a universal environment. Some papers focused on children with autism, rather than the autistic population as a whole. We think that the high-ranked architectural elements that can positively or negatively affect autistic users, obtained through these studies can be scaled up and replicated in other environments as well, and extended from children to all autistic people. The tool prototype is defined based on these studies, but the feasibility of expanding the research has not been verified. The hospital space is very different from the above three types of buildings in terms of the built environment and function. The feasibility and effectiveness of the application of 3STI for hospital still need to be verified and verification of the research results will become part of the future perspectives. Further investigation is planned to study the performance of the hospital post-implementation of the tool, and measure the actual impact of the interventions outlined in this thesis on the performance of ASD users, the accessibility of using the medical service and the general autism friendliness of its built environment for ASD users. Overall, there are three main goals for the future perspective: (1) Test and verify the feasibility and effectiveness of 3STI for hospital; (2) Expand the application of 3STI to other built environments; (3) Research on how to properly weight the criteria in the 3STI tool.

This thesis proposes a research framework for autism-friendly architectural environments, including the methodology of the development of a tool prototype and the methodology of its application in the hospital, which can be used as an example and a touchstone for autism-friendly building research. In the follow-up research. The 3STI prototype can be tried to be used in other environments, such as classrooms, dining rooms and libraries of the university, reception hall and circulation spaces of exhibition centres.

Although the unified design guidelines proposed for the autistic population is a relatively debatable goal, because of the diversity of symptoms of individuals along the spectrum. The 3STI tool aims to provide some best practice of an autism-friendly built environment and guides the design of architects. It is hoped that the efficacy of tool 3STI as an important framework for the conducive design for autism can further be verified and the application of it in other environments is expected.

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