EXPLORING
THE UNCANNY VALLEY EFFECT
IN VIRTUAL REALITY
FOR SOCIAL PHOBIA

DIGITAL AND INTERACTION DESIGN
MASTER DEGREE

RESEARCH THESIS

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IN VIRTUAL REALITY
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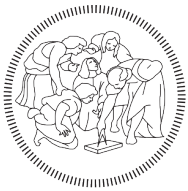

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"NOTHING IN LIFE IS TO BE FEARED,

IT IS ONLY TO BE UNDERSTOOD.

NOW IS THE TIME TO UNDERSTAND MORE,

SO THAT WE MAY FEAR LESS."

-MARIE CURIE

THANK YOU

To PROF. PILLAN, for not only supervising this thesis work, but for helping me understand better how to combine and balance in me being a software engineer and a designer at the same time. Already in the first semester she told me "When logic meets design, that's a jackpot." This became like a mantra for me, reminding why I wanted to learn about design in first place.

To PROF. GALLACE, for his advice on this thesis. I have learned a lot, which shaped the direction of my research topic.

To ALL MY PROFESSORS during these two years. As Albert Einstein says, "Student is not a container you have to fill but a torch you have to light up." I came to Politecnico di Milano inspired to learn new things. I am leaving with knowledge and even more inspired to learn more.

To my partner, RICCARDO, for the support in the full meaning of the word.

To my parents, MARGARITA and PLAMEN, for feeding my striving for improvement. During my bachelor degree, my mother told me "You can get a diploma, but you leave the university with as much knowledge as you want to get." This thought resonates with me even nowadays, making me more curious and motivating me to keep on reading about what we are taught in class.

ENG ABSTRACT

This thesis aims to explore how visual realism affects the emotional response in subjects with social phobia in the context of applications in Virtual Reality (VR) technologies. The focus is on the uncanny valley effect and on how perception differs in cases of fear of public speaking, also known as glossophobia. The reference context of the research is the practice of treating phobias with VR-based therapies and the goal is, hence, to understand the level of realism required by the therapy to be effective.

The research includes the study of phobias and therapeutic treatment methods; VR and its applications; the studies on the uncanny valley effect. They are followed by the use of VR for phobia treatment, thus an experimentation on the realism in VR and the uncanny valley impact.

Our hypothesis is that in virtual environments the emotional response in subjects is determined by the presence of social phobia, in particular glossophobia. In other words, it is argued that, for subjects with glossophobia, the uncanny valley effect either has no basis or it is accentuated in VR.

To support the hypothesis, a prototype-based experimentation was created. Three levels of realism are implemented in the virtual environment: low, medium and high. A questionnaire is used to compare the anxiety level in the participants in previous experiences with that experienced by using the assigned prototype.

The analysis of the collected data suggests that the anxiety level of people without social phobia increases at high levels of realism, which is aligned with the uncanny valley hypothesis. It is also noted that the opposite is true for people with social phobia. Their anxiety level is lowest for high levels of realism.

We can conclude that the perception of avatars in virtual environment is individual and depends on the user's individual characteristics, in particular whether they experience a social phobia.

Finally, the thesis presents the implications of this research and how it is possible to obtain a positive emotional response by manipulating the level of realism, depending on the group of individuals under examination. The research suggests the potential of the contribution of Interaction Design in the research of psychological therapies to contrast phobias, based on virtual reality solutions.

ABSTRACT ITA

Questa tesi si propone di esplorare come il realismo visivo influenzi la risposta emotiva di soggetti con fobia sociale nell'ambito di applicazioni in tecnologia VR - realtà virtuale. L'attenzione è sull'effetto valle perturbante, "uncanny valley effect", e su come si differenzia la percezione nei casi di fobia da oratoria (discorsi in pubblico), altrimenti nota come glossofobia. Il contesto di riferimento della ricerca è la pratica di trattare le fobie con terapie basate sulla realtà virtuale e l'obiettivo è comprendere, di conseguenza, il livello di realismo richiesto dalla terapia affinché sia efficace.

La ricerca comprende lo studio delle fobie e dei metodi di trattamento terapeutico; la realtà virtuale (VR) e le sue applicazioni; gli studi su l'"uncanny valley effect". Seguono inoltre gli studi sull'uso della realtà virtuale per il trattamento delle fobie, e quindi una sperimentazione sul realismo nella VR e l'impatto de l'"uncanny valley".

La nostra ipotesi è che in ambienti virtuali la risposta emotiva dei soggetti è determinata dalla presenza di fobia sociale, in particolare di glossofobia. In altri termini, si sostiene che, per soggetti con fobia da oratoria, l' "uncanny valley effect" o non ha fondamento oppure è accentuato in VR.

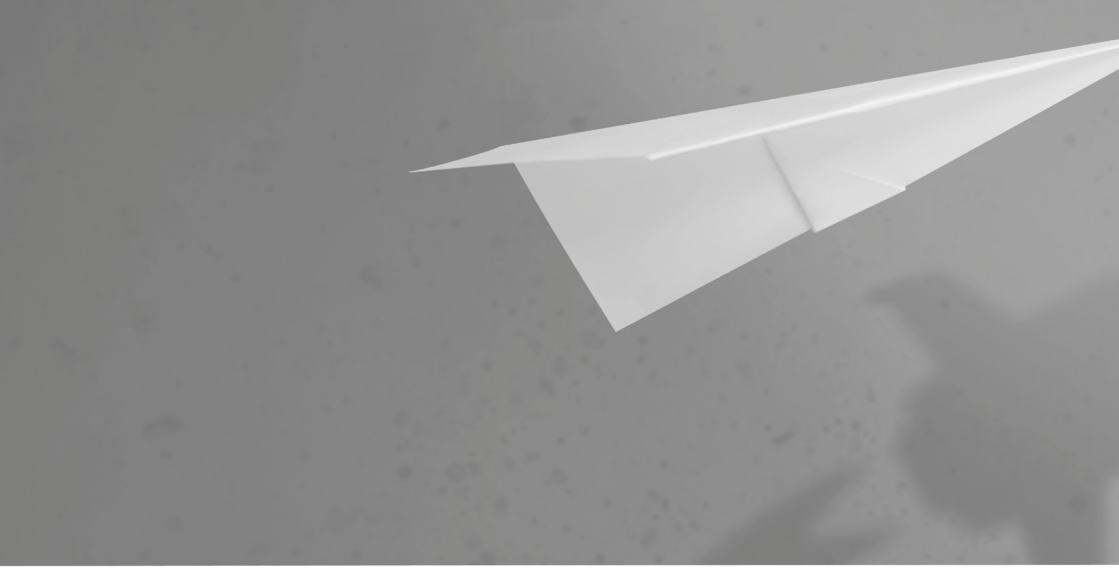
A supporto dell'ipotesi, è stata create una sperimentazione basata su prototipo. Sono stati implementati tre livelli di realismo nell'ambiente virtuale: basso, medio e alto. Un questionario è impiegato per confrontare il livello di ansietà dei partecipanti in esperienze precedenti con quanto sperimentato dall'utilizzo del prototipo assegnato.

L'analisi dei dati raccolti suggerisce che il livello di ansietà in soggetti senza fobia sociale cresce per alti livelli di realismo, il che è in accordo con l'ipotesi "uncanny valley". Si nota inoltre che è valido l'opposto per i soggetti con fobia sociale. Il loro livello di ansietà è minimo per alti livelli di realismo.

Possiamo concludere che la percezione degli avatar in contesti virtuali è individuale e dipende da caratteristiche individuali, in particolare dalla presenza di fobie sociali.

Nella tesi sono infine presentate le implicazioni di questa ricerca e come sia possible ottenere una risposta emotiva positiva, manipolando il livello di realismo, a seconda del gruppo di individui in esame. La ricerca infine dimostra le potenzialità del contributo dell'Interaction Design nella ricerca per le terapie psicologiche a contrasto delle fobie basate su soluzioni di realtà virtuale.

INDEX



0.1 INTRODUCTION

Alfred Hitchcock's "Vertigo" is considered the best movie ever made (Wikipedia contributors, 2020u). It starts with an accident, which the main character Scottie - a police detective - could not prevent due to a fear of heights. His acrophobia is forcing him to retire earlier. Afterwards, he is hired as a private detective and as the story goes further, it becomes clear that his phobia was exploited as a weakness.

Social phobias is one of the three categories of phobias, the others being agoraphobia and specific phobias. It is also referred to as social anxiety disorder (SAD). The source of fear is the presence of other people and their judgement on us. SAD can influence friendships (Rodebaugh, 2009) and career development. Majority of the people with social phobia are afraid of public speaking, making it the most common social phobia (Becker et al., 2007). Glossophobia, as this phobia is officially called, can make people avoid not only to do presentation, but also job interviews. The fear can be so strong that it is compared to the fear of dying (Croston, 2012).

The phobia treatment targets to show to what level the fear is rational (American Psychiatric Association, 2013). Exposure Therapy is the treatment method, in which the patient is exposed to the cause of their fear in a managed way by the therapist. In the recent years, Virtual

Reality (VR) technologies are getting more and more used as part of the Exposure Therapy. This application is called Virtual Reality Exposure Therapy (VRET). Amongst the reasons for the success of VRET is the simplified access to representation of the situations, causing the fear. It is time and cost efficient in comparison to the traditional approaches. In addition, it is critical for situations, which are challenging to be set up in real life for a therapy session. Other important advantage of using VR for phobia treatment is that the environment can be controlled by the therapist in order to produce the suitable situation and level of exposure for each patient. This is the methodology, applied by the companies, doing business in this field. They are trying to replace the real-world exposure with a realistic representation in a virtual environment. The tools are designed to support the work of the therapist, rather than to replace them. A number of researches demonstrate that this application of VR can lead to patient's improvement in 3-5 sessions (Ambienti VR - Limbix Italia, no date).

The development of a virtual environment for social phobia treatment requires the design of virtual characters. For this reason, it holds a challenge due to the uncanny valley effect (Schwind, Wolf, & Henze, 2018). The hypothesis behind the effect states that too realistic humanlike representation of a robot leads to a negative emotional response in people. When the outlook is less realistic, the robot is perceived positively. The theory, originally developed for humanoid robots, can easily be translated into human figures in virtual environments. Further, a research suggests that the effect is even stronger in VR (Schwind, Wolf, & Henze, 2018).

The trend in the VR industry is towards photorealism, especially in the game field. However, this is not the element that guarantees the feeling of presence and immersion in the users. Mel Slater, an Investigator in the Department of Clinical Psychology at the University of Barcelona, discusses that even if the cognitive system realises that this is not reality, the body reacts as it is (Slater, 2018). This highlights the importance of the reaction on subconscious level. Ken Perlin, the director of Future Reality Lab at New York University, criticises the industry trend for "confusing realism with believability" (Vanderbilt, 2016). Another strong statement on that matter is made by William Bricken from Lake Washington Institute of Technology. He says that "Psychology is the physics of virtual reality" (Vanderbilt, 2016). In other words, the user's

approval of a VR environment is more complex than how to achieve photorealistic representation.

The successful anxiety management during a session leads to patient's recovery. This raises the question regarding the suitable level of realism for social phobia treatment with VR. On one hand, all existing solutions on the market are developed in high realism. On the other hand, the experiments with uncanny valley effect in VR have not considered individual characteristics in the participants, including whether they experience any kind of phobias.

This multidisciplinary thesis aims to explore how the emotional response by people with glossophobia is influenced by the level of realism in VR. The hypothesis is that it differentiates between people with and without social phobia. The outcome of this research contributes to the design of VR and provides understanding of the impact of the environment realism on the user's subconsciousness. We suggest that the level of realism is a variable, which the designer can decide, depending on the design brief and targeted audience.

0.2 CHAPTER DESCRIPTION

PART 1: RELATED WORK

Part 1 contains detailed literature review about existing research on the topic. Starts with the base - Emotions. Then it continues with Phobias, Virtual Reality and the Uncanny valley. It ends with the combinations of the chapters into Phobias and Virtual Reality and Realism in Virtual Reality.

1.1 EMOTIONS

The chapter covers the universal emotions and how they are expressed. Definition and explanation of anthropomorphism is provided. The last sections contain review on researches regarding detecting fake smiles and feeling of the emotions throughout the entire body.

1.2 PHOBIAS

Phobia classification is listed with examples for each type. A section is dedicated to glossophobia. Explanation from neuroscience point of view about the process in the brain is given. Last section is about the most commonly used phobia treatment by therapists - Exposure Therapy, the different types of it and their methods ar e reviewed.

1.3 VIRTUAL REALITY

Virtual Reality chapter talks about the term means, the history and forseen future of VR. The main characteristics of a virtual environment are reviewed. Last section is dedicated to the application of VR, in particular in the fields of Education, Medicine and Entertainment.

1.4 PHOBIAS IN VIRTUAL REALITY

The terminology of Virtual Reality Exposure Therapy is introduced along with its advantages in comparison to the traditional exposure therapies, applied by the therapists. State of art review covers the leading existing companies and solutions in the field of using virtual reality for phobia treatment. The VRET application for glossophobia is discussed and the similarities in the existing solutions on the market.

1.5 THE UNCANNY VALLEY

Explanation on the uncanny valley hypothesis is provided, as well as researches performed to verify the effect. It is discussed at what level of realism the uncanny valley is observed, as well as theories about the explanation behind the effect. In addition, discussion on the ethical implication of too realistic humanlike robots is available.

1.6 REALISM IN VIRTUAL REALITY

Graphics in virtual reality are reviewed in relation to how they are perceived by the user. Approaches for creating realistic VR are reviewed. The uncanny valley effect for virtual characters is discussed, along with expression of emotions by the avatars and how they are read by the user. At the end of the chapter, it is provided a guideline for creating virtual characters to avoid the uncanny valley.

PART 2: RESEARCH

In Part 2, the outcome from the research in Part 1 is used in building a concept and prototype. Details on the prototype development are revealed, as well as analysis on the performed survey and its conclusion.

2.1 CONCEPT AND PROTOTYPE

The chapter explains the concept and the hypothesis of the thesis work. It starts from clarifying missing pieces in the conducted researches and experiments so far and how it is developed further in the prototype and the experiment.

2.2 PROTOTYPE DEVELOPMENT

The development of the prototype is described in details. There is an explanation about the selected technology and software tools and why. In addition, occured problems and their overcome are mentioned for facilitating future development work on the topic.

2.3 SURVEY

Details about the questionnaire and how the survey was conducted are covered in this chapter. This includes from how the developed prototype is provided to the participants to what are the questions before and after the experiment. It also hints about the intention how the analysis will be performed in order the organisation of the questionnaire to be planned properly.

2.4 ANALYSIS

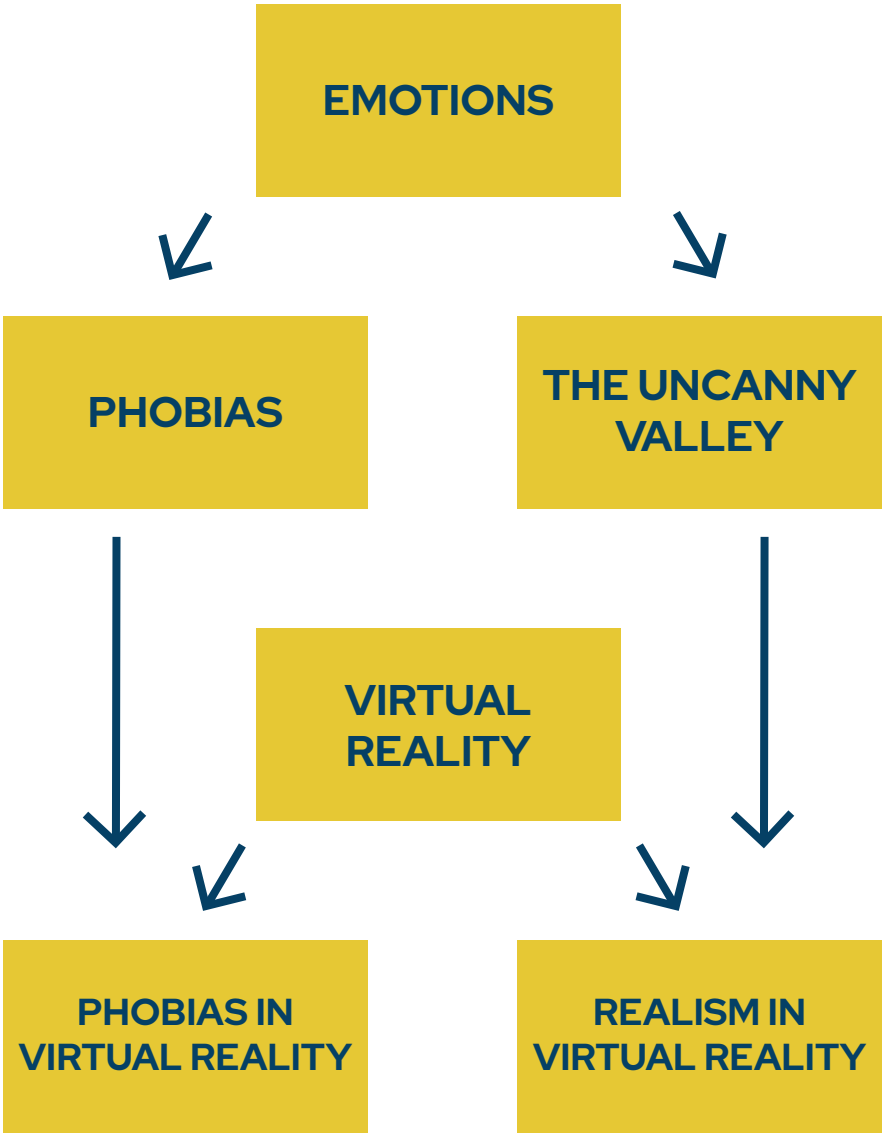
Statistics about the participants and their answers are listed in the first paragraph. It is followed by the used formula for calculating the level of anxiety. With this data available, three main graphs are drawn - for all participants, for the ones with phobia and for the ones without phobia.

2.5 DISCUSSION

In the chapter, interpretations of the analysed results are provided and how the made hypothesis is influenced by them. Next, the implications of the made conclusions are comments and what is the impact on the designer's role. Limitations on the performed experiment are shared and how it can be improved by researchers. Finally, recommentdations how the research can be continued and what is its potential.

2.6 CONCLUSION

The chapter provides a walk-through the entire related work review and research. It explains the observations made during the literature review. After that, descriptions on the hypothesis and the conducted experiment are given. Finally, the outcomes of the thesis work are summarised.


EMOTIONS
PHOBIAS
THE UNCANNY VALLEY
VIRTUAL REALITY
PHOBIAS IN VIRTUAL REALITY
REALISM IN VIRTUAL REALITY

PART 1

RELATED WORK

1.1 EMOTIONS

"I don't want to be in the mercy of my emotions.
I want to use them, to enjoy them
and to dominate them."

- Oscar Wilde
"The Picture of Dorian Gray"

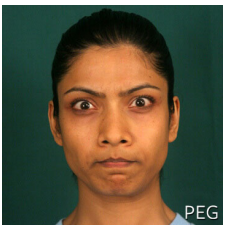
If someone is asked to give a proper definition of "emotion", most probably will find it hard to pick up the right words. Even without a clear definition, every one of us has a good understand what emotion is. We feel them every single day, being influenced by situations or other people. In fact, not feeling emotions is abnormal. One thing is for sure – we are not in control of our emotions, they appear automatically. What is in our control is the reaction, generated as a consequence of a certain emotion. And this is what changes our life, because we are perceived by others with our own behaviour. The way we see the world is influenced by our internal state.

An easy example is when someone feels sad and feels like everything goes bad, against them, which is not necessary the case. If we are aware of our emotions, we are capable of more adequate responses. Emotions have timeline and they usually last for about an hour. If they persist longer than that, they can be called mood or could be a type of disorder (Paul Ekman Group, 2019a).

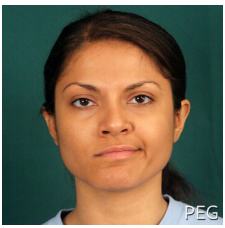
UNIVERSAL FACIAL EXPRESSIONS OF EMOTIONS

The psychologist Paul Ekman has contributed significantly for the understanding of the emotions. In his research, done alongside to his daughter Eve Ekman, he defined the most common emotions and their facial expressions. According to other researchers, there are at least 5 core emotions. Paul Ekman believes that there are 7 universal facial expressions of emotions (Figure 1):

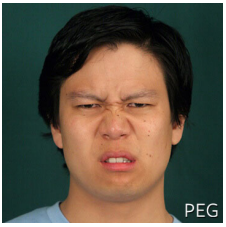
- anger
- contempt
- disgust
- enjoyment
- fear
- sadness
- surprise



ANGER



CONTEMPT



DISGUST

Figure 1.
Facial expressions of the universal emotions (Source: Paul Ekman Group)

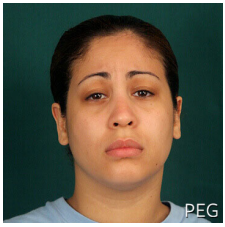
These 7 expressions are considered universal, because they go beyond culture, language, location or ethical differences. Each emotion has specific set of facial muscles involved and that is what makes them recognisable. They are usually symmetrically express with the exception of contempt (Paul Ekman Group, 2019a). Another exception from the seven emotions is fear, because it is the only one that is related to the future. The fear is that something bad will happen to us in the next moment or later. All other

emotions are expressing feelings towards the present.

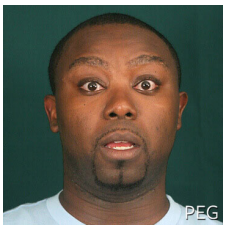
Revealing our inner state through the face is believed to help us fill it stronger. MRI included research gives evidence that the expression is not only to show others our feelings, but also, for example, forcing yourself to smile might make you a bit happier (Andrews, 2010).

ENJOYMENT

FEAR



SADNESS



SURPRISE

ANTHROPOMORPHISM

Apart from expressing our emotions, we are capable of reading such in others. This skill is so strong in our perception of the world that we tend to see emotions in inanimate objects. An example, given by Donald Norman (Norman, 2005), is about the chair in Figure 2. Surprisingly or not, we empathise with a motionless chair. It looks like it is trying to catch back its ball. The shape of the leg so much represents a hand with fingers that it gives the illusion of a movement, caught in a specific moment for the picture. It is weird to feel the emotions of a chair, which logically does not have a soul and mind to feel so, but it is a fact. This phenomenon is called anthropomorphism.

As defined by encyclopaedia Britannica, "**the interpretation of nonhuman things or events in terms of human characteristics**" is called anthropomorphism (Guthrie, 2008). The terminology itself is composed by two words – "Anthropos", in Greek translated as human, and "morphe", meaning form. Originally, the term was used in religious context when people assigned attributes of physical or mental features to deities. Even though the

Figure 2. The chair, trying to catch his ball (Source: Norman)

anthropomorphism can happen consciously, it is very likely to appear subconsciously as well. Examples include when the shape of a cloud reminds us of an animal or a face. Many times in novels the death has been depicted as human-shaped. This is a technique, used as well in graphic design, called personification.

There is no clear reason behind the phenomenon of anthropomorphism. Two good explanations have been given, however, none of them seems to be complete. Already during the 18th century, the Scottish philosopher David Hume tried to give reasoning. He believed that it is an approach by human beings to explain the unknown by applying the rules of the known. In other words, people use patterns that they have already encountered. The gap in this theory is that it misses to explain why people see emotions in their pets, for example, or faces in everyday objects like kitchen utensils.

Another candidate is given by Sigmund Freud. He speculated that the anthropomorphism exists in people to help them see the world through the known. In respect to the proposal by Hume, which is more on intellectual reasoning, Freud was looking for an emotional explanation.

By seeing something more familiar, people feel less threatened by the world surrounding them. It is a defense mechanism for protection from constant fear.

Whichever is the reason for this skill, it is undoubtful that it impacts the way we perceive the world. In general, a perception is a choice between many possibilities in front of us. We decide which one sounds more convincing or convenient to us. As Ernst Gombrich, a psychologist of art, pointed it out – "Perception is betting" (Guthrie, 2008).

HEIDER-SIMMEL ILLUSION

An example for the skill of applying emotions is the short film by Heider-Simmel, created in 1944. They conducted an experiment with a movie with a random repositioning of a smaller and a bigger triangle and a circle (Kenjirou, 2010), as drawn in Figure 3. The video is in black and white, which further removes the possible influence by the presence of colours to create certain mood.

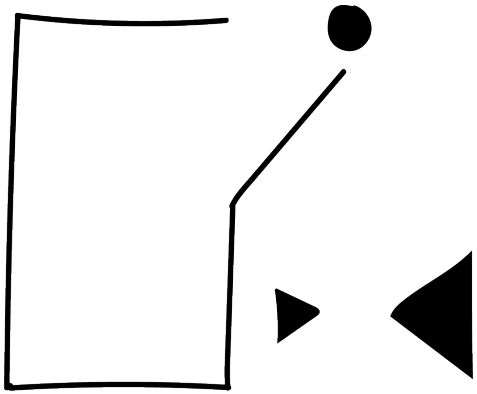


Figure 3. Heider-Simmel illusion

They showed this to a number of people and asked them to describe what they saw (Bjorksten, 2017). Even if there was no specific story behind the creation of the movement for each of the shapes, people projected emotions on them. They believed to be describing the story, while, in reality, they were building their own. People tend to think

in stories, because it makes it easier to remember events in the form of action-consequence matrix. "Seeing" emotions makes the process even easier, because often the actions are based on the emotions. In fact, people might sympathise with any of the three main "characters" in the movie, being influenced by their personal experience. Instead of remembering a move from left to right of the circle, the brain gives a meaning to this movement to create understanding. The rectangle can be easily associated with a home, including the door for it. The triangles might look like they are having an argument, even one of them looking aggressive. And during the "fight", the circle can be seen as feeling scared and trying to stay away. Julianna Bjorksten is a student, who participated in an in-class experiment with this video (Bjorksten, 2017). In her article, she points out that everyone in class created a story, personifying the three shapes. Some of the words, used by the students, included "escaped", "danced", "slammed" and "kissed".

A similar animation, known as the Frith-Happé animation, is about two triangles in a rectangle. In the video the two shapes seem like dancing. It was developed to test the Theory of Mind, which is about attributing mental states to ourselves or others . Such states include beliefs, intents, desires, emotions and knowledge (Wikipedia contributors, 2020s). The relation between the theory and the abovementioned anthropomorphism is that the latter is applying the process of theory of mind on non-human entitie (Atherton and Cross, 2018). Using Frith-Happé video as a test, it is possible to detect the deficits of understanding of emotions by people with Autism spectrum disorders (Rudacille, 2011).

FAKE SMILE

Paul Ekman's findings are directed towards facial expression. However, we all have noticed when someone puts "a fake smile" on their face. Donald Norman is criticising the design of the robots when it comes to expressing emotions (Norman, 2005). He states that the common approach by engineers is to add movements on the face of the robot, trying to demonstrate certain emotion. Still, this does not seem to be convincing enough for humans.

Richard Wiseman, a psychologist, performed a test to understand more about people's skills in detecting a fake smile (McKie, 2015). For his experiment, he took two photos of the same person. In the first

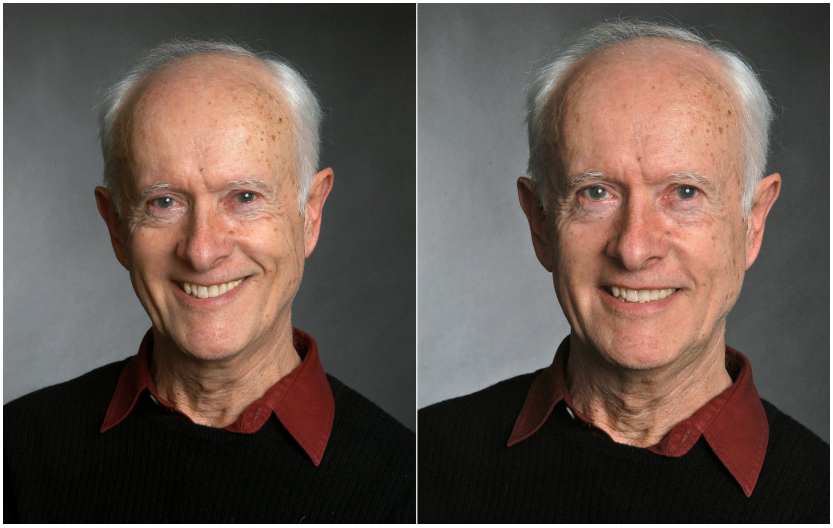


Figure 4. Images, shown to participants during the experiment (Source: Wiseman)

one, he asked them to image that they are meeting someone, who they do not like very much. In the second one, he asked them to imagine meeting a good friend. Wiseman placed the two photos next to each other and showed them to participants in the experiment (Figure 4). He was trying to understand how accurate people are in detecting the sincere smile. It has to be considered that a genuine smile involves more facial muscles that the ingenuine one. It came out that the people, who have stronger empathy, are demonstrating better "reading" of the emotions. In particular, 60% of all participants replied correctly. Moreover, the test was also targeting professionals to see if there is any difference. Journalists did much better than scientists with a score of 73%. The conclusion, we can easily make from the experiment by Wiseman, is that even in an image, lacking any motion, people are still good in detecting a fake smile.

EMOTIONS IN THE ENTIRE BODY

Another explanation behind the detection of a fake smile is because emotions are not expressed only with our faces (Paul Ekman Group, 2019a). The entire body is involved in sending information about

our emotional state to the others around. A study aimed to find how people feel their bodies, when feeling a certain emotion (Nummenmaa et al., 2014). The participants were asked to colour the part of the body, in which their experience was felt. Regardless of culture or region, the results were synchronised. In Figure 5 the outcome of the research is visualised. What can be observed, is a similarity in the feeling of fear and anxiety. Both are centred in the chest area, which could be the explanation about the typical symptoms of anxiety like increased heart rate or problems in breathing. The researchers point out that happiness was the only emotion, which was experienced through-out the entire body. In disgust, it is easy to notice that the feeling is all the way from the mouth to the stomach. It represents that this emotion is associated with the unpleasant feeling, usually caused by food, and projected on other experiences.

CONCLUSION

Expression and detection of emotion are a complex and not completely understood processes. This makes the task of designers and engineers harder when it comes to creating robots or avatars in virtual reality environments (Norman, 2005). In order to be accepted by humans, they need to possess skills in expressing emotions in a way that is convincing on subconscious level. People need to trust them. As Donald Norman explains "We can control the final emotions through reflective analysis, but those initial impressions are subconscious and automatic." (Norman, 2005). Thanks to our ancestors, we are wired with a set of skills that help us to protect ourselves from potential danger. This includes recognising the risks in being in contact with another human-like creature. From anthropomorphism point of view, we are looking for emotions in others in order to feel comfortable. If they cannot express emotions, we believe they are not capable of such, therefore, they cannot empathise with us. If they cannot empathise with us, they hide the potential of being cruel to us and even put us in danger, including to try to kill us.

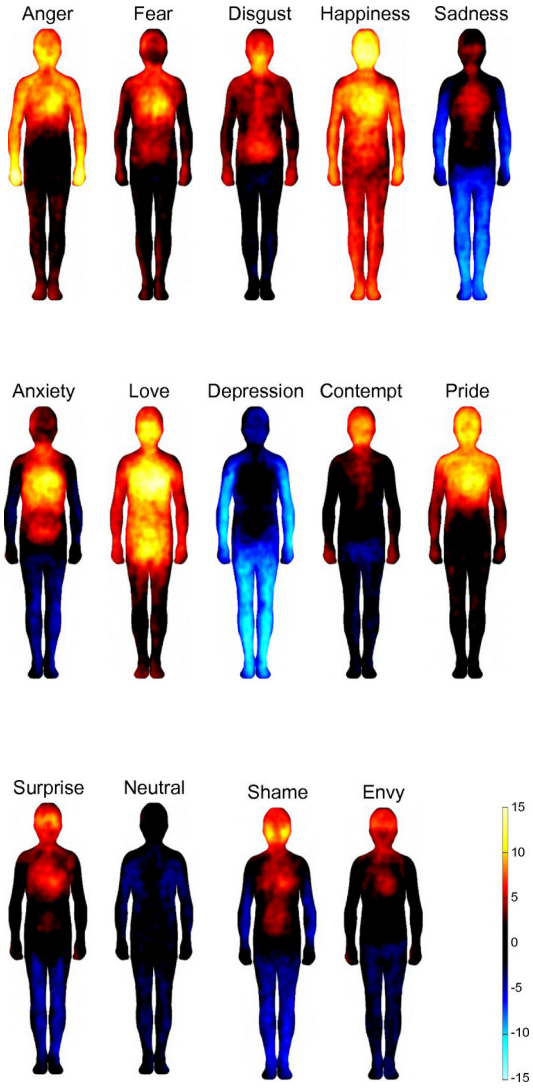


Figure 5. Colourful expression of sensation of emotions in the entire body (Source: Nummenmaa)

1.2 PHOBIAS

"Men are not afraid of things,
but how they view them."

- Epictetus

Charles Darwin has said that "**There is no fundamental difference between men and animals in their ability to feel pleasure and pain, happiness, and misery**". What makes us different from the rest of the animal world, is the fact that we have mind. This mind helped us evolve, from inventing the fire to going out in space. Regardless of the power of mind, we are "trapped" in a fragile body, which makes us feel the pain. Pain is unpleasant and we fear being hurt physically or mentally. Fear helps us to avoid threats and is protecting us. That makes it important for our longer existence. Fears in their nature are rational. However, they can become irrational when they are not representing a real threat, but perceived as so. In such case, they become phobias.

According to the American Psychiatric Association, "a phobia is a type of anxiety disorder defined by a persistent and excessive fear of an object or situation" (American Psychiatric Association, 2013). The word "phobia" comes from Greek with literal translation of "fear" or "horror". The concreate phobia name is created by using the Greek word for the object or situation of fear and adding "phobia" at the end (Osborn, 2017). Even though both fear and anxiety are about experiencing danger, there is a difference between the two. While fear is regarding a concrete foreseen possibility of injury, anxiety is not directed at a specific object or situation, but more general feeling of worry about possible future negative experience (Heshmat, 2018). Anxiety, like fear, in its nature is useful, because it is warning us about something, which can hurt us. The problem starts when the anxiety is caused by irrational understanding of the object of fear. In that case, it is referred as disordered anxiety (Therapy in a Nutshell, 2019). As Donald Norman speculates in his book "Emotional Design: Why we love (or hate) everyday things" if more intelligent robots need a red warning for potential danger, it would be the equivalent of anxiety in human beings (Norman, 2005).

Amongst the most common symptoms of experiencing phobia are sweating, increased heart rate, feeling dizzy and difficulty breathing (Mayo Clinic Staff, 2016).

PHOBIA CLASSIFICATION

American Psychiatric Association is in charge of publishing The Diagnostic and Statistical Manual of Mental Disorders (DSM). This manual contains the classification of mental disorders. It is actively referred by psychiatrists, clinicians, pharmaceutic companies and researchers. Diagnosis are defined based on the criteria, described in DSM (Wikipedia contributors, 2020d). Since anxiety disorders and phobias are a type of mental disorder, they can be found in this manual. It is periodically updated to be aligned with the changing conditions and add newly found mental disorders. The list of existing phobias is long, however, phobias can come out of any object or situation, which leads to discovery of new phobias (Osborn, 2019). One quite modern example is nomophobia – the phobia of being without a cell phone or computer (King et al., 2013).

According to DSM, there are three main groups of phobias: agoraphobia, specific phobias and social phobias:

Agoraphobia is an anxiety disorder, caused by anxiety in situations perceived to be unsafe. Usually, such places are public areas, squares, public transport, etc. (Wikipedia contributors, 2020f). The word "agora" in Greek means "public square", which leads to the name of the phobia. Agoraphobia can have serious impact on the quality of life, because people with such condition are trying to avoid the places that cause them the anxiety. In most of the cases, they might experience panic attack. This makes people feel embarrassed that they might relive another attack, while there are others around. As a consequence, they prefer to stay in environments, in which they have more control and feel relaxed, often this is their own house. The feeling of safety comes also from the presence of someone close like a relative, someone they can count on in case of another panic attack. Considering that this phobia is unlikely to be resolved on its own, it can limit the possibilities for normal life (Wikipedia contributors, 2020a). About 1.7% of the adults have agoraphobia (Wikipedia contributors, 2020f).

When talking about phobias, the most common examples, known by everyone, are falling in the category of specific phobias. They are associated with irrational fear of a concrete object or environment.

They are usually divided in 5 categories (Mayo Clinic Staff, 2016):

- Situations, such as airplanes, enclosed spaces or going to school
- Nature, such as thunderstorms or heights
- Animals or insects, such as dogs or spiders
- Blood, injection or injury, such as needles, accidents or medical procedures
- Others, such as choking, vomiting, loud noises or clowns

One of the most well-known specific phobia is the fear of heights, called acrophobia. This is the phobia experienced by the main character in Alfred Hitchcock's movie "Vertigo" (Wikipedia contributors, 2020u). Another example is arachnophobia – the fear of spiders. And of course, claustrophobia, which is caused by small spaces.

National Institute of Mental Health reports that 12.5% of the American adults experience specific phobia at some point of their lifetime, highlighting higher numbers among women than in men ("Specific Phobia," 2017). Such phobia can cause severe impairment and lead to limitations in functioning at work, school or in social context. There are three main reasons for developing a specific phobia. One possible cause

is previous negative experience. The object might have led to serious fear or panic attack and it is avoided in the future to evade the same experience. This approach is called Classical Conditioning (Wikipedia contributors, 2020e). Another cause, called vicarious fear acquisition, is if this fear was observed in someone else, like a parent or relative, and their negative experience and outcomes were transferred as fear in another person (Mayo Clinic Staff, 2016). For example, as a kid someone saw a dog barking at their parent and the parent with a reaction, demonstrating stress, then the kid grows with the perception that the dogs are dangerous. A third way, or informational/instructional fear acquisition, is by being told or read about the possible outcome of certain activity or object. An example is with the electric wires and being told that they can cause pain and even death, so people avoid them (Wikipedia contributors, 2020e).

The third category of phobias is **social phobias**. They cause fear or anxiety in social settings, in particular due to negative judgement by others (Wikipedia contributors, 2020n). Even though they share similarities with agoraphobia, they are conceptually different. In a social phobia, the person is in interaction with others. In agoraphobia just the presence of another person is sufficient. People, experiencing social phobia are not avoiding interaction in general, but they prefer to interact with people they trust (Editorial Staff, 2016).

Another important clarification regarding social phobias is the relation to social anxiety disorders (SAD). These two terms are interchangeable, however, there is a slight difference between the two conditions. Social phobia is associated with the action of performing or presenting in front of others, while social anxiety disorder is related to one-on-one meetings or group gatherings. In other words, social phobia requires active presence in a social setting, leading to physiological and psychological reaction due to the fear of scrutinizing. For social anxiety disorder it is enough the passive presence to cause high level of distress. In DSM social phobia was recorded in 1980, while social anxiety disorder was entered later – in 1994 (What is the difference between social anxiety and social phobia?, 2017).

SAD is also called "an illness of the lost opportunity", due to its severity forcing people to make life decisions, which might be missing opportunities (Stein and Gorman, 2001). In that sense, the anxiety is like a wall, preventing people from achieving their goals and having successful

careers. And as said in the famous speech by Ronald Reagan in front of the Berlin wall in 1987, what is needed in this case as well is to "Tear down this wall!" (Wikipedia contributors, 2020r).

Social phobias are divided in specific social phobias (SSP) and generalised social phobias (GSP). GSP is more often referred to as generalised social anxiety disorder. In GSP people would feel anxious in more than one social setting, while in SSP they might feel so in only one specific situation (Wikipedia contributors, 2020p). A research by Hook and Valentiner (Hook and Valentiner, 2006) distinguishes GSP and SSP not only by quantitative, but also in qualitative aspect. They are suggesting different background and reasoning for developing one or the other. They go further by hypothesising that GSP is likely to be due to genetics, rather than due to situations, experienced later in life. About 7% of the world population suffers from some social phobia (Editorial Staff, 2016). In 38% of the cases with only one social phobia, there is the presence of another anxiety disorder. With the increasing number of social phobias, as much as 92% of the cases are accompanied by another disorder (Hook and Valentiner, 2006). The combination of a few disorders is called comorbidity. The average lifespan of a social phobia is 19.2 years (Hook and Valentiner, 2006). Due to the high percentage of comorbidity and prolong existence of social phobias, they represent a serious issue for the health care system and requires action from their side. In addition, a research by Rodenbaugh demonstrates that social phobia has significant impact on quality of friendships, reporting that often people with some social phobia have no close friends (Rodebaugh, 2009).

Examples of some social phobias (Acarturk et al., 2008), (Wikipedia contributors, 2020p):

- Glossophobia – the fear of public speaking.
- Stage fright – the fear of performance
- Fears of intimacy
- Paruresis – the fear of using public restrooms
- Eating or drinking in public places

About 82% of all people with social phobias, have glossophobia, which makes it the most common one. 77% for the entire population experience some anxiety related to giving a speech (Fritscher, 2020).

PUBLIC SPEAKING

Already Mark Twain pointed out that "There are two types of speakers: Those who get nervous and those who are liars."(Weissman, 2014). The fear is so strong that for many people it is stronger than the fear of death. There is possible explanation, referring to our evolution. One version is described by Sarah Gershman (Gershman, 2019). During a speech, the audience is looking at you. In a way, this replicates the moment when a predator is observing its next victim and preparing to attack. Another reasonable explanation, given by Glenn Croston (Croston, 2012) is again related to predators, but in a different way. For humans to protect themselves from bigger predators, they had to live in tribes. They needed to warn and help each other in order to survive. If you lose your status in the group, you are risking your own life. Under these conditions the exclusion, also called ostracism (Wikipedia contributors, 2020k), is equal to a death sentence. Not performing well in front of the audience, could lead to the risk of being excluded from the tribe. There is no such risk in modern times, however, the stress from bad performance remained.

To give a speech means to share knowledge, which you have previously obtained. Not being capable to manage the anxiety, gives the impression to the audience for lack of knowledge. Matt Abrahams talks about the second-hand anxiety (TEDx Talks, 2018). It is the anxiety, which the speaker transfers to the audience. By overcoming it, the message conveyed.

Even if glossophobia is unlikely to have comorbidity (Becker et al., 2007), it still has a serious impact on the quality of life. There are numbers of situations that require public speaking. It is not necessary about giving a lecture or presentation, but such situations include even job interviews.

Due to the commonality of this fear, there are a lot of suggestions available what to do during a presentation. The techniques to apply vary from focusing on the audience (Gershman, 2019), (Communication Coach Alex Lyon, 2017) to focusing on oneself (TEDx Talks, 2018). By suggesting to pay more attention to the people in front, the speaker can be more empathetic with them, therefore, build a connection and transfer the knowledge. A concrete tip for achieving this is to find a few people in the audience, which are likeable, and look at them in the eyes.

However, the side effect is that the rest of the people might notice this and feel neglected. Another technique is to focus on the prepared notes. The risk with this is that the speaker is so prepared for one possible turn of events, ignoring quite a lot the audience and their influence on the speech. By checking regularly the notes, it is the same if the audience is from one person or from many. This way no connection with the people is created and it might put in danger the overall outcome of the presentation. Another common hint is related to breathing and moving. Like in situations of anxiety, breathing helps to calm down, as well as, using gestures and moving around. Often in such situations people tend to blush. An interesting tip for this is to hold something cold in the hand to help cool down the temperature, causing the blushing (TEDx Talks, 2018).

Regardless of the numerous advice available for overcoming the fear of public speaking, there is no unique formula, which works for everyone. The levels of distress are different for each person and each situation. Even if someone usually does not have glossophobia, due to the importance of a particular speech or presentation, it is possible to generate anxiety. It happens that the inner condition of stress is not expressed and from outside the audience enjoys the presentation (Communication Coach Alex Lyon, 2017). This is another proof that what is going on in the head is not necessary the reality.

THE BRAIN

Understanding well the phobias and their reasoning behind cannot happen without understand how the brain works. In fact, there are two ways to experience anxiety in the brain – the amygdala pathway and the cortex pathway (Pittman and Karle, 2015). Both have their significant role in our survival and existence.

The cortex pathway involves all sense organs and the received information processing in different parts of the brain. Eyes, ears, nose, taste buds and skin send information to the thalamus, which forwards it to different part of the cortex for interpretation. In the frontal lobes all the interpretations are collected and further handled to give us perception of the situation and the world around us. This is where anticipation of events and response planning happen. Such interpretations might cause anxiety, thanks to its ingredient developed in the cortex – worry. The difference in the size of the frontal lobes in human and animals is an

explanation why people are able to predict future events and worry about them, while animals can be much more relaxed and enjoy the present. The human skill to build images of possible future situations is in a way creativity. It is believed that more creative people tend to worry more often.

The amygdala pathway is responsible for the quick reactions in the body, including the typical symptoms of anxiety like increased heart rate and muscle tension. It reacts in a tenth of a second, in which it can induce adrenaline. In such a short time, it is impossible to construct thoughts and analysis of the danger. Amygdala is a small organ near the centre of the brain. To be precise, there are two amygdalas in each hemisphere, but for simplification often it is referred to as one single organ (Pittman and Karle, 2015). It is part of our body from ancient times. In fact, its structure is very similar to the amygdala in other animals like rats, dogs and fishes. Thanks to this, researchers have been able to investigate and learn more about how fear and anxiety work in our bodies. We are born with ready-made list of responses in case of danger. However, with our daily experience, we can add more responses in the list, or even to alter existing ones. When facing an object or situation from this list, amygdala does not evoke the image from the previous experience, but rather the negative emotion. Therefore, it might be felt as anxiety without understanding why or even read as a bad feeling of what is going to happen, believing to be based on intuition.

The time reaction is the main difference between the two pathways (Figure 6). While in the amygdala pathway everything happens fast and with no control, in the cortex pathway there are analysis and

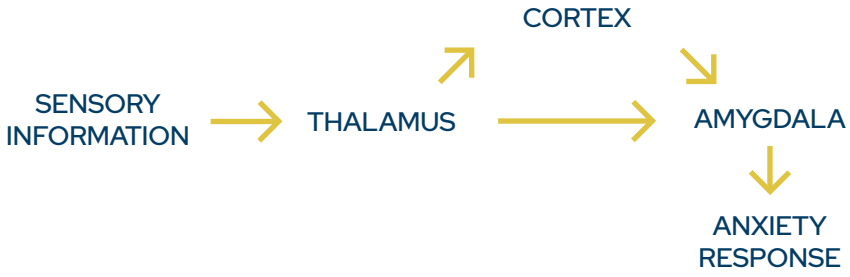


Figure 6. The two pathways to anxiety response

thoughts that give explanation for the experience. On one hand, therapists often focus on the thoughts and look for a way to rationalise them. On the other hand, doctors and psychiatrists focus on the amygdala and its treatment with medication. The well-known tranquilizers like Xanax, Ativan and Klonopin work on the amygdala in attempt to calm it down (Pittman and Karle, 2015). Their effect is temporary and they do not provide long-term treatment to decrease the anxiety in future situations. This is why some therapist work in parallel with psychiatrists, when the level of worry is too high to allow them to work on the rationalisation.

Both pathways are important and contribute to each other. On one side, we need the amygdala to react quickly in danger situations, because by the time the frontal lobes handle the information and build thoughts, it might be late for a proper reaction. On the other side, we cannot count only on quick reactions without thoughts and analysis to survive as species.

The quick reaction in the amygdala pathway is referred to as fight-or-flight response (Pittman and Karle, 2015). As the name suggests, in danger there are two possible reactions – to start fighting the enemy or to try to run away as an alternative to protect oneself. These two responses are typical for animals as well. However, there is a third one, which the human amygdala can produce. It is called "freeze". This is the feeling when a person paralyzes under the condition of a fear. The fight, flight or freeze response is so strong that it replaces all other ongoing logical processes and takes full control of the reaction.

Anxiety is fed every time, when we try to avoid the situation. The reason why the anxiety grows with every flight response, is the so-called anxiety cycle (Figure 7). In the example, given by the family therapist Emma McAdam, she refers to the phobia of dogs. It starts by seeing the dog, thinking that it will bite and feeling anxious. The reaction to escape shows that nothing bad happened and the brain believes that it managed to run away from a very dangerous situation. It wants to do the same when facing a dog again. This demonstrates that the avoidance feeds the anxiety, making it stronger (Therapy in a Nutshell, 2019).

The brain works by creating connections from our memories and experiences. It has also another skill – to alter these connections. This is called neuroplasticity and is the key behind successfully overcoming of anxiety disorders. Researches demonstrate that it is enough even only to think about performing a certain action for the brain to start creating

new connections (Pittman and Karle, 2015). In other words, the brain is like a muscle and therefore, needs training and practice (Therapy in a Nutshell, 2019).

Figure 7. Anxiety cycle example by Emmy McAdam (Source: YouTube)

TREATMENT

The most commonly applied treatment for any kind of phobia is the so-called Exposure Therapy, which is a type of Cognitive Behaviour Therapy. It is believed to be the most successful treatment, proven through the decades it has been used with patients. A research to follow up the phobia status 4 years after exposure therapy treatment, demonstrated that 90% of the patients kept a significant reduction in the levels of stress and avoidance. 65% of all did not possess symptoms of the phobia, for which they got treatment (Wikipedia contributors, 2020c).

In the 1950s, the psychiatrist Joseph Wolpe considered the psychiatric problems as behaviour ones. He came up with the concept behind Exposure Therapy, used even nowadays. The therapy got its origin from an idea by the Russian physiologist Ivan Pavlov. He observed his dog's strange behaviour, which was starting to salivate in the presence of the scientist preparing to feed it, rather than simply in the presence of food (Figure 8). Pavlov concluded that the dog made a connection from previous experience of his owner ringing a bell to signal the time for food and the pet expected to be fed when he arrives (Wikipedia contributors, 2020e). By definition, "**learning procedure, in which a biologically potent stimulus (e.g. food) is paired with a previously neutral stimulus (e.g. a bell)**" is called Respondent Conditioning or Classical Conditioning. It is often referred to as Pavlovian extinction (Wikipedia contributors, 2020h), (Wikipedia contributors, 2020e). Pavlov stated that a person with a phobia learned through the classical conditioning that the feared stimuli is leading to a negative outcome (Wikipedia contributors, 2020j). Classical conditioning differs from Operant Conditioning, known also as Instrumental Conditioning. In it, the unwanted behaviour is punished, rather than wanted behaviour being awarded (Wikipedia contributors, 2020e). In that sense, Exposure Therapy differentiates

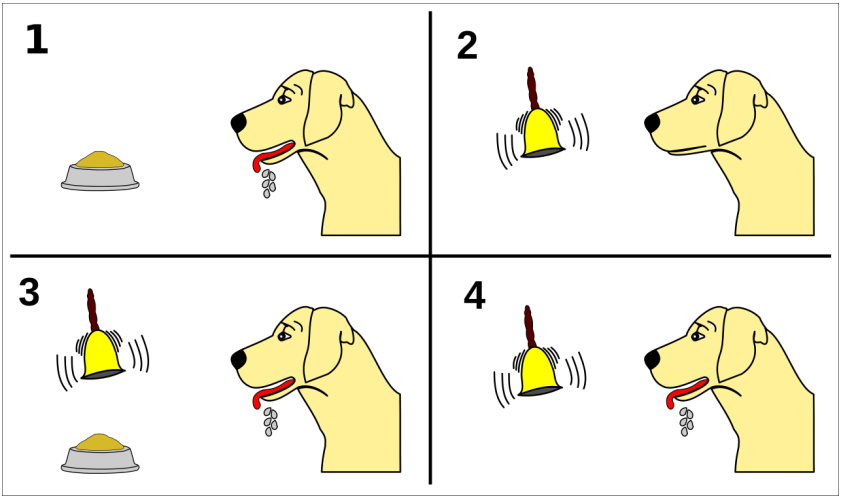


Figure 8. Pavlovian dog (Source: Wikipedia)

from other therapies like Aversion Therapy, in which the patient feels some type of discomfort when performing the undesired behaviour. For example, when people try to stop biting their nails, they use nail polish with unpleasant taste (Wikipedia contributors, 2020b).

There are a number of ET versions. Three of them are the most well-known and applied ones, which can be used in a combination as well (Wikipedia contributors, 2020e):

- In-vivo ET

  The patient is asked to perform or present in the real-life context of the phobia origin.

- Imaginal ET

  The patient is asked to imagine the environment, in which the phobia is triggered. They are guided by the therapist about what and how to imagine as part of the session.

- Interoceptive ET

  More common for panic disorders or PTSD. The patient is focusing on the body reaction like heart rate or shortness of breath.

In-vivo ET is applied directly in the environment or context, in which the fear arouses. For example, a person with glossophobia might be asked to perform a speech in front of a small group of people. As part of the therapy, usually this is done along side with the therapist, who is observing and guiding the patient. There are two variations:

- Systematic Desensitization (or Progressive Exposure)
- Flooding

In both variations the patient is exposed to the stimuli in steps. The difference is that in Systematic Desensitization, it starts from the stimuli with the lowest level of stress, while in Flooding the patient is exposed directly to the highest level of stress (Wikipedia contributors, 2020e). In the latter, there is a risk that the patient might increase the fear or that it might reoccur in the future (Wikipedia contributors, 2020j). This is one of the reasons why Systematic Desensitization (also called graduate exposure therapy) is more often applied by therapists. According to Joseph Wolpe, 90% of the patients are successfully treated through Systematic Desensitization (Wikipedia contributors, 2020q).

The steps in the dynamic hierarchy method are the following (Brady and Raines, 2009):

1. The method of factors

The patient and the therapist sit together and discuss the source of the fear. Together they identify the steps in the exposure. They can be variables of closeness, size, colour, texture, expected negative consequences, etc.

2. Arousal set-point

The level of arousal is selected by the patient themselves. The therapist can give suggestions regarding the suitable level, trying to target the highest in which the patient can maintain their fear throughout the session. The target is to reach habituation under the selected conditions before increasing the stimuli.

3. Moving up the scale

Once the patient is ready, the set-point is moved with the next one, in which the level of stress is manageable, but causes discomfort.

With this systematic approach, the patient can realise that the fear is not corresponding to the realistic possibilities of danger in the situation (In Vivo Exposure Therapy, 2016). The role of the therapist is to support the process and observe the levels of stress in the patient in a discreet way, so the person feels more in charge and builds independence. The method is called desensitization due to the fact that it aims at making the fear sensed less. A common practice, applied by therapists during the session, is the use of breathing exercises. It is to lower the stress and the increased heart rate. Already Joseph Wolpe discovered the benefits of the exercises, because people are not capable of being relaxed and anxious at the same time (Wikipedia contributors, 2020q).

The second most popular Exposure Therapy is Imaginal ET. It starts with creating a scale and steps, similar to the Systematic Desensitization approach. After that, the therapists and the client construct the scenes together in a safe environment. For example, in aviophobia the visualisation can start from packing the luggage at home, taking the taxi to the airport and queueing at the check-in desk. The therapist's role in that step is to guide the images to lead to anxiety or discomfort.

anxiety or discomfort. In addition to the patient's actions and scenery, the description should include sound, smell, touch, etc. Once this is achieved, it is the moment for the imaginal exposure. The therapists let the person immerse in the scene and get more passive role, while they lead the description for the stimuli. The visualisation description is recorded and the patient is asked to listen to it a few times at home as part of the process (Tompkins and ABPP, 2016).

Even though In-vivo Exposure Therapy is considered more effective, sometimes it is not practical to perform a session in the real environment (Tompkins and ABPP, 2016). For example, aviophobia requires travelling with an airplane, which is quite time and money costly. Nevertheless, therapists use Imaginal Exposure as an easier approach, combining it with in-vivo in case it is possible. Another challenge to be considered by the specialists, is that some people are with poorer imagination and might face difficulties in the process. Additional training can be performed to achieve better results (Tompkins and ABPP, 2016).

CONCLUSION

The most common social phobia is glossophobia – the fear of public speaking. This phobia, as well as the others, can have a severe impact on the quality of life. In particular, glossophobia can influence the performance during presentations, job interviews or exams and, therefore, limit the opportunities for career development. Specialists use In-vivo Exposure Therapy as a proven technique for treatment, in which the patient faces the phobic environment in real life along with the therapist. It can be approached by direct exposure to the highest level of distress (Flooding) or gradually in steps, designed together during the session with the therapist (Systematic Desensitization). More effective is the latter one, respectively more applied in practice.

1.3 VIRTUAL REALITY

"Reality exists in the human mind,
and nowhere else."

- George Orwell
"1984"

There is no doubt that Virtual Reality (VR) is one of the most talked about technologies nowadays. In the past 5 years, VR technologies have become more and more affordable from developing the software to getting access to the needed hardware. And this seems to be only the beginning of bringing VR more into our lives.

WHAT IS VIRTUAL REALITY

Virtual Reality is the representation of another world, giving the perception of a reality, in which you can move in 3D space. This world can be a replication of a real place or completely invented, including not looking realistic at all (Intel, no date).

When talking about VR, it is good to separate Augmented Reality (AR) and Mixed Reality (MR), which are often associated with it.

AR uses elements from the real world, while VR does not. By saying "elements from the real world", it refers to using the device camera and adding digital elements on the screen, which are not visible otherwise. The most famous example for AR is Pokemon Go. (Intel, no date). In this game, people play by going around in real streets and public places to collect pokemons, which are digitally added through the mobile app. A practical example for AR app is by Ikea. With it, the user can apply an Ikea furniture to their house and decide if it fits well like this and then to buy it (Ikea App Page, no date).

Mixed Reality (MR) is as well bringing virtual elements in real world with the enhancement that you can interact with both digital and physical elements. This happens with the use of advanced sensors and devices (Intel, no date).

Paul Milgram positioned the three technologies (VR, AR and MR) on a scale and called it "virtuality continuum" (Wikipedia contributors, 2020m). The scale is spanning from completely real to completely virtual world (Figure 9). While VR is only digital, MR comes in between VR and real world. On the reality side of the spectrum stays AR. On the other side of MR is the so called Augmented Virtuality (AV), which is about visualising real objects into a virtual world.

Figure 9. Reality-virtuality continuum, according to Pilgram (Source: rework from Wikipedia)

All realities, VR, AR and MR, are often referred to with a common terminology as Extended reality (XR) (Wikipedia contributors, 2020i).

HISTORY

As the famous English philosopher George Santayana says "To know your future, you must know your past" (GoodReads, no date). For this reason, we will review the history of the VR (Barnard, 2018), (Berkman, 2018) and the evolution it has undergone.

1812

Panorama paintings

One of the main targets of VR is to create the illusion of presence in another world or place. Taking that into account, we can refer to first attempts for such illusion in paintings. An example is "The battle of Borodino" from 1812, which is a panoramic painting covering 360 degrees. In such a panorama, the painter aims to develop the feeling of presence in another place, or in that case another historical moment.

1838

Stereoscope

One of the most important research, leading to the VR as we know it, is done by Charles Wheatstone. He understood that if two images of the same view with slightly moved viewpoint are placed one for each eye, they are perceived by the brain as depth. This is called stereopsis. Wheatstone tested this by using mirrors at 45 degrees, reflecting the two images (Figure 10).

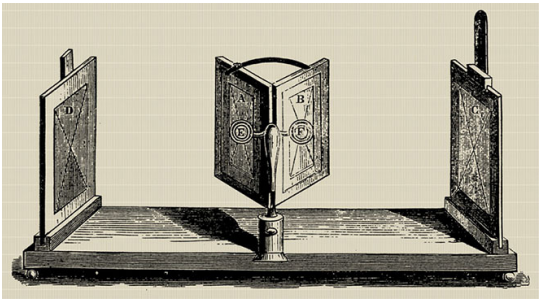


Figure 10. Wheatstone used mirrors at 45 degrees to create stereopsis (Source: Barnard)

1929

Link Trainer

In 1929 the first flight simulator 'Link Trainer' was developed by Edward Link. Fully electromechanical, it even had sensors to simulate turbulence. It was actively used during the World War II to train over 500 000 pilots.

1935

Pygmalion's Spectacles

Many of the new technologies first appeared in books or movies. VR is no exception to this rule. In 1935 Stanley Weinbaum wrote his book "Pygmalion's Spectacles". The story is about a professor, who designed special goggles that take you to another world. Not only that, it involves senses like hearing, smell or touch. As said in the book, "the story is all about you, and you are in it". There is no doubt whether this sounds familiar.

1956

Sensorama

In 1956 Morton Heilig designed a machine for showing movies on a stereoscopic 3D screen. He included scents as well. The device is called Sensorama and it is considered the first VR machine.

1960

First head-mounted device

Heilig continued the direction of full immersion and in 1960 he patented the first head-mounted device (HMD). It was equipped to show stereoscopic view with a stereo sound. No motion tracking was available yet.

1961

Motion tracking in head-mounted device

The motion tracking in HMD was introduced a year later, in 1961, by Comeau and Bryan. The aim of the device was for military purposes to observe dangerous situations.

1975

Videoplace

The first example of interactive VR environment can be considered the work by Myron Krueger. In 1975 he developed "Videoplace". In it, the user's movements are detected in space.

1987

Virtual Reality term

In 1987, Jaron Lanier gave name to the Virtual Reality. Prior to this, the researchers were doing development and experiments, but no terminology was used.

1991

Games with VR and HMD

1991 marks the introduction of VR and HMD to the public for game purposes. Still quite at a price, The Virtuality Group released a few arcade games, using goggles. In the same decade, a lot of other companies like Nintendo and Sega would attempt to bring HMD in the gaming.

2010

Oculus

A prototype of Oculus is developed in 2010. 2 years later the company gets funded, which was a clear sign of the potential of the product.

2014

Facebook buys Oculus

In 2014, Facebook acquired Oculus VR for $2 billion. Google released a low-cost headset, called Google Cardboard. With it, the user can use their own phone for viewing the VR.

2016

HTC Vive HMD

In 2016, HTC Vive HMD was released. It goes with a sensor-based tracking, allowing the user to go around and explore the space in the VR environment. This is one of the examples of new products on the market. The VR industry starts its bloom.

2019

VR devices everywhere

By 2019, the market is flooded by affordable devices for VR. Mixed Reality attracts more attention and it gives signs that it is the next big thing in the XR technologies.

2020

COVID-19 impact

2020 is the year that will be remembered with the COVID-19 pandemics. It forced millions of people all over the world to stay at home, which complicated the daily work activities. This increases the public demand towards VR due to the experienced limits in physically changing locations. Working or studying from home can be improved significantly, or made possible, with the use of VR. Many events all over the world gets cancelled. LAVAL organised its exhibition virtually with the use of goggles (Fortune Business Insights, 2020).

NEXT

VR/AR and 5G

Next years with the wider availability of 5G, VR is expected to be boosted further. Thanks to its high bandwidth and low latency, 5G can bring VR/AR to being experienced in real time and across locations (Nokia, no date). At Mobile World Congress 2019, a collaboration between Nokia, Intel and Sony Pictures VR resulted in Spiderman VR gaming experience, using the 5G network (Fourtané et al., 2019).

2027

Future market share

By 2027, the VR market size is expected to reach $57.55 billion, growing from $3.1 billion in 2019 (Fortune Business Insights, 2020).

MAIN CHARACTERISTICS

To define a solution as a virtual reality, it needs to consider these characteristics (XinReality, no date), (Barnard, 2017):

- Immersive
- Interactive
- Computer-generated

Immersive

When thinking about VR, it is often directly associated with the use of goggles. In fact, VR has been in our lives longer than we can think of, especially in the game industry. All computer games, in which you can move around, are nothing else but VR on a screen. However, the big change since then is in the use of headsets or head-mounted devices (HMD). There are 3 level of immersion: fully-immersive, semi-immersive and non-immersive (Poetker, 2019). Fully-immersive requires HMD, due to the fact that they complete the user's 360 degree view entirely and this way they get more immersed in the environment. Semi-immersive is achieved thanks to the use of big screens or entire rooms. An example is the simulation training rooms for pilots, in which they have the airplane windows in screens and all the rest of the panel is real. The non-immersive VR is the most commonly used one, because its hardware requirements are limited to a monitor. This is the least immersive, because the user sees the VR only through the "window" with the size of the screen.

Interactive

The market gets flooded with cameras, which can record videos with 360-degree view. There are even cameras that can create the perception of 3D space in the video (Lawton, 2020). Even though, such recording often is referred to as VR, in reality it is not interactive. The possibility to interact is one of the characteristics of a virtual environment. In a multimodal-multisensory interaction, many channels for communication between the user and the system are used at the same time. In multisensory, there are at least two sensory modalities used at the same time. For example, vision and hearing are combined frequently to give more information about the object of observation. Multimodality combines sensory and motor interaction. When grabbing an object, a person would use the vision and haptic feedback (James,

Vinci-Booher and Munoz-Rubke, 2017). In a nutshell, multisensory interaction together with motor modality is multimodal. In other words, a software system can communicate to a user through multisensory interaction, while the user himself can use multimodality. However, the software needs to be implemented in a way to be able to handle input information in any of the modalities needed.

Computer-generated (Barnard, 2017):

The VR environment is computer-generated and gives the feeling of space, in which you can move around. When the user walks in the place or even only turns head around, the view is adjusted in real-time.

APPLICATION

Once the VR technology became more accessible, the industries quickly found numerous applications of it. More than 20 fields are using it already (Thompson, 2017). Nevertheless, due to the fashionable and modern image of VR, it is often applied in an excessive way without giving the extra value to the user.

Amongst the areas with highest benefits from VR application are Education, Medical and Entertainment.

Figure 11. Employer of BP using Virtual Reality for training (Source: BP)

In **Education**, which includes trainings and simulation, an example of a VR is developed by Igloo for British Petroleum (BP). They developed a room with screens to project a VR environment, replicating a real petrol platform (Figure 11). The space is used by new employees of the company, who need the training. Some of the trainings are regarding emergency situations. The risks of conducting such a training in real context are high due to the danger of the job on field for the person and for the environment itself. As quoted, previously such trainings were done on paper or in a classroom set up, which is less effective (BP, no date). This case is an example of semi-immersive application of VR.

Another field is the **Medicine**. VR can be used for training doctors to perform surgeries, which demonstrates that fields of application can intersect. Aside benefits for the staff, it can be helpful for the patients' recovery. In particular, during the rehab VR can support and navigate the patient. Examples for such cases are the products by VirtualRehab (VirtualRehab, no date). The company is developing solutions for rehabilitation of arms or legs. For the hand detection, they integrate the VR with Leap Motion (Ultraleap, no date). It is a device, specialising in recognising hand movements in details to each joint of the palm. For the

Figure 12. Rehabilitation with Virtual Reality (Source: VirtualRehab)

recognising hand movements in details to each joint of the palm. For the rehab of the entire body, the solution is with Kinect device, which detects the body movements in space (KINECT REHABILITATION with Biofeedback, no date). This use of VR makes the rehabilitation process easier and more fun for the patient, but it also gives more information for the progress to the physiotherapist. A system like this can provide feedback in details, which is harder for a human being to detect. With this, the therapist can make more accurate decisions and be more helpful for the recovery. In both products, VirtualRehab uses a screen to show the VR environment. This makes the solution a non-immersive one.

VR can be applied for Entertainment purposes. There are already games that try to create a fully-immersive experience for the player (Thompson, 2017). Tourism can fall into the entertainment category as well. An interesting example is by the world's largest art museum in the world – Louvre. Without a doubt, the most famous exhibit there is the painting by Leonardo da Vinci "Mona Lisa". For the painter's 500-year anniversary since his death, the museum organises a dedicated exhibition to him till February 2021. A part of it, is a recreation of the masterpiece in VR, called "Mona Lisa: Beyond the Glass", giving the opportunity to the visitor to be immersed in the universe of the painting (Louvre, no date). The designers and the developers of the experience

Figure 13. Screenshot from the virtual experience of Mona Lisa (Source: Louvre)

created a 3D model of La Gioconda, as well as, trying to speculate about the environment and what could have looked like (Figure 13). The visitors jump back in time through a headset, which makes this experience fully-immersive. They can see her moving and giving them one of the most famous smiles in the history of art.

CONCLUSION

Virtual Reality main characteristics are immersive, interactive and computer-generated. The environments can be non-, semi- or fully-immersive, depending on their screen. From interaction point of view, they can be multimodal-multisensory, which means to involve more than one sense in the communication. VR is entering variety of fields, including Education, Medicine and Entertainment. Its future is forseen to be bright with significant increase in the market size by 2027.

1.4 PHOBIAS IN VIRTUAL REALITY

"He, who overcome his fears,
will truly be free."

- Aristotle

Besides using Virtual Reality for entertainment, educational or medical purposes, it can be used for supporting the phobia treatment.

VIRTUAL REALITY EXPOSURE THERAPY

According to American Psychological Association, Virtual Reality is well suited for exposure therapy (Levski, 2018). It is not a surprise that a terminology is dedicated for the VR application in such scenarios – Virtual Reality Exposure Therapy (VRET). In the recent years, the research in the field has expanded, as well as the number of startup companies investing in this niche. VRET bases its success on the proven efficiency of the Classical Exposure therapy (refer to Chapter 1.2 Phobias). A study in a 6-year follow-up demonstrated same level of efficiency in VRET and In-vivo Exposure Therapy (Takac et al., 2019).

Scientists at the Clark University in Atlanta performed the first experiments with VRET back in 1992. They managed to demonstrate its efficiency in phobia treatment, starting with fear of flying (aviophobia). The combination of cognitive behaviour therapy and virtual reality let to VRET existence (PSY C2 Care, no date).

Some examples for phobias, for which VR can be used, are specific phobias like arachnophobia and aviophobia, social phobias like public speaking, as well as spatial related phobias typical for agoraphobia. One example for easier overcoming of phobia in virtual environment, is Post-traumatic Stress Disorder (PTSD) (Horváthová and Siládi, 2016). In fact, one of the first application of VRET for PTSD treatment is BRAVEMIND, developed since 2005 by University of South California Institute for Creative Technology. It is aimed for war veterans, who experienced traumatic events at the battlefield (Rizzo and Hartholt, no date).

The application of VRET in the future shows steps in the direction of psychiatric use for patients with Schizophrenia, Personality Disorders and Persistent Depressive Disorder (Dysthymia) (PSY C2 Care, no date).

ADVANTAGES OF VRET

Virtual reality experience can be quite immersive, especially in a multisensory environment (Chapter 1.5 Realism in Virtual Reality). Thanks to the power of technology, VRET provides a number of advantages compared to traditional treatment (Levski, 2018):

- It gives easy access to different environments from the comfort of the therapist office. As so, it is time and money efficient approach for getting the needed exposure.
- The therapists can customise the treatment plans in more aspects than what would be possible in In-vivo or Imaginal Exposure therapy. This is important feature, because each patient is different and handles the treatment in their own pace.
- Real time control by the therapist is a further step in the customisation of the therapy plan. Managing the anxiety levels during the exposure is a key for overcoming the fear. Too much stress might produce the opposite effect and the therapist has to avoid such possibility.
- The therapy can be continued by the patient in their home setup. This could increase the speed of recovery and

gives autonomy to the patient, therefore, more confidence and independence in future real-life situations.

› More information about the stress levels, experienced by the patient, can be collected with biofeedback sensors. Therapists need to observe the behaviour and reactions during the exposure session. With biofeedback data, they can be more precise in their judgment and produce in-time adjustments on the virtual environment.

STATE OF ART

The number of companies around the world, developing virtual reality for phobia treatment, are still a relatively low number. However, two types of approaches can be outlined. The first one aims to replace the need of a therapist in the phobia treatment process. In other words, the therapy is fully in the hands of the patient and they can get the treatment at their home. However, not all phobias can be treated in this mode, due to their severity or possible complications of improper therapy. The second approach is to support the therapists, rather than replacing them. This means that the end-customer is a mental specialist, therefore, the included features should make their work smoother, easier or more efficient. In this case, the patient is benefiting from a better therapy, delivered by the therapists.

Psious is a pioneer in creating VRET for the market, started their business in 2013. The idea for the company was inspired by one of the founders' own phobia of flying (Blender, 2016). Currently, they support more than 70 scenarios in 360-degree videos or VR environments for wide range of phobias, as well as relaxation setup for supporting the stress management during therapy (Psious, 2019). Their business has spread to over 2000 therapists and 15 000 patients in 50 countries. They offer three types of plans, depending on the need and client base of the therapist. The kit, shown in Figure 14, includes VR headset, therapy platform and biofeedback sensor (Psious, 2019).

The therapy platform is where the therapist can get access to the configurations. The specialist can select the suitable environment for the patient's phobia. Then, modification on the specific environment can be applied, including setup for each scene in the environment. During the session, the biofeedback sensor reports data about the stress level. In the online platform, the therapist can observe the progress in all

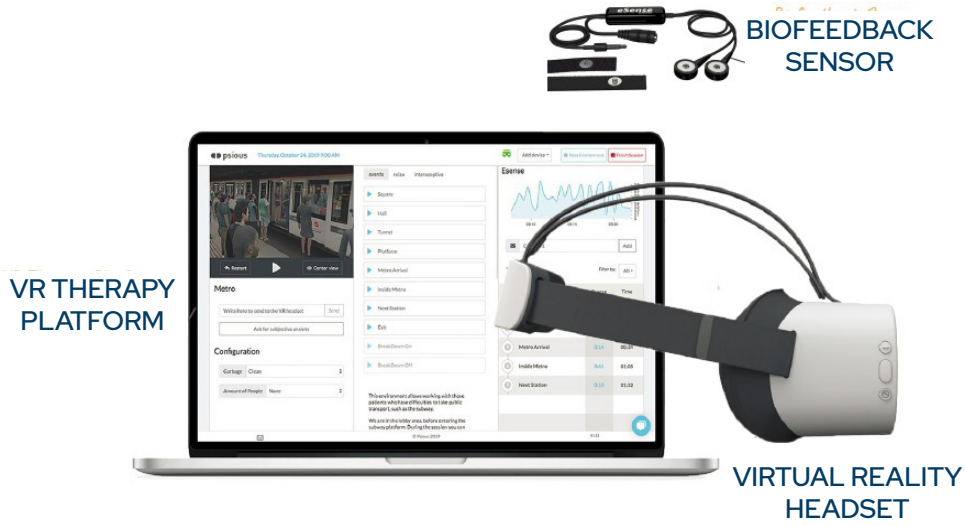


Figure 14. Psious VR kit (Source: rework from Psious)

sessions as part of a report. This simplifies their work in checking the overall progress and efficiency of the therapy for each specific patient (Psious, 2019).

For the development of the environments, Psious development team uses Blender software, while Unity is used for the animations. The realism in human figures is achieved with photometric approach. The way this is done is by having a real person in a room with roughly 90 cameras. They take simultaneously a picture and from the image through photometry, the volume is generated, in other words – the 3D model. The company admits that this solution gets expensive and instead of buying 90 cameras, they used less by moving them quickly. Facial expressions were developed by using the face mesh and real time video camera. Then they reuse it for all the others, instead of creating the expressions each time. For the animation realism, motion-capture approach is applied.

tricks. For example, prepared version for the textures of day and night for the lightening is used, instead of leaving this calculation in real time. For long scenarios, the animations of the characters are reused by creating a mixture between them to avoid looking i a loop. Quite an important hint hint is about compression. Even if they admit it is not the preferred approach by a designer, because it compromises the quality of graphics, it is a must in order to guarantee good performance on the device. For example, to compress is in scenes, where the characters are sitting. In this case, there is no need to design all the bones, but rather only the ones that are related to the needed animation (Blender, 2016).

Another company, demonstrating advanced platform for VRET, is Limbix. They provide VR solutions for treating large number of phobias, including public speaking, addictions, agoraphobia, traumas, claustrophobia, etc. The end-customer of the company is considered the mental specialist, rather than the patient directly. The offered kit is composed by VR headset, stand for it and a tablet. The tablet is the access point for the therapist, providing variety of configuration options. From it they see in real time what the patient sees in the VR environment and can perform adjustments, if needed (Figure 15). The tablet itself is used only for the purposes of the therapy and is made of medical components, which makes it easy for sanitising in hospital environment.

The focus of Limbix Italia is on improving the protocol, executed by therapists along with the VR kit. For the company, the level of realism and possible configurations has already reached a satisfying level and the important part is how it is utilised as part of the therapy sessions. One session is around 45 minutes, starting with a conversation for predisposition. After that, the VR environments are used. The mindfulness environments are commonly used by the therapists at the end of the session because it helps decreasing the anxiety level of the patient. The difference, in respect to traditional approaches, in the breathing exercises is that the VR headset guides the person when to inhale and exhale with visual hints. So far, they had to follow the voice of the specialist, but the stress could be so high that they are not able to perform properly the exercise. Therapists report that it takes 3 to 5 sessions once a week to get improvement of the condition (Ambienti VR – Limbix Italia, no date).

The company is investing as well in another product, called Limbix Spark – a mobile app for treatment of depression (Digital therapeutics for adolescent mental health, no date).

Figure 15. Configuring parameters for acrophobia (Source: Limbix)

C2 Care is a French company, developing software in the medical and mental fields, along with academics and healthcare professionals. PSY is their product, based on the principles of VRET. Currently, there are 176 3D environments available, used by 2000 clients to treat nearly 20 000 patients (PSY C2 Care, no date). They give full control to the therapist through a browser-based platform. From there, the specialist

can select the suitable environment and adjust the anxiety stimuli according to the patient. For example, the number of cigarette packs on the table for the cases of addiction treatment. The therapy demonstrates high level of connection to real world knowledge. In particular, 80-90% of the patients can transfer what they have learned in VR to real life scenarios. In addition, the VR kit is well accepted by young people, finding this new approach as "fashionable" (C2Care, 2020).

Zerophobia is a mobile app for the treatment of fear of heights (acrophobia), developed at University of Twente in Netherlands. It is different, in respect to the above-mentioned cases, because it is targeted for the people with the phobia, rather than the therapists. With a basic viewer like Google cardboard (Figure 16), anyone can use it in the comfort of their home and in suitable timing for them. People themselves decide the level of stress, to which to be exposed to. In the acrophobia, this is translated in terms of floors from which the view is visualised. The website provides a screener test to evaluate the severity of the fear prior to using the app or as a way to advise whether it is suitable. The price is 15euro and it is advertised as a cheaper alternative to sessions with a therapist. Currently, the team is extending the existing approach to fear of flying with a new mobile app (Home - ZeroPhobia, no date).

Figure 16. Google cardboard and Zerophobia app (Source: Zerophobia)

#BeFearless is another mobile app. It is developed by Samsung, using Gear VR (Huub van Veenhuijzen, 2017). The app is designed in collaboration with Yonsei University's Gangnam Severance Hospital in South Korea. It can be connected with a smart watch to provide heart rate feedback in addition to the eye contact and voice recognition. Some of the included phobia environments are fear of heights and fear of public speaking. The app costs $99, which makes it among the more affordable VR solutions for phobia treatment. However, a patient with social anxiety disorder evaluated low the experience, in particular, the attempt to make a conversation with an avatar on a train. The virtual character initiates the conversation, asking a question. The user has to talk back for a minute. The lack of reaction by the avatar to the answer and no further continuation of the conversation makes the experience less immersive and not so effective (Anxiety United, 2017).

FEAR OF PUBLIC SPEAKING AND VIRTUAL REALITY

As mentioned in Chapter 1.2. Phobias, glossophobia is the most common social phobia. It is often referred to as fear of public speaking (FOPS), speech anxiety or public speaking anxiety. However, it has to be differentiated from stage fright, which is the stage phobia related to performing in general in front of an audience. By being a social phobia, FOPS requires the presence of many people to increase the anxiety levels. This makes it more challenging to prepare a suitable setup for In-vivo Exposure therapy, because it would require finding and engaging a group of people. With this condition, glossophobia becomes a great candidate for VRET. The researches are mainly focused on validating the distress, produced by the VR environment. Still, there are experiments in evaluating the stress habituation with VRET, because this adjustment is what leads to proper stress management in real situations later on. In a collaborative research by University of Melbourne and Virtual Human Technologies in Czech Republic demonstrates that "distress habituation is neither uniform, nor systematic" (Takac et al., 2019). This is important conclusion, because it highlights the need of individual approach to every single case.

Psious and Limbix already provide on the market VR environments for public speaking. Psious has 4 setups for giving a speech – audience, auditory, the office and broadcast conference. What is covered with these

scenes, is from giving a presentation in a small or bigger auditorium to doing a job interview or exam. In all cases, it is possible to select the amount of people and to have distractions during the exposure (Psious, 2019). In Limbix platform for public speaking, the therapist can select the type of clothing for the people in the audience (formal or informal), as well as their reactions (positive, negative, neutral) (Ambienti VR – Limbix Italia, no date).

A free mobile app for FOPS is provided by a Hungarian startup, called AncientC (AncientC, no date). In the app, there is one environment and the user can control the number of people in the audience (3, 8 or 20 people) (Figure 17). In addition, the voices and the tone can be controlled to be friendly or unfriendly. The app is developed with Unity3D and can be used with Google Cardboard or similar simple VR goggles.

Figure 17. The mobile app by AncientC for fear of public speaking (Source: AncientC)

The common in all currently available VR solutions for FOPS treatment is that they lack interactivity and audience reaction, based on the speaker's behaviour. At the Computer Science and Engineering Department at University of Madrid a research was conducted to explore VRET in this direction (El-Yamri et al., 2019). The team points out that the reaction of the audience is the only feedback, received by the speaker during the speech. However, creating realistic feedback in the audience for the presentation is a complex task. It is influenced not only by the words, but from the emotions, transmitted by the presenter. In the development of the prototype, the researchers considered the tone of the voice, while talking, in order to understand the emotions and produce a corresponding reaction in the audience. The prototype contains a few scenarios (large audience for giving a lecture, a class or a job interview) as a videogame. By establishing a game approach, the player can feel more motivated in "winning", therefore, performing better. Another aspect of the gamification is that it encourages more attempts even after a failure. Since the ultimate goal of the experience is to learn, failing is part of the process and it has to be served to the person with the phobia in a positive way. In this game, the aim is to make more people in the audience following the presentation. All speaker's components like voice

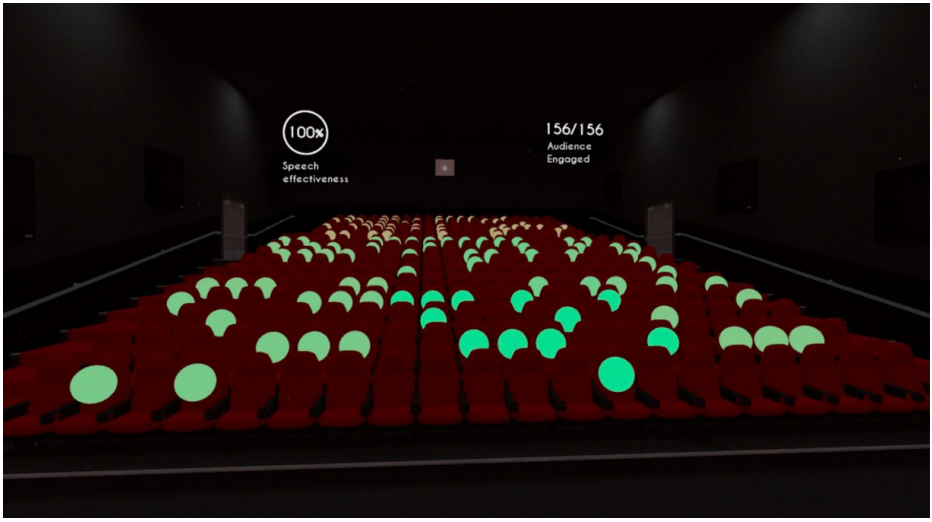


Figure 18. The audience in the game environment (Source: El-Yamri)

tone, speech content and gaze direction, with corresponding weight of 50%, 30% and 20%, are analysed to produce the reaction. The audience is depicted as a ball with colour from red to green with 7 shades in total to visualise the emotional reaction in the listener (Figure 18). The selected shape is done so for simplification reasons, however, it is important to point out that this creates different level of realism between the audience and the room setup in the VR environment.

The main outcome from this research is regarding the algorithm for detecting voice tone and producing emotional reactions in the audience (El-Yamri et al., 2019). Still, what could be suggested as a missing component, is real-time guidance for the speaker. By seeing the negative (red coloured) audience, the presenter can understand that the speech is not so well received. This way the anxiety can be fed and keep on increasing, making the situation even worse. Showing only the result is not giving hints how to improve the speaking to win back the audience.

CONCLUSION

Virtual Reality Exposure Therapy is a good alternative to the classical exposure therapy methods, applied by the therapists. It is not only an alternative, but has a number of advantages related to saving cost and time for both patients and therapists. In addition, more information and feedback can be collected to improve the process, including altering variables of the VR environment in real time during the session.

A small number of startup companies are developing VR kits for supporting the treatment of phobias. The approaches are mainly two - the kits are designed and used by the therapists, or they are used by the patients directly on their own. The first one is more common as it gives possibility to treat more phobias due to their severity.

Due to the glossophobia frequency, there are quite some applications for this phobia. VR environments with audience are developed by the leading companies in this field, as well as by researchers. The similarity in these environments is related to parametrizing the reaction by the people in the audience. The environment options are typically a hall, office presentation or job interview. However, there is no outstanding approach to the treatment of this fear with VR, since all reviewed examples are attempting to replicate realistic environment and adding parameters to be manipulated during the session.

1.5 THE UNCANNY VALLEY

"Part of inhumanity of the computer is that, once it is competently programmed and working smoothly, it is completely honest."

- Isaac Asimov
"I, Robot"

The concept of "uncanny" was first introduced by the German psychologist Ernst Jentsch in 1906 (Tinwell et al., 2011). He described it as the psychological experience in people questioning whether something is real or unreal, dead or alive. A bit more than a decade later Sigmund Freud continued his work by defining further the meaning of uncanny as **a feeling of confusion whether an object is animate or not**, such as wax figures.

THE HYPOTHESIS

In 1970 the Japanese professor Masahiro Mori hypothesised that too realistic robots, they can be perceived as uncanny. He noticed his own reaction to a prosthetic hand. Even if it looks quite real, once he had a handshake with it, he felt immediately the difference. There were no bones, as well as the skin temperature was not the normal one (Caballar, 2019). It felt like the hand of a dead body. From there, he started to develop further his observation about robots as a whole replication of the human body. As a professor in Tokyo Institute of Technology, he published his essay about the uncanny valley effect, basing his concept on his own intuition.

His hypothesis was that the emotional reaction by humans to robots, depends on their outlook. When a robot has some elements from the human body like eyes, mouth or hands, it can be easily defined as cute. It looks rather as a toy and it leads to positive reaction. With increasing the human likeness, the emotions are more positive, but till a certain point, when an eerie feeling is triggered, and the emotions fall down in a valley. This is what he called the "uncanny valley" (Figure 14). It is believed that the effect is visible when the human likeness is reaching 70-85% (Tinwell et al., 2011).

Professor Mori believed that after the valley, the emotions jump high, because the robot is perceived as a real human. Christopher Bartneck, who is an associate professor at the University of Canterbury in New Zealand, makes the point that maybe the uncanny valley is rather a cliff (Caballar, 2019). Even after nearly 50 years of research of the valley, it is still not clear how it can be jumped over, reaching the highly positive emotions. Masahiro believed that the motion should increase the emotional effect of the uncanny valley. The positive emotions and empathy are stronger, while the depth of the uncanny valley is bigger. As demonstrated in the diagram (Figure 19), the difference is like between a corpse and a zombie. The motion contributes to the fear of the robot – if it can move, it can also hurt someone (Mac Dorman, no date).

Researchers all over the world managed to perform experiments and observed the effect of the uncanny valley. A team at the University of California, San Francisco, in particular, performed a test with a collection of 80 photos of robots. The participants in the experiment had to evaluate them on the scale from 1 to 100, depending on their mechanical or human

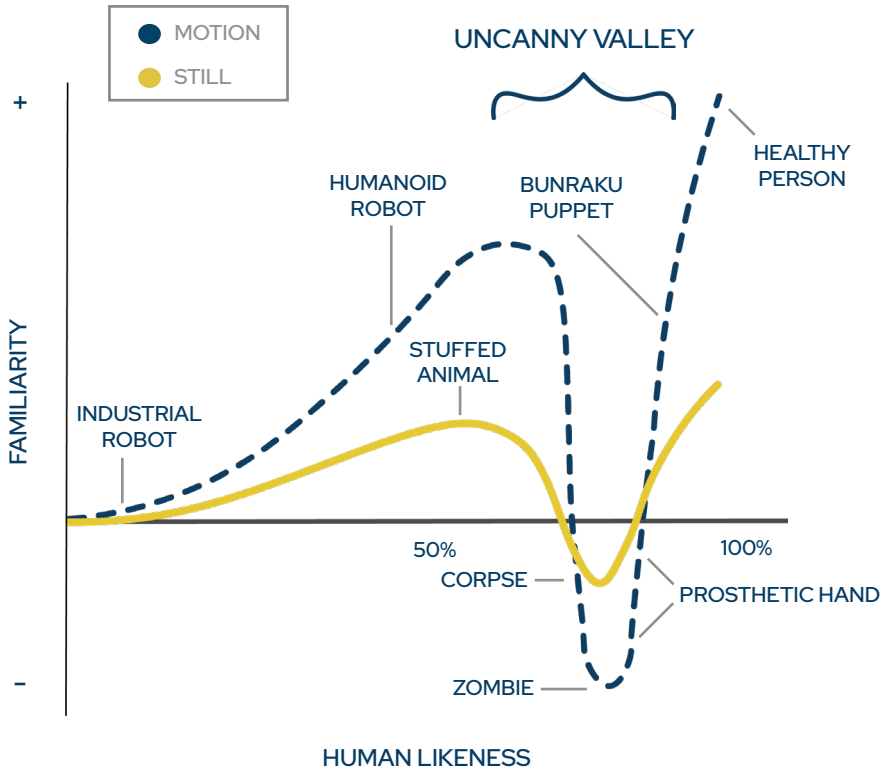


Figure 19. The uncanny valley curve with moving robots (blue) and standing still ones (yellow) (Source: rework from Tinwell)

appearance. The scientists noticed that from the mechanical to human likeness, the level of perceived friendliness jumps, then falls down and then goes up again. It is important to point out that in these photos, only the head of the robot was visible. In another experiment, the researchers tried to test how much the participants trusted the robots. They had to give up to $100 to each of the robots as an investment, because the robot has to decide how much, if any, to give back. The curve of the trusted amount of money, positioned on the scale for human likeness, was aligned with the curved from the emotions in the uncanny valley effect (Reynolds, 2015).

As any other theory, it has its own supporters, as well as people, who are more sceptical about it. Christopher Bartneck skeptics about using the uncanny valley effect as an excuse. The uncomfortable feeling might be caused not by falling in the valley, but by poor design. So, we risk avoiding going in the direction of improvement, believing that it is due to the effect (Guizzo, 2010b). On one side, this strive for perfection could be aiming at the curve after the valley. On the other side, Masahiro Mori himself proposed to designers and engineers that it is better to target the first peak of the emotional curve, rather than chasing the second one (Schwind, Wolf, & Henze, 2018).

HOW MUCH HUMANLIKE

The hypothesis suggests the existence of the valley somewhere between no human-likeness, which can be interpret as robot-likeness, and full human-likeness or a human. To avoid falling into the trap of the uncanny valley, however, it is important to know where exactly it is located on the axis of human-likeness. This is the kind of experiment, conducted by Patrick Weis and Eva Wiese (Weis and Wiese, 2017). They created a smooth transition between a robot and a human, mixing them at 5% steps, as shown in Figure 20.

Their hypothesis is that it takes more cognitive effort for evaluation of human-likeness and this is the cause of the uncanny valley effect. To test this statement, they asked people to select between human and non-human each of the steps from the mixture of faces in a random order. They calculated the speed and mouse movement when making this decision on a computer as a criterion for the cognitive effort. With this experiment, the researchers proved that the cognitive effort peaks around the uncanny valley, which is calculated to be around 70% human-likeness. Interesting observation, during this experiment, was that people with stronger skills in anthropomorphism demonstrated less effort in the uncanny valley, compared to the rest of the participants.

EXPLANATION OF THE EFFECT

Understanding the reasons for the phenomenon is the key to its proper application in technology. In reality, we do not need a robot to experience this eerie feeling. If you think about wax figures or Victorian dolls, they do not have any technology behind, but they still

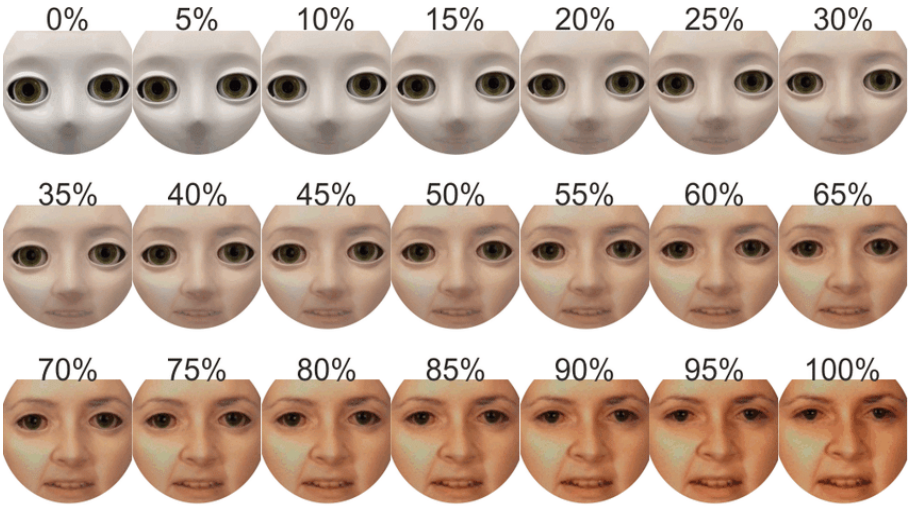


Figure 20. The transition from a robot to a human image (Source: Weis and Wiese)

are successful in looking creepy to many people (McRobbie, 2015). A possible explanation behind the uncanny valley effect is hidden in our evolution. As humans, we are "programmed" to make sure that the species survives. When we detect even a small misalignment between human appearance and natural human movements, we consider it a sign for illness or improper choice of mate. In other words, we are fearing dying by getting sick or not able to continue the generation – in both ways, we are risking the species. As stated by Valentin Schwind, "**Atypical features at high level of realism can cause the uncanny valley**" (Schwind, Wolf, & Henze, 2018).

Karl MacDorman hypothesised that the uncanny valley phenomenon is caused by fear of death. He used evaluation criteria from Terror Management Theory to prove his point (Mac Dorman, no date). Terror is considered the highest severity of fear, as visualised by Paul Ekman Group (Figure 21) (Paul Ekman Group, 2019b). Terror Management Theory deals with the anxiety, caused by the thought about inevitable death. People use numberless techniques to handle this fear, building worldviews and beliefs about their contribution to the society and their overall value (B. Arrowood and R. Cox, 2020). MacDorman's concept was inspired by the eerie feeling, caused by motionless androids. Since

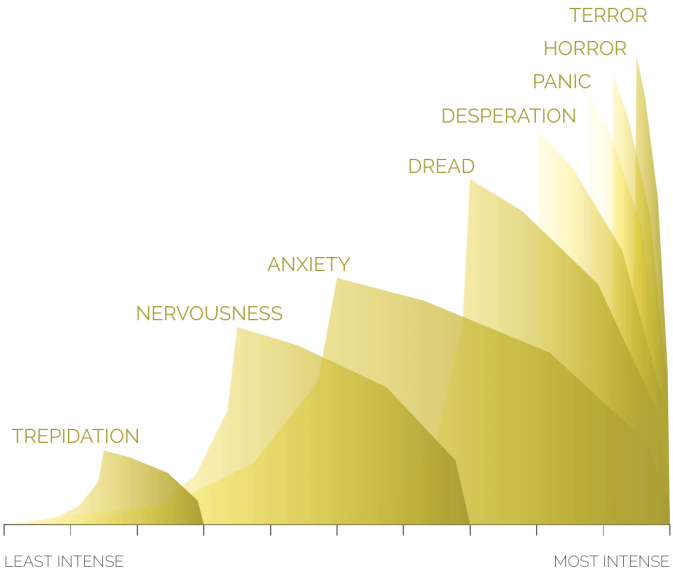


Figure 21. Levels of fear, based on severity (Source: rework from Pauk Ekman Group)

they look dead, this acts as a reminder to the observer that they are mortal as well. The results from his research support this hypothesis (Mac Dorman, no date).

Another explanation for the existence of the valley is the cognitive dissonance effect (Tinwell et al., 2011). People tend to try to categorise new object, using their knowledge and previous experience. By putting it in a category, they can build expectations about the behaviour in this new object. In the example of robots and humans, they would expect corresponding skills like empathy in humans and mechanical movements in robots. There is no doubt that making predictions about one's behaviour increases our chance for survival, but this habit also gives the feeling of control. When a humanoid stands in front and it is challenging to be classified as potential set of skills, it can create unease in people exactly due to the lack of control over the situation. It is enough to have a machine or computer system that demonstrates feelings to cause the feeling of insecurity.

A more philosophical point, aiming to explain the effect, is related to the feeling of threat to our uniqueness in the world due to the existence of an intelligent machine (Tinwell et al., 2011). Emotions and mind are what makes humankind outstand in the animal world. If it is possible to artificially create a machine that resembles these components, it causes insecurity about our oneness. This belief can be an explanation for the high level of acceptance towards technology and robots in countries like Japan. The main religions there are Buddhism and Shintoism, which could be the explanation why machines with spirit are not seen as competitors. However, a study shows that people fear job replacement by robots in roles, which are more emotion-related rather than pure mechanical tasks (Tinwell et al., 2011).

TARGETING THE EFFECT

Experiments demonstrate that the effect of the uncanny valley appears in people, when looking at humans and animals. It is noted that there is no such effect in other inanimate object (Schwind, Wolf, & Henze, 2018). This increases the credibility of the hypothesis, mentioned above. The most common example for humanlike creatures with unrealistic appearance are cartoon characters. They seem to be well perceived by people and generate positive emotions (Schwind, Wolf, & Henze, 2018). For example, Popeye is a famous cartoon character, who eats spinach. His food makes him stronger and his arms are drawn much bigger than what fits the rest of his body. Regardless of the obvious inaccurate body proportions, he is appreciated as a positive character.

With the knowledge of the mismatching humanlike appearance and behaviour, the uncanny valley effect can be used as a technique to communicate information to the audience or to set a certain mood for a character. Lord Voldemort from Harry Potter books is a good example for creating a character with abnormal human body. His nose, in particular, has slits instead of nostrils (Figure 22). Such feature makes it hard or impossible to breath normally, while breathing is associated with being alive. This way, the impression for this character is that he is cold or even not alive, which is well aligned with his role in the series. Through visual anomalies in the human body and cruel character behaviour, the negative emotions towards Voldemort are established successfully with the audience.

Figure 22. Lord Voldemort from Harry Potter series (Source: Pinterest)

HUMANLIKE ROBOTS

Scientists are already trying to create robots that are looking as human as possible. Such robots are called humanoids. They have head, torse, hands and legs. Androids are another type of robots. The difference between the two is blurred, because both are representing human shape. What is a good criteria to differentiate them, is the purpose for their creation. Humanoids are representing well the human body shape. They are relatively simple in the tasks, which they are capable in performing. This is why they are often used to replace people in tedious jobs. Androids are shaped as human body as well with the intention to look realistic. If for the humanoids the starting point is the behaviour, for the androids is the appearance. They often are combined with Artificial Intelligence (Brown, 2019). One of the most famous examples is Sophia, who is an intelligent humanoid with language processing capabilities (Wikipedia contributors, 2020o). She is so advanced that she is able to express emotions. Another interesting example is Geminoid HI by Hiroshi Ishiguro. The name comes from the word "gemini", which means twins. It is appropriate for this robot, because it is a copy of its creator. Ishiguro even used his own hair to recreate the head as realistically as possible (Guizzo, 2010a).

ETHICAL IMPLICATION

The technologies are getting advanced so quickly that it is only a question of time to be able to create a humanoid, which cannot be differentiated from a real person. Although, this might be useful, especially in replacing people in highly risky jobs, it raises some ethical questions. There are already examples for replacing staff with humanoids like receptionists at a hotel (SocialTables, 2017). However, there are certain type of jobs that are unlikely to be replaced by robots, but more like only supported by them. This includes medical staff, for example. The question whether people should be informed about the fact that they are served by a robot remains with unclear answer. It might take generations before people trust so blindly the robots that for now sharing such information with them might make them look for a real human as an assistant. And this is natural, because we are looking for empathy or at least sympathy, when we need to be helped. Nowadays call centres are more and more replacing real staff with Artificial Intelligent (AI). In companies, like Apple, they inform their customers about the fact that they are assisted by AI. This is aligned with their image, since Apple is a technological company (Apple Business Chat and Digital Transformation, 2020). In other companies and business fields, this is not the case. When the AI assistant is not able to find the right answer to the customer, a real person pushes it. Meantime, the customer on the phone can hear the sound of a keyboard, which gives a realistic impression that they are talking to a real person.

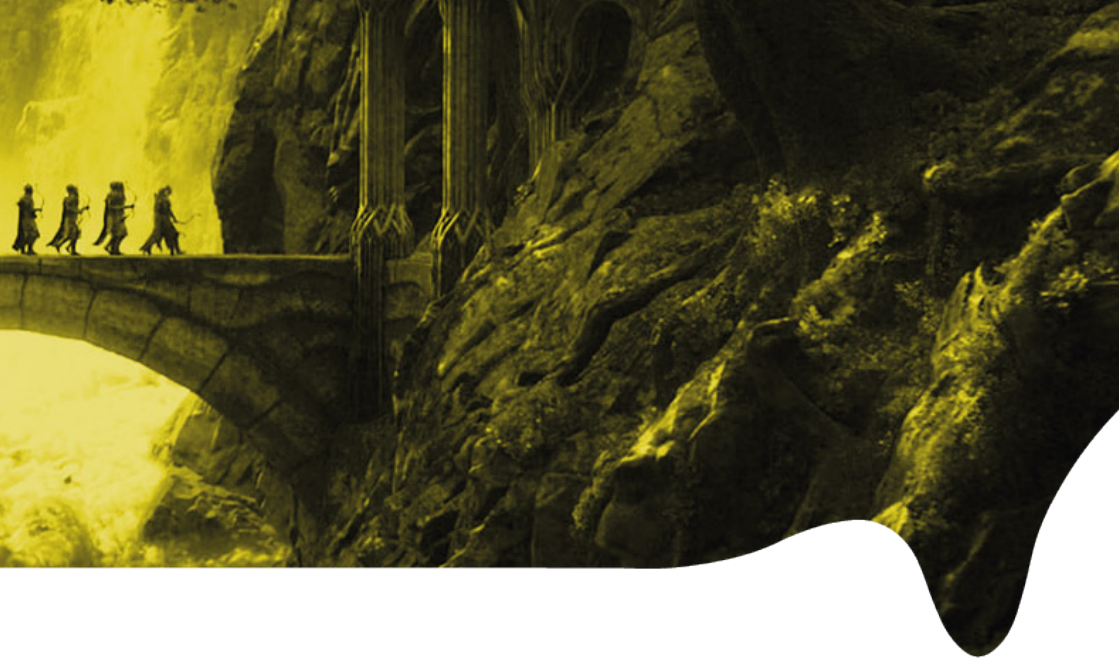
The controversial humanoid Bina48 by Martine Rothblatt raises questions as well (McGinley, 2015). It visually replicates Rothblatt's wife Bina. The inventor did not stop there and asked his wife to recall her childhood memories, which afterwards were uploaded to Bina48. This is putting us, humankind, in the role of God and questioning whether there is a line, which we should not cross, regardless what technology becomes capable of. Ridley Scott's movie "Blade Runner" goes further in this direction by asking if it is us, who have created the humanlike robots with mind, does this give us the right to "kill" them as well or they are now considered a human with rights (Boissoneault, 2017). A Chinese AI engineer created "the love of his life" – a robot, who was inspired by his struggle in real relationships. He even decided to marry her in a traditional Chinese-style wedding, regardless of the fact that

the state is not considering such marriage official (Haas, 2017). In the software inside a robot, it is easier to program the set of skills and traits, which someone cherish the most, rather than look for someone who meets these "requirements". Such partners are likely to obey and they do not age – sounds easier and better solution than a real person. However, this should not be the case and social interactions between humans should be only improved by technology.

CONCLUSION

Whenever creating humanlike robots, making it as realistic as possible seems a clear direction, but hides its challenges. The uncanny valley effect is when a humanoid triggers negative emotions in a person. This is observed at 70-85% of human likeness of the robot. The understanding about the uncanny valley effect is important for generating the right emotional reactions in people. It might be used to lead to eerie feeling on purpose or exactly the opposite - avoiding the feeling of unease.

1.6 REALISM IN VIRTUAL REALITY



"What is real? How do you define 'real'?
If you are talking about what you can feel,
what you can smell, what you can taste and see,
then 'real' is simply electrical signals
interpreted by your brain."

- Morpheus
in "The Matrix"

In May 2020 Amazon released a series, called "Upload" (Wikipedia contributors, 2020t). The sci-fi comedy speculates about future-based scenarios, in which Virtual Reality (VR) is used to keep the consciousness of deceased people alive, by uploading them in a VR environment, called "Lakeview". The atmosphere is so realistic that the main character, Nathan, feels like being on a holiday. The show goes further by creating a love story between Nathan and his service representative, who is a real person. Watching such series raises a million questions, but the main one is – Could ever such a VR environment feel so real?

FEELING OF PRESENCE

Nowadays, but also in the distant future, a virtual reality can not be real. Only reality is real, although it is highly influenced by the way we perceive it. In other words, any virtual environment is in fact an illusion. As such, the tricks to make it perceived as a convincing one are hidden somewhere. Like the secrets of the magicians. Even with basic knowledge in physics, we know pretty well that the magic tricks are not real magic. However, it is not hard to be amazed by good magicians and their skills to distract us in the right moment to give us the perception of breaking the laws of physics.

Mel Slater discusses the immersion and illusion in VR (Slater, 2018). He points out that the cognitive system, responsible for rationalisation, keeps on reminding us that what we see is not real. However, reflection analysis take time and is slower than what our intuition and emotions are telling us. By that time, we are already immersed in the environment, generating the same reactions as if it were real. Therefore, the creation of a VR environment is about building an illusion of being there, regardless the user knows this is not reality. As William Bricken says, "**Psychology is the physics of virtual reality**" (Vanderbilt, 2016). Since it is all about creating a proper illusion, designers and developers would have to consider how human brain works, what and how it is perceived and how to "create the magic".

PSYCHOLOGY IS THE PHYSICS OF VIRTUAL REALITY

Ken Perlin, the director of Future Reality Lab at New York University, states that the sense of reality is driven by the proprioception (Vanderbilt, 2016). Although, people use mainly their vision for perceiving the space surrounding them, the feeling of presence with the whole body in an environment, the freedom to move around and to move object is the key. Another important technique to create feeling of presence is related to the fact that we are social creatures. People have the unique capability of imagination and sometimes they create totally new worlds in their heads. These fantasies should be clearly separated from reality, because it can lead to social complications. This is why, when it comes to "other worlds", the presence of another real person in it, can change the perception (Vanderbilt, 2016). It is not possible another real person to be in a fantasy, so it must be real. The presence of

of another human being confirms the one's existence and the existence of the space itself. Another thing, which helps the feeling of presence, is if the person is noticed by an avatar in the environment. A simple eye contact can make the difference (Vanderbilt, 2016). If someone can see me, it means I have body. If I have body, it means I exist.

GAME GRAPHICS

Game industry has been going in the direction of improving the graphics to create realism. Perlin criticises this tendence for "**confusing realism with believability**" (Vanderbilt, 2016). An example for a game, which increased dramatically its visual effects, is NBA 2k game. As a sports game with a lot of movement, it holds the challenge about the basketball players movements in space (Figure 23). If the jumps seem weird and not respecting the gravity law, the whole effort in photorealistic graphics is lost.

REALISM ≠ BELIEVABILITY

The strive for visual realism pushes the companies to invest a lot of money in designers and developers to achieve good results. The realistic rendering is a very complex calculation of lights and reflections. It takes quite some computational power to do it in real time, because the games are interactive and responsiveness is critical. Marketing teams are using the graphics as a way to prove to the audience that the game is good (Masuch and Röber, no date).

What the game business forgets, is that for the players the important component is the gameplay, not the photorealism. By designing more and more realistic setup in games, the "**realism will be one of the first qualities to be discarded**" (Vanderbilt, 2016). Masuch and Rober propose alternatives to photorealism in game graphics (Masuch and Röber, no date). They argue that average graphics are not destroying the experience of the game, while at the same time, great graphics do not improve it either. There are 5 graphical elements to be considered, when developing a game:

- Dimensionality
- Perspective
- Colour
- Presentation
- Realism

Figure 23. The graphics evolution in NBA 2k visualisation of Shaquille O'Neal (Source: Pinterest)

The types of dimensionality are 2D, 2_D and 3D. 2_D is considered between 2D and 3D, because it gives the perception of 3D, while it is composed only by 2D elements. An example for 2D game is Super Mario and for 3D game – Counter Strike.

Perspective is related to the camera position, which gives view to the player. It could be from the eyes of the player himself or from a third person's point of view.

The use of colours can influence the mood of the game scene. For example, darker colours and less light reflection can be used in creating scary environments. And the opposite – bright colours can set up a cheerful mood for a fun game experience.

Presentation is related to how the player and the world are visualised. It could be done with a text, sprite or 3D model. The arcade games are usually presented with sprite, while the modern game industry is using heavily 3D models.

Realism can be photorealistic in visuals and movements or non-realistic. To give the perception of realism to the player, other components contribute, for example sound and character animation.

The experience for the players strictly depends on the feeling of immersion. Masuch and Röber compare the immersion to a soap bubble. It takes a little imperfection to pop the bubble. Instead, they propose the use of non-realistic graphics as an alternative. They point out that immersion can be achieved even in a cartoon-like game. Since in a game, for maintaining the storyline, sometimes the laws of physics are modified, it can be done as well for the visual representation. Some techniques, they propose, are oil painting, cel-shading and pencil or coloured crayon drawing styles (Masuch and Röber, no date).

METHODS FOR CREATING REALISTIC VIRTUAL ENVIRONMENTS

The game industry has invested millions, or even billions, of dollars in creating realism in the games. Thanks to this, there are many known approaches for designers and developers to achieve such high-quality result. However, this knowledge can be easily applied in any other use of VR environment.

These are a few approaches to create photorealistic virtual environments (El-Yamri et al., 2019):

- Modelling using computer graphics
- Modelling animation using an animation program
- Taking pictures of static objects and scenes using special scanning technique to create 360 degrees panoramas
- Filming moving objects and scenes using special scanning techniques to create 360 degrees panoramas
- Combining all of the above-mentioned methods

The modelling approach is the one, used by most of the modern games. Apart from creating the 3D model in any preferred modelling software, to build proper realistic view, other components should be considered. The texture is important, especially in combination with illumination and reflections. Not only the characters, but also the surrounding environment has to match the same level of realism. Blender is open-source software toolset, commonly used for achieving high-fidelity (Wikipedia contributors, 2020d). It has an advanced set of features for rendering. The images, created with it, can hardly be differentiated from real ones (Figure 24).

Figure 24. Realistic environment, created with Blender software (Source: Wikipedia)

Modelling the animations is the next step to make the realistic image "alive". Having the proper texture and light is not enough, because our brain is used to constant movements around. In fact, the lack of movement creates tension in people and is perceived as suspicious (El-Yamri et al., 2019). Blender has animation functions, which gives the possibility to create easily natural movements like wind, smoke, fire and rain (Wikipedia contributors, 2020d). When it comes to characters, the 3D models can be designed with skeleton structure. This structure might have more or less bones, depending on the need of the scene and the movements. By using bones, it is easier to create natural gestures, minimising the strangeness that can be perceived by the user.

Taking photos has its advantages and disadvantages in respect to the above-mentioned approaches. There are already 360-degrees cameras, available on the market (Lawton, 2020). It simplifies the process, because there is no need of modelling, and it is already realistic, because it is an image of the real world. Afterwards, with software tools the animations can be added. Nevertheless, the limitations derived from the fact that the environment, needed in the virtual reality, has to exist.

Similar is the case for filming in 360-degrees, helping to avoid the animation creation step. But, as mentioned for the photo capturing, it means that also the animations need to be created in the real scene.

Regardless of the selected method or any combination of them, the sound is to be considered equally important. Even though we perceive roughly 70% information from outside world through our vision, without sounds the environment cannot be immersive to the user. And the sounds have to be well aligned with what is happening in the scene, including synchronisation of mouth moving while speaking by the characters in the VR.

REALISM OF VIRTUAL CHARACTERS AND THE UNCANNY VALLEY

The increase of realism in games and any other virtual reality environments raises the question about the uncanny valley effect. Even if the original hypothesis for the emotional response by Masahiro Mori is considered for robots, it can relate to the representation of virtual characters in VR. Moreover, it is believed that the effect is even stronger in virtual environments (Schwind, Wolf, & Henze, 2018). This could be explained with the fact that VR can be more immersive than interaction with a robot in real context.

A research by MacDorman and Chattopadhyay aims to understand what could lead to the difficult acceptance of virtual faces. They created two types of images. The first one is with the original image of the real person, animal or object. The second one is computer-modelled version of the same entity from the original photo (Figure 25). The research was based on Realism Inconsistency Theory, which they have developed earlier. This theory states that anthropomorphic entities appear unfamiliar due to the realism inconsistency. The results of the experiment demonstrated that the familiarity of objects is not reduced by the computer version of it. This holds that they did so for the humans and the animals (Chattopadhyay and MacDorman, 2016).

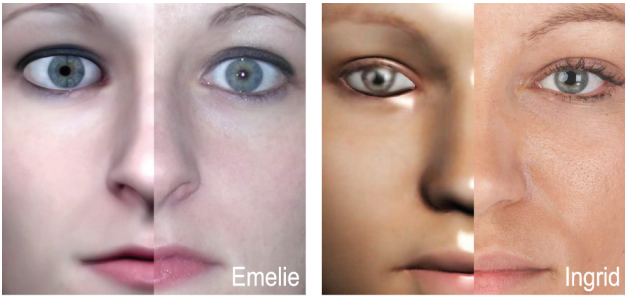


Figure 25. Computer-generated models (left) and the real photo (right) (Source: Chattopadhyay and MacDorman)

As mentioned in Chapter 1.1 Emotions, emotions are an important aspect of our humanity. Expressing them through a virtual character has to be considered as well. A research at University of Bolton experimented exactly with this (Tinwell et al., 2011). The researchers ran tests to detect how well people detect emotions in avatars. Three groups of images were shown – one with the real photo of a person; second one is with the virtual version of the person, but with upper face movement; and the third is the same as in the second one, but with no limitations in the face. They created such categories for each of the six emotions (anger, disgust, fear, happiness, sadness, surprise) and one additional neutral expression. In the survey the participants were asked to evaluate the emotion recognition and level of human-likeness. In the results for recognition, it comes evident that fear and sadness are better recognised in virtual characters, rather than when the same emotions are express by real human faces. The most recognised emotion in real

cases was anger, while sadness was the most recognised in virtual cases. Happiness was not so familiar in real human, but was more accepted in full facial expression rather than the limited version. Disgust and surprise were noted similarly in all three scenarios. However, fear faced problems to be recognised when the virtual face is with limited upper face expression. A possible conclusion from the results could be that emotions, like happiness or surprise, are positive and therefore less marked as uncanny. The participants ranked the facial expressions as uncanny for the cases with lack of upper facial movement. In particular, fear, sadness, surprise and disgust were found more eerie than the same expressions in virtual characters with full facial expressions. However, emotions like anger and happiness were not evaluated as uncanny as the others, regardless of the upper face limitations. This research gives evidence that the human-likeness depends highly on the emotion, expressed by the virtual character. Such outcome is to be considered carefully when creating avatars.

These researches lead to the conclusion that graphic fidelity is not the same as human fidelity. In fact, previously, in game industry actors were hired for voice-doubling the virtual characters. The new tendence is that they are used not only for the voice, as well as for the movement.

VIRTUAL CHARACTER CREATION GUIDELINES

Designers are provided with unlimited options for designing a VR environment. Giving the tools is not enough and good practices or detailed guidelines are needed. Valentin Schwind lists suggestions, which can help with the creation of virtual characters to avoid the uncanny valley effect (Schwind, Wolf, & Henze, 2018):

1. Steer clear of atypicalities at high level of realism

When there is high level of realism, people become more critical for each difference with a real and natural outlook or behaviour. Even a small gesture like blinking can lead to rejection by the users. Nevertheless, if the level of realism is lower, people are more open for compromises with misalignments with the natural. This could be due to the fact that it is unknown and it is harder to be compared to real world. In other words, regardless which level of realism is decided by the designer, it must be all aligned to avoid falling into the uncanny valley.

2. Avoid "dead eyes"

According to Schwind's experiment with eye-tracking, the first thing, people focus on, is the eyes. It appears that the level of realism is evaluated based on the eyes and how realistic they are. Considering that the blinking is a symptom of being alive, it is a possible subconscious check that is performed.

3. Use stylisation and childish features for stylisation

The caretaking trait is embedded in our view towards others. Naturally, we tend to take care of younger and weaker ones. The baby needs the attention of the mother to get food, protection and any other essential condition for surviving. And so, it is admittedly expected that such representation of a character or an animal to trigger caretaking in people. By assigning childish outlook to the virtual character, it can be avoided creating negative reaction, therefore, potentially it might generate a positive one.

4. Use aesthetics and appealing features

Skin matters. Even if the eyes are the first thing to pay attention to, the user checks the skin as well. Sick people usually have pale skin colour, therefore, this is a verification if the other is healthy and we can be closer to them. Other aesthetic aspects to be considered are the lips and clear depiction of the gender, as well as realistic proportions overall. However, there is a tricky part in this hint. Way too realistic vision might look perfect. People are more open to imperfections, because this is what makes people "real". Even though people are tolerant towards imperfections, it is not clear to what level, because exactly the imperfections cause the uncanny valley diving.

5. Lean on user creativity

It might be a good idea to provide the user himself with a tool for creating their own virtual identity. An example for such tool is faceMaker, but there are many others available. Recently both Apple (Dove and Chandler, 2020) and Facebook (Kaser, 2020) released an avatar feature. The users can select through a number of options for each face component in order to create their own replica in the avatar. This is an elegant approach to create emotional connection between the real and the virtual representation of a person. It gives them control on

their virtual appearance and, if they feel more comfortable with it, they can alter their outlook, not necessary following the realistic one.

6. Use the uncanny valley effect

If it is needed to create a negative personage in the virtual environment, the uncanny valley effect can be used to achieve such impression in people. It could be enough to break some rule in this list, but it has to be done with care and without exaggeration.

7. Consider the user's diversity

Presenting the real person inside the virtual environment remains a big challenge for designers. We tend to be even more critical in accepting if a representation is us. A simple difference can cause rejection. In high realism, it has to be considered all, starting from skin colour and hair to smaller details like scars or tattoos.

8. Avoid altered body structures at high level of realism

Many cartoon characters are simplified by cartoonists. One of the most famous cartoons is The Simpsons, in which the characters have 4 fingers instead of 5. This is just one example of stylisation. However, this approach is applied by designers when creating virtual environments for games and not only. Studies prove that the lack of a finger type of stylisation is not affecting the perception of the character in the user. This is accepted when the level of realism is according and it allows such imperfections. When the realism is higher, the designer should avoid such practice, because this could be the subtle detail that pushes into the valley.

9. Users get used to their avatar

Even if people complain about their avatar in the virtual environment, they tend to adapt to it within a few minutes. It might even need another cycle of adaptation once they go back to the reality with their own body. Assuming that the person will adapt to the virtual appearance is potential risk, because it might cause underestimating the effect of the valley.

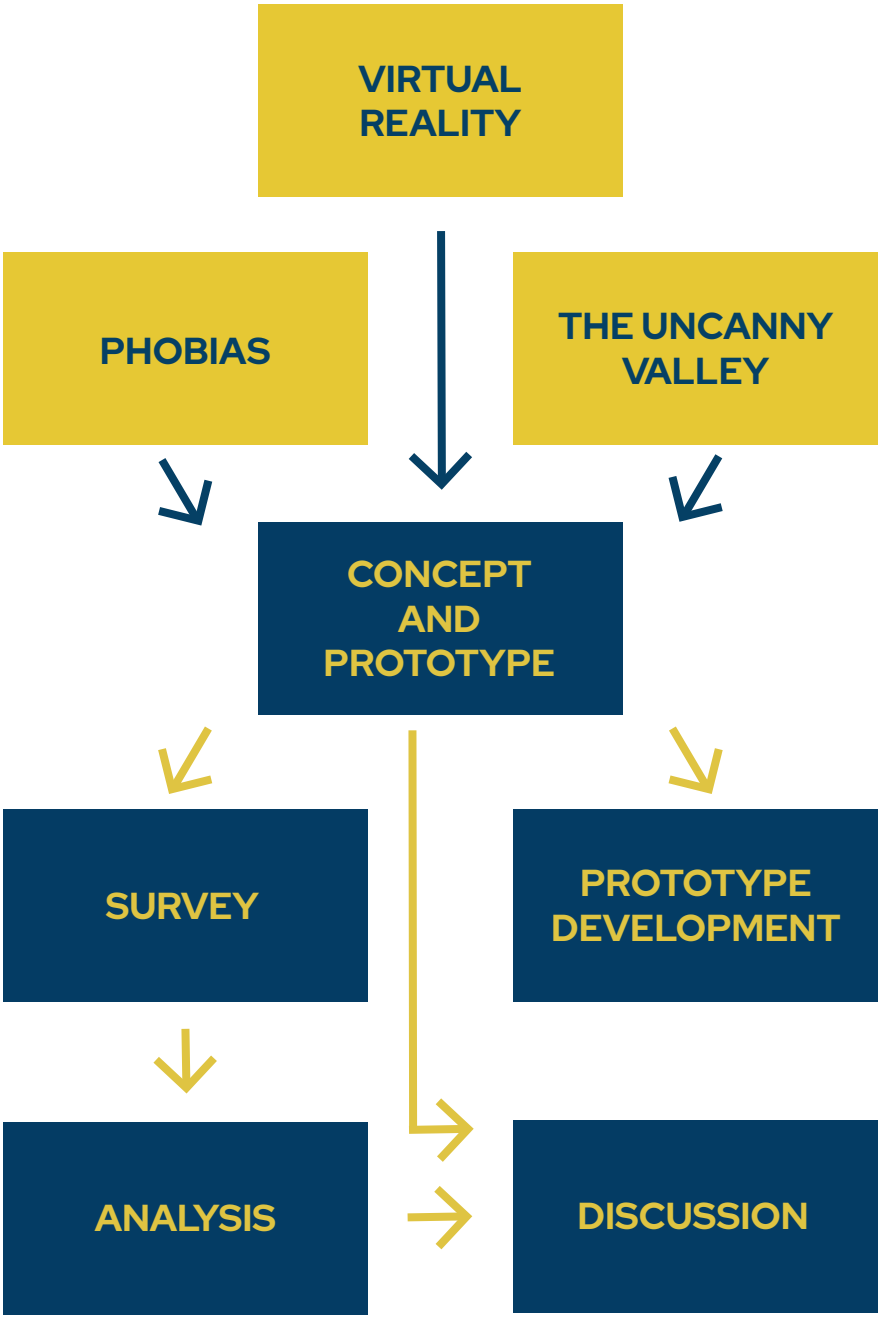
10. Consider depth cues

The perception of depth is important in creating feeling of presence. For example, a shadow helps to understand how far an object or surface from another object is. A design should consider this when creating the virtual environment, due to the risk of causing disorientation in the users.

CONCLUSION

Whenever a VR environment has to be designed and developed, there are a lot of things to be considered carefully in order to generate the targetted feelings and emotions in the user. However, the feeling of presence in the environment is not necessarily deriving from photorealistic representation. It is more important if you are noticed by another avatar, rather than if all lights and reflection are too realistic. Whatever is the selected level of realism, all aspects in the VR have to be aligned with it - from surroundings to avatars.

The uncanny valley effect can be experienced for virtual characters as well. People tend to check subconsciously eyes, skin colour or breathing to make sure the avatar is real, or in other words alive. The expressed emotions are read even in a digital environment like a VR. Therefore, the facial expressions and body movements are to be designed with attention to the detail.


VIRTUAL REALITY
PHOBIAS
THE UNCANNY VALLEY
CONCEPT AND PROTOTYPE
SURVEY
PROTOTYPE DEVELOPMENT
ANALYSIS
DISCUSSION

PART 2

RESEARCH

2.1 CONCEPT AND PROTOTYPE

"An idea, like a ghost, must be spoken to a little before it will explain itself."

- Charles Dickens

The performed research on related work has constructed the main components, leading to the concept of this thesis.

PHOBIAS + VIRTUAL REALITY

In Part 1, Chapter 1.4 "Phobias in Virtual Reality" the research reviews the state of art in the field of using Virtual Reality (VR) for phobia treatment as part of the so-called Virtual Reality Exposure Therapy (VRET). The leading companies, providing VR solutions with VRET, are demonstrating similarities in the approach towards the creation of virtual reality environment. Even though there are slight differences in the offered packages, for example, whether it includes biofeedback sensor, they are common when it comes to representing realism in the

VR. They all try to replicate the real world in order to use it for phobia treatment. The advantages of the technology, as described in Chapter 1.4, section "Advantages of VRET", are mainly related to time and cost of achieving the same situation in real world. Nevertheless, the VR technology might hide further potential in phobia treatment rather than only moving the real world into the VR environment.

THE UNCANNY VALLEY + VIRTUAL REALITY

In Part 1, Chapter 1.6 "Realism in Virtual Reality" the concept of the uncanny valley effect is introduced. Its main point is about the fall into negative emotional response by people towards humanlike virtual characters in VR. With the increase of the realistic representation of avatars, the risk of experiencing the uncanny valley effect gets higher. However, in the competition of creating environments as realistic as possible, the designers and developers often forget that this is not what is the main component for generating feeling of presence in people. Moreover, the researches in the exploration of the uncanny valley have been limited to understanding what causes the effect, rather than the variations of the emotional curve. In the experiments, the participant background is poorly considered. Hence, to our knowledge, to that date no research of the uncanny valley for a specific group of people is performed.

HYPOTHESIS: THE UNCANNY VALLEY + VR + SOCIAL PHOBIA

The companies' development of VR environments for phobia treatment sticks to realism. The research in the uncanny valley effect in VR sticks to experimenting without considering the predisposition of people to experiencing phobias in the tested context. In particular, social phobias are highly influenced by the presence of other people or virtual characters in the context of VR. In other words, these two directions for research have not been crossed so far.

The uncanny valley is a section in the emotional curve. As such, the individuality in experiencing the emotions has to be taken into account. The starting point of the curve is neutral emotion when there is no other people or avatars around. Nevertheless, people with fear of public speaking start to feel anxious even prior to getting out in front of the audience. Even only thinking about it is enough to generate negative emotions. In other words, the emotions are potentially negative, rather

than neutral, for people with a social phobia. On the other end of the curve, the emotions are very positive, because it is representing the presence of real people. However, in the case of social phobia, also this is not valid due to the anxiety, raised by the social context (Figure 26).

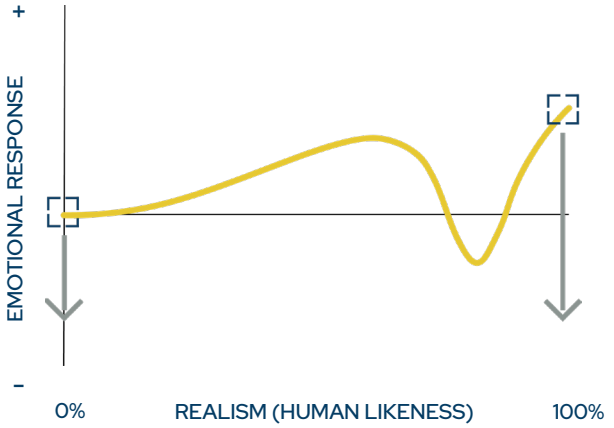


Figure 26. The uncanny valley curve

The mismatch in the two ends of the curve raises questions about the visualisation of the curve in a combination with a phobia. How is the curve changing if the person is with a social phobia? Does the uncanny valley exist in this case? If yes, is it deeper?

The hypothesis is that the emotional curve in the presence of social phobia (glossophobia) differentiates from the well-known curve with the uncanny valley.Therefore, we state that the emotional response at high level of realism differentiates between people with and without social phobia.

PROTOTYPE

To be able to draw the emotional curve in the presence of social phobia, a prototype is developed. It is an experimental one with no intention of being a prototype of a product. Glossophobia is the right candidate for the social phobia due to its commonality. As part of the testing, the participant is asked to give a speech for 5 minutes, in which he or she talks about a book, they have read. This topic is selected, because it requires speaking about gained knowledge, which is a common reason for giving a presentation to people.

For the purposes of the analysis, 3 variables are considered: **level of realism, audience reaction and immersion**.

Regarding the level of realism, four points in the axis of realism are selected in order once connected, to draw the new curve.

1. Low Level of Realism – no clear human structure, but a shape capable of expressing emotions
2. Medium Level of Realism – around 50% realistic representation of the virtual characters and the environment
3. High Level of Realism – 70-85% realism
4. Real

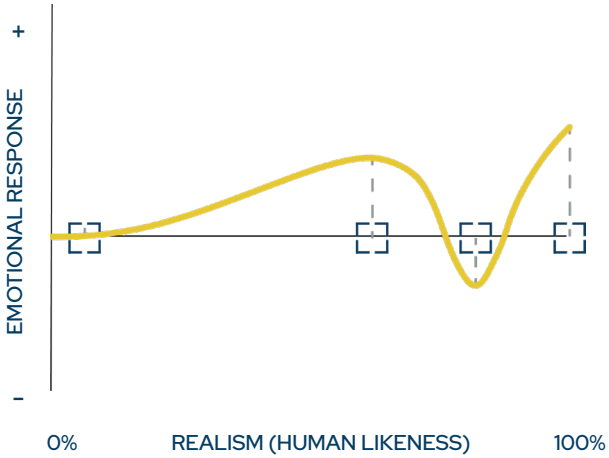


Figure 27. The four points on the realism axis, selected for the prototype

The first three are developed as a separate version of the prototype. The last one is calculated from the questions regarding the general experience of giving a speech.

There are three types of audience reactions considered – positive, negative and neutral. Facial expressions for the positive one include smiling and surprise. The ones for the negative audience are contempt and disgust. The people in the neutral one have none expressions. According to the research in Part 1, Chapter 1.1 "Emotions", facial expressions should not be separated from the body gestures. Therefore, the movements of the avatars are selected to express the emotion associated with their type of audience. For example, the nodding is in

agreement in the positive audience and in disagreement in the negative audience. At the end of the speech, once the timer of 5 minutes has finished, the audience is clapping. The sound and the excitement in the clapping are different for each type of audience.

The third variable in the prototype is immersion. During the survey, the participant is given the option to chose between using headset or a screen for the VR environment. This is more for practical reasons, due to the fact that the survey is conducted mainly online and it is not expected the majority of the participants to have headsets at home.

The prototype aims to test participants both with and without glossophobia. The reasons are two. First, to understand whether the development of the prototype proves the existence of the uncanny valley of people without fear of public speaking. Second, performing experiment under the same conditions for participants with the phobia, a control group results are collected. Afterwards, a proper comparison can be run as part of the analysis. In the presence of uncanny valley without phobia it is traced how the emotional curve is changing with the increase of the phobia severity.

CONCLUSION

The hypothesis is that the emotional response at high level of realism differs in the presence of social phobia in the participants. To verify this statement, a prototype is developed with 3 points on the axis of realism are selected. The chosen social phobia for the testing is glossophobia. An online survey is conducted for gathering data for analysis.

2.2 PROTOTYPE DEVELOPMENT

"An idea that is developed and put into action is more important than an idea that exists only as an idea."

- Buddha

The development of the prototype covers from 3D models of humanlike or basic virtual characters, through their body movements to facial expressions. Three levels of realism are implemented– high, medium and low. For each version, the avatars in the audience demonstrate 3 types of reaction – positive, negative and neutral. In total, 9 versions of the prototype are created. For the online survey purposes, the participant can select between headset and screen solution for testing.

3D MODELS

The use of avatars in virtual reality (VR) is quite common. For this reason, there are a number of tools available for creating virtual characters without the need of building a 3D model from scratch. Among the free software tools, the most used ones are MakeHuman (www.makehumancommunity.org, no date) and Adobe Fuse (Mathews, 2019). Even though MakeHuman provides higher level of flexibility and configurations, Adobe Fuse was used for this prototype due to its integration with the other selected software tools. In Fuse there are limited sets of human faces and body parts available. First, the avatars for the high realism version (HR) were created, balancing in the number of males and females (4 of each). The clothes are semi-formal with detailed textures (Figure 28).

Figure 28. An avatar in HR prototype

To decrease the realism in the medium version (MR), the textures were simplified to solid colours, removing specific prints. The targeted realism in MR version is around 50%. Following the diagram for facial realism from Part 1: Chapter 1.4 "The Uncanny Valley" section "How much humanlike", a number of changes in the eyes are done, starting from the HR avatars. They include the increase of the eye size and upper part of the skull. Smaller details like veins in the sclera were removed and, as a result, the eyes look whiter. Also, the size of the pupil and iris are enlarged (Figure 29).

In the low realism version (LR) the body shape needs to be less humanlike. Thus, Fuse was not used for creating the characters in this version. The availability of 3D modelling software is enormous and the main requirement would be the export file format in order to fit the use of the other software tools. Blender is used for that purpose. The shape of

Figure 29. An avatar in MR prototype

the character is inspirited by the French children cartoon Barbapapà (Figure 30) (Wikipedia contributors, 2020c). The reasons for this choice are mainly two. The first one is due to the fact that cartoon characters are perceived positively, regardless of their anomalies in the body shape and that they are less humanlike (refer to Part 1: Chapter 1.5 "The Uncanny valley", section "Targeting the effect"). The second reason is because people tend to react more positively to curved shapes rather than angular. In a conducted research, it was observed that people perceived curved shapes as safe and tend to associate them with female names. On the opposite, angular shapes are sign of a danger and are given male names (Palumbo, Ruta and Bertamini, 2015). In fact, the two arguments for selecting this shape for the LR version might be related. The success behind Barbapapà series could be hidden behind the positive perception of curved shapes.

Figure 30. The characters from Barbapapà cartoon (Source: Lichtophethart)

Each person in the audience has a colour from the palette of the cartoon characters. The same colours are used for the clothes in MR and HR. They are – orange, blue, violet, black, yellow, green, red. In addition, white colour is used. In Figure 31 is one of the 3D models in the LR version with the same colour as the avatars in Figure 29 and 30.

Figure 31. An avatar in LR prototype

BODY MOVEMENTS

The challenge of the avatars comes when they are in the context of a game or other dynamic use of virtual environment. To achieve realistic feeling, their movements in the space have to look natural. The approach to this is with the so-called "rigging" of the avatar. This is the creation of a skeletal structure with joints in the 3D model. The software tools for virtual characters are providing the rig, however, in Unity in some cases it might need to be remapped bone by bone to match the structure there.

The reason why Adobe Fuse was selected for this prototype is due to its integration with Adobe Mixamo. Mixamo provides pre-made animations for humanoids. The company was acquired by Adobe in 2015, targeting the integration with Fuse. Currently, the development of the products is on hold. Nevertheless, it remains useful and free combination of tools, saving a lot of time for 3D modelling and animating afterwards. For comparison, MakeHuman is commonly in a combination with Blender for creating the animations. In that case, all the animations need to be

designed from scratch and after that they can be used in Unity. Note that it is not possible to animate avatars in Unity. Due to the high number of avatars and gestures for all versions of the prototype, a selection of a more efficient way of implementation was critical. The animations from Mixamo can be downloaded and applied on any of the characters in the VR environment. Once added in the scene, it is enough to change the rig animation type from Generic to Humanoid, and the software will recognise the bones structure. After that, it is ready to be used for any of the characters.

The new virtual character for the LR version has no bones and they have to be added in order to create animation in Unity afterwards. Blender provides such options. For the barbapapà, two connected bones are enough, because there are no hands or legs attached to the body (Figure 32). Hands are used for clapping at the end, but they are animated as separate objects. The mesh of the 3D model is increased to provide more flexibility in the body movement. To make more natural the moving of the upper part, where the head is, modification of the weight paint is done. Using the colours like from a thermal imaging camera, it visualises the areas, which are affected by the movement in the selected part. By

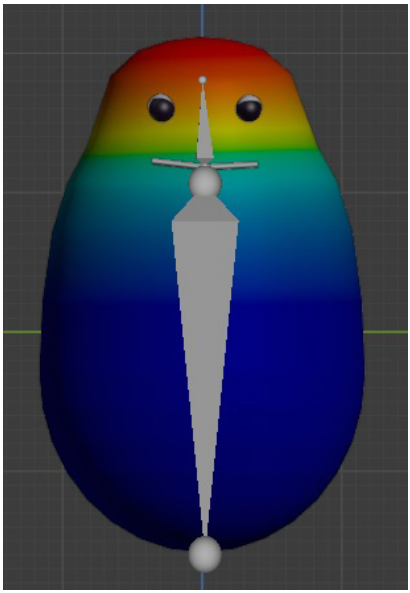


Figure 32. The 3D model with armature and weight paint

default, moving the "head" was moving also the rest of the body. The warmer colours were modified to impact only the upper part and the dark blue area represents no secondary movement (Figure 32).

It is possible to animate the body movements in Blender and then to import them in Unity. Still, the animations of this model were created in Unity directly and reused throughout all other models in that version. Since the for this 3D model the bone structure is Generic, instead of Humanoid, it is possible to rotate and move a specific bone to animate it.

In addition to the main posture, all avatars blink and have slight movement to imitate breathing. For the characters in LR version, the breathing is done by increasing and decreasing the scale of the model. These two animations are important in order to create the impression of characters that are alive.

FACIAL EXPRESSIONS

The biggest challenge in the development of the prototype was the implementation of facial expressions in addition to the body movements. It is recognised by many of the software companies in this business that face movements are important part of a realistic VR environment. Majority of the tools available are paid or if they have a trial version, it is quite limited. For example, in **NaturalFront** (Home - NaturalFront, 2018) the export in Unity native format fbx is possible only in the pro version. **CrazyTalk** (CrazyTalk Animator reviews and pricing - 2020, no date) is another software, which helps in creating realistic lips movement in speech for the avatars, but the trial version is limited to not being able to save the project. **FaceCap** (Face Cap - Motion Capture, no date) uses the camera to detect the facial muscles movements, but it works only with iPhone. **AvatarMaker** is good examples for creating an Avatar from a single selfie and having it in Unity (Unity Technologies, no date b). The problem is that it is only for the head. It can be combined with **UMA** (Home, no date), which has a free version. In it, you have to pay for the clothes of the avatars, which is again not convenient if you need many people in your scene. **MakeHuman** has a configuration for facial expressions of some emotions like anger and happiness. This is not fully meeting the needs, because it is static rather than an animation.

Having the rig is not enough for animating facial expressions. For animating an avatar from MakeHuman, for example, Blender can be used to modify the so-called shape keys. This is the terminology for describing

the mesh on the face skin. This solution is not efficient as well, because it has to be carefully done to avoid weird faces. And it has to be performed for each expression for each avatar. The shape key in Blender has a different name in Unity – blendshape (Unity Technologies, no date c). The combination of Adobe Fuse with Mixamo in Unity was already identified as fast and working solution for the body movements in the prototype. The question was if blendshapes can be used with an avatar, created in Fuse. They have to be additionally "unlocked" and not all 3D models available online have that already. There are 2 ways to move a model from Fuse to Mixamo –to download it and then upload it manually, or to use "Send to Mixamo" button in Fuse. Even if they might look the same, in fact, the second option has more possibilities. For example, by manually uploading the model in Mixamo, the user has to rig the body themselves. This means that they have to mark the conjunctions like elbow or knee. Then the software calculates the bones. By uploading directly from Fuse, more information is sent to the server in addition to the model itself. When the Mixamo page automatically loads, it has already the rig and no additional step is needed. The other important information sent is about the blendshape. There is an option to enable facial blendshape, which is not available with the first method. With this, later in Unity it is possible to manipulate parts of the face to imitate smile or frown, etc. By clicking "Send to Mixamo" in Fuse, a web page in Mixamo is loaded automatically. However, there was a challenge experienced at that step, because no page was opening. It was identified that the reason for this is because Fuse is not available or has limited functions for company and school accounts, which is the case if you use a university email address. By creating a personal one, it was possible to upload the models in Mixamo and get the option for facial blendshapes enabled.

Once the model with blendshapes is uploaded in Unity, the additional section of parameters is visible. In a similar approach to creating any other animations, it can be recorded. All the animations with facial expressions are created for one avatar and reused by all the others. Thanks to blendshapes, also the blinking animation can be done. The emotions in the scenario with positive audience are enjoyment and surprise, while for the negative one – disgust and contempt. The movements on the face are following the Paul Ekman's research and recognition of the expressions.

Enjoyment is the most obvious way to express pleasure from a certain situation. Even though happiness and enjoyment are similar in their

meaning, people tend to differentiate them by the first being related to a concrete moment, while the second – related to overall well-being in life (What is enjoyment?, 2019) (Figure 33). In Figure 34 is how this expression looks on the avatar in the prototype.

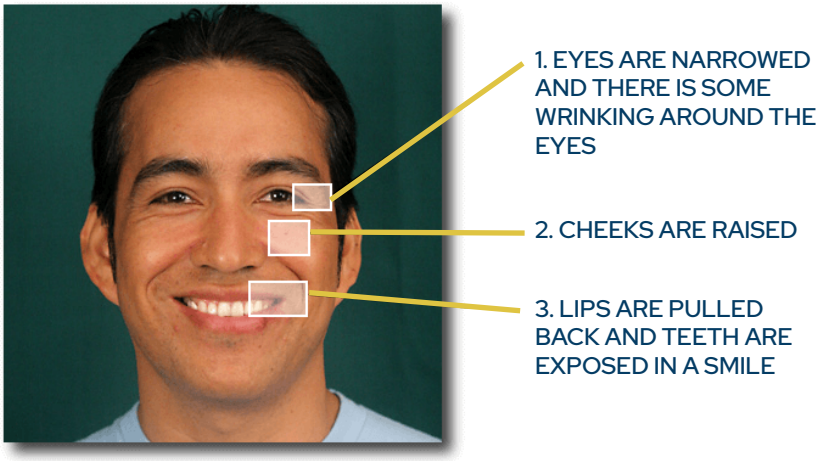


Figure 33. Facial expression of enjoyment/happiness (Source: rework from Pauk Ekman Group)

Figure 34. Enjoyment facial expression in the prototype

Surprise can be considered both positive and negative. In any way, it demonstrates focus and paying attention (What is surprise?, 2019). This is why it is added in the reactions by the positive audience. Despite dispute about surprise being an emotion or not, Ekman's position is that it is an emotional state even if it is the briefest among the seven (What is surprise?, 2019) (Figure 35). Figure 36 demonstrates the implementation of this expression in the prototype.

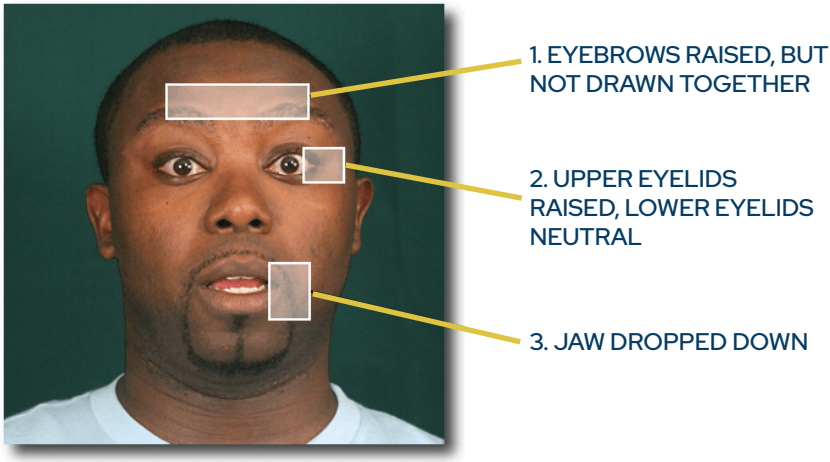


Figure 35. Facial expression of surprise (Source: rework from Pauk Ekman Group)

Figure 36. Surprise facial expression in the prototype

Contempt is an emotion, sending the message of feeling superior to the person in front (What is contempt?, 2019) (Figure 37). It is an expression that involves less movements, compared to the rest. How this expression is visualised on an avatar in the prototype, is demonstrated in Figure 38.

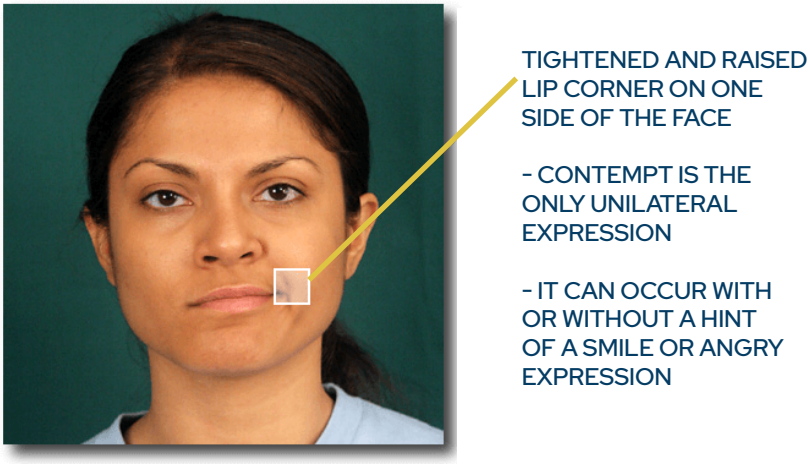


Figure 37. Facial expression of contempt (Source: rework from Pauk Ekman Group)

Figure 38. Contempt facial expression in the prototype

Disgust is expressed when we do not like the appearance of a person or their ideas (What is disgust?, 2019) (Figure 39). The expression in the prototype is shown in Figure 40.

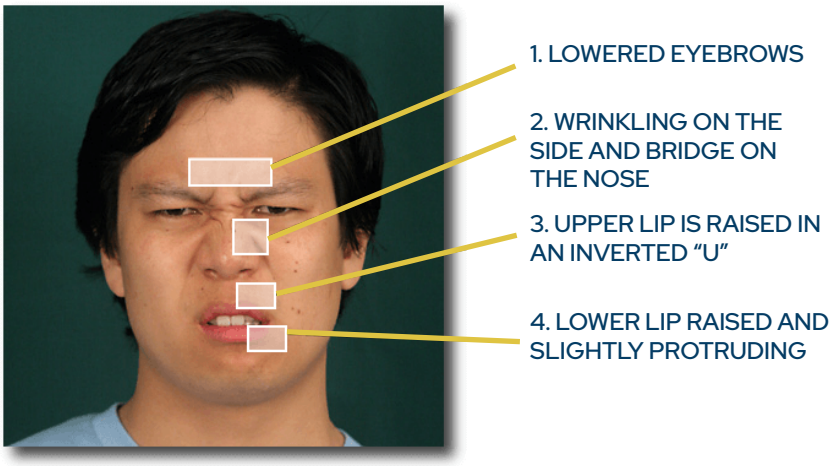


Figure 39. Facial expression of disgust (Source: rework from Pauk Ekman Group)

Figure 40. Disgust facial expression in the prototype

The models in the LR version do not have blendshape. The animations for them are done by standard movement of objects (eyes, eyelids, mouth and eyebrows).

COMBINING BODY AND FACIAL MOVEMENTS

With the avatars, their body movements and the facial expressions, the next step is how to combine them in a smooth transition. Mixamo offers a good number of sitting postures as animations. Despite that, if the characters are staying still with very little move for 5 minutes during the entire speech, it would look weird. The target is to make them seem alive, therefore, they need more diversity in the movements.

In Unity the way to put animations in parallel on the same model is with the use of layers (Working with the Layer Editor, no date). They are applied on the animator controller of the character and there is no limit on the layers that can be used. Along with the sitting animations, in Mixamo there are many others for head movements. They are usually in a standing position. Avatar mask is called the feature in Unity, used to utilise an animation for only a part of the body of a humanoid (Unity Technologies, no date a). It can be applied directly on the animation, so whenever it is used, the mask is active. Another option is to apply the mask on the layer. In that case, all animations in this layer will be with the mask. This is the way it is implemented in the prototype (Figure 41). When combining animations with layers, there is an option how the particular layer to be applied – Override or Additive. In Override option, the animation overrides the current one. Therefore, the ordering of the layers is to be considered carefully. With the other option Additive, Unity tries to find a smooth way to mix the two animations. Three types of masks are used in the prototype. The first one, used for the breathing, has active only the chest and the head. The other two are only with the head or head, chest and hands. They are applied in the mixture of sitting and other body movements.

The following layers are considered for the avatars in the prototype: Main Pose, Breathing, Blinking, Gestures, Facial expressions, Final Clap and Final smile. The Main Pose is the sit and a different version is applied on each avatar. There are universal postures, as well as female or male sitting applied to the avatars with such gender. Breathing layer is with an animation for idle character, applied with a mask with Additive option. Some of the sitting animations come with breathing already. For these avatars, the Breathing layer is skipped. The Blinking layer is for all characters and it is reusing the same animation. To avoid the effect of blinking simultaneously, the speed of the animation is manipulated in

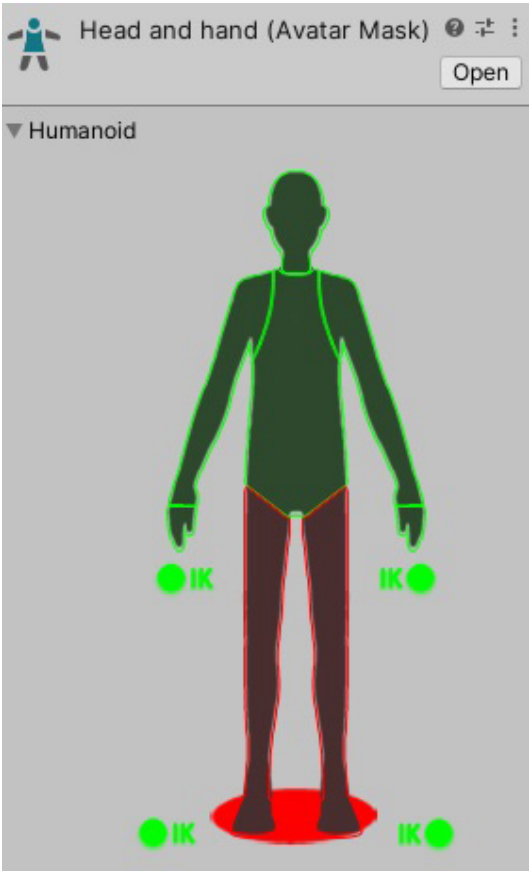


Figure 41. An avatar mask in Unity, used in the prototype

the animator controller. The Gestures layer include moving of the head, nodding in agreement or disagreement, waving hand for making wind or scratching an arm. All these animations are executed after waiting time. The Facial Expressions layer contains the animations for surprise, enjoyment, disgust and contempt.

In the Final clap layer, the characters start clapping after 5minutes to mark the end of the speech. Final smile layer is available only in the positive audience versions for all levels of realism. It is to put along with the final clap a smile on the faces of all people in the audience – an additional positive feedback to the presentation.

PROCESS

The prototype was started from high level of realism (HR). First, the avatars were created in Adobe Fuse. They were uploaded in Mixamo to get the facial blendshapes enabled. After that, they were imported in Unity. Suitable animations from Mixamo were selected and imported in Unity as well. There is no need for them to be combined with the project avatars in Mixamo, because this can happen in Unity directly. Moreover, applying the animation on a pre-made character in Mixamo increases the size of the file. Using the basic model, called XBot, generates an animation file of 5MB in comparison to 35MB with the others. Once all the characters and animations were available in Unity, they were organised in layers and a timeline. Figure 42 contains a timeline of the body and face movements for all avatars.

The first version of the audience to be implemented was the negative one. The body movements and facial expressions were aligned with that.

To create the positive audience in the HR version, a few steps were performed. First, the project was copied and then all body movements, associated with negativity, were replaced with a positive version. Also, the facial expressions of contempt and disgust were exchanged for surprise and enjoyment. The sound of the final clap was pointed to the more cheerful audio. In addition to the final clap, a smile is added on the face of all people in the audience.

Similar steps were performed when creating the neutral version. Copy the project and replacing all positive body movements to neutral ones, as well as the final clap sound. All layers with facial expressions were removed. Creating the alternative versions with this approach, the timeline and the amount of gestures is kept throughout all versions. This is important to avoid additional influence, for example, due to the move frequent positive or negative expressions. Figure 43 is with a view of the audience and the room in HR version.

The medium level of realism version started from the existing models for the HR version. After the modification to make them less realistic, the steps through Mixamo to Unity were the same. The room space was simplified with less objects and details. The animator controllers from HR version were copied and applied on the new models. This was enough to make the new audience act like the one it is copied from. For

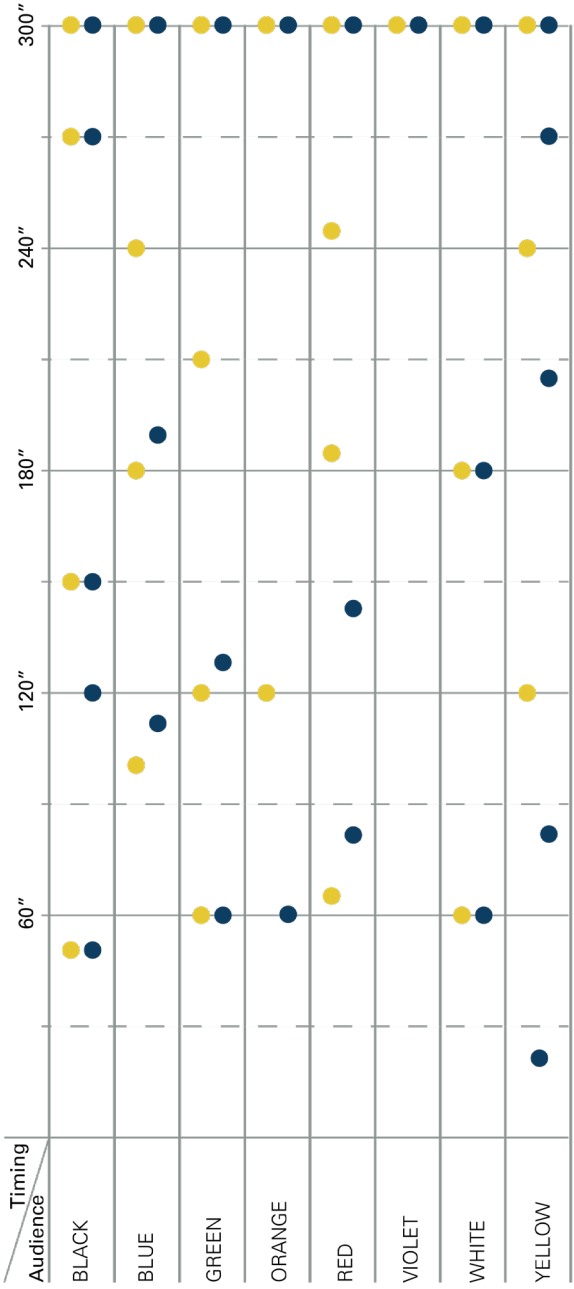


Figure 42. Timetable for body movements and facial expressions for each audience member

Figure 43. View from high realism version of the prototype

the positive and neutral audience, the MR project was copied and the animator controllers from HR corresponding version were applied. The similar change on the sound was done to be aligned with the audience in HR prototype. In Figure 44 is shown a view from the virtual reality environment in medium realism.

Figure 44. View from medium realism version of the prototype

The low realism version (LR) started with creating a single model in Blender. With its bones, it was ready for use in Unity. There, it was copied 8 times and different colour applied on each one. Animations for the body movement were created. Due to the fact that there are less distinguishable parts of the body, the movements were mainly turning left or right and nodding. The facial expressions were animated, following the formula for the HR and MR ones. The animator controllers were copied once again and all animations were replaced with the corresponding ones for this audience. After that, the steps for creating the positive and neutral versions were the same as in the other levels of realism. In Figure 45 is a screenshot from a moment in the low realism prototype version.

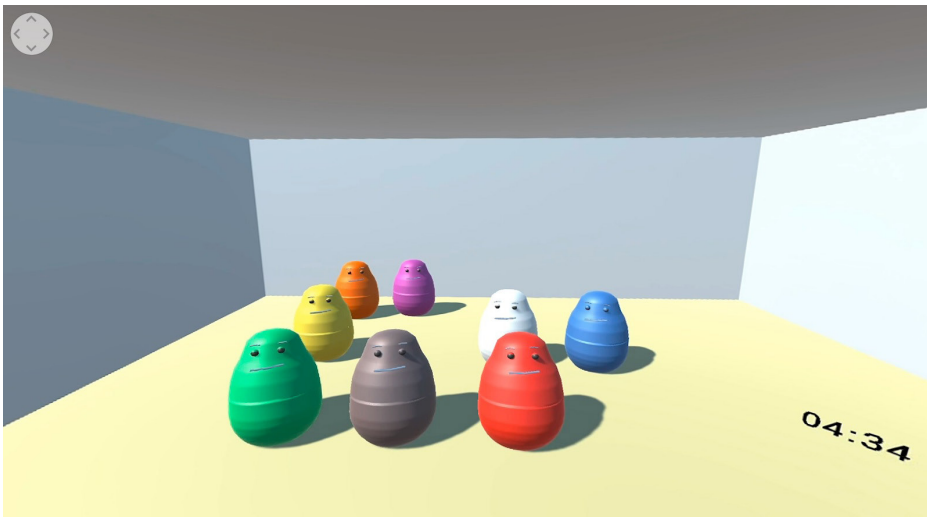


Figure 45. View from low realism version of the prototype

Important aspect to make the presenter feel part of the VR environment is when others are looking at him. As discussed in Part 1, Chapter 1.5 "Realism in Virtual Reality" section "Feeling of presence", if others are looking at you in a virtual world, then this gives the feedback that you exist in it. This effect is achieved through a simple C# script, attached on the avatars (Unity Technologies, no date a). In the positive and neutral audience all the people are looking to the presenter, while in the negative one only half of the audience does so.

During the speech, there is a light room noise as a background.

After the time is up, the noise of the clap is activated. For the work with sound, another generic C# script is used (Unity Technologies, no date c).

The third and last script to be used in the project is for the countdown. It is the only script, developed specifically for the purposes of this prototype. It is displayed in a UI element, positioned on the screen of a laptop on a table in front of the speaker.

A summary view of the used software tools for the development of the prototype is available in Figure 46.

Figure 46. Summary of all software tools, used for the development of the prototype

CONCLUSION

The prototype variations are developed with a combination of software tools to achieve easy and free approach with no coding. For high and medium realism, the prototype was developed in Unity, using avatars from Fuse and body animations from Mixamo. With enabling blendshapes in the model, in Unity were done animations for facial expressions. For the low realism, the model was done in Blender and the animations in Unity.

2.3 SURVEY

"A prudent question is one-half of wisdom."

- Francis Bacon

The step after developing the prototype is how to use it in a proper way to get sufficient results for analysis. Due to existing constrains during the time of this research, publishing the survey online was identified as the most suitable option. This leads to counting on the participants to perform the instructions on their own. No additional evaluation with biofeedback sensors could be executed, therefore, the only form of evaluation possible is a self-report.

QUESTIONNAIRE

Public speaking anxiety has been investigated for decades. Thanks to this, there are a number of questionnaires available, which have been used through the years and improved multiple times. The

most suitable one for the purposes of the survey in this thesis, was identified to be "Personal Report for Public Speaking Anxiety" (PRPSA) (McCroskey, 1970). Examples of PRPSA application is in a research for students and their public speaking anxiety (Mörtberg et al., 2018), as well as it can be filled online in the website of Indiana University Southeast (Personal Report of Public Speaking Anxiety (PRPSA), no date).

There are 34 questions in PRPSA. All of them require answer in a 5-step scale from "Strongly Disagree" to "Strongly Agree". The questions are in the form of a statement, regarding feelings or experience before, during and after giving a speech. Some of the questions refer directly to common symptoms of glossophobia like sweating, shortness of breath and shaky hands. For full list of questions, refer to Appendix A: Survey. With PRPSA it can be evaluated the level of anxiety in the participant. For the purposes of generating a control group, participants without fear of public speaking are needed. In other words, no requirements regarding who can participate are applied. However, as described in Part 2, Chapter 2.1 "Concept and Prototype", the survey includes 4 points of experience with different level of realism. Each participant is going through one version of the prototype, because if they have to go through all of them, the collected data might become unreliable. For the evaluation of the prototype experience, 17 out of 34 questions from PRPSA are selected. They are the ones with statements right before, during or right after giving a speech. For example, questions like "I have trouble falling asleep the night before a speech" are excluded. The questions are minimally rephrased from present to past tense to refer clearly to the past speech with the prototype. This result is placed on the graph of emotional response/realism in the point, defined by the assigned prototype version. The scoring from the same 17 questions from the full questionnaire is calculated for positioning it on the graph with point 4 "Full Realism".

PROTOTYPE INSERTION

A well-known way to provide access to the Virtual Reality in the prototype is by downloading a mobile app. This can be easily achieved in Unity because the tool has the possibility to build the development for mobile devices. Despite that it can be done in a quick matter, this has a few aspects to be considered. First, this is available for Android devices for free, while for iOS it is needed to pay additional licenses. Second,

even if the app is built for Android, it needs to be published in Play Store, which requires subscription and payment. The third and most significant challenge, is that the participants would be asked to juggle between the online survey and downloading an app. This holds the risk of complicating the procedure too much and, therefore, demotivating the participants to complete the questionnaire. The fourth problem was that even if the app is installed, the participant might not own a VR headset at home to view the Virtual Reality in 360 degree.

For solving the first three issues, it was identified that embedding the Unity application inside the web browser could be the solution. For the fourth one, as an alternative to 360-degree view with a headset, a possibility to view the virtual reality environment in full screen on a computer should be provided. Unity provides the option to do a build for WebGL. Its stands for Web Graphic Library and it gives the possibility to embed the virtual reality application in the browser, keeping it interactive. No installation of plug-ins is needed, which makes it easy to be used (Wikipedia contributors, 2020v). WebXR, which is the evolution of WebVR, is an API that is used to embed VR/AR in a web browser (Fundamentals of WebXR, no date). The difference with WebGL is that handles the input and output from external devices for the interaction and does not deal with the rendering. This part is managed by WebGL. Even if Unity can do builds for WebGL, it is not with a stereoscopic view, which is needed for a headset. As a conclusion, the use of WebGL and WebXR seems to be feasible, but more complicated solution.

The simplest solution was to upload the prototype as a VR video in YouTube. The platform provides the possibility to view the VR environment in full screen and with a stereoscopic view for mobile phones and headsets. For navigating in the full screen mode, the mouse can be used. For the mobile phone, it uses the gyroscope from the device itself. These features meet the needs of the survey – no additional installations, both full screen and headset views are available, compatible for any device and any screen. For uploading in YouTube and get the VR capabilities, a few steps had to be executed. First, the VR environment had to be recorded in 360-degree view. This was done with the use of Unity Recorder (Working with the Unity Recorder - 2019.3, no date). It is an asset, which is still experimental, but gives the possibility to do recordings of the VR environment with a set of parameters. It can record with stereoscopic view as well. Nevertheless, the recording was done

done with a normal view with 4K quality. The result is in an equirectangular projection, which is like the world map visualised on a flat surface (Wikipedia contributors, 2020g). The second step is to make the video as a VR one. To do this, Adobe Premiere Pro was used (Professional video editor, no date). In it, it is enough to load the video and set as a VR. With this, it is ready for YouTube upload. The platform itself calculates the stereoscopic view for the VR (Figure 47).

Figure 47. Screenshot from the "Watch in VR" view in YouTube

WEBSITE

There are quite many free or paid survey platforms available. Google Forms is among the most famous ones, being completely free. Others, like SurveyMoney (SurveyMonkey: The world's most popular free online survey tool, no date) and Qualtrics (Qualtrics XM - Experience Management Software, 2015), are more advanced, but require subscriptions. Their free versions are too limited for the purposes of this research. With the facilitation of embedding a Youtube video, the next question was regarding the prototype version assignment. There could be two approaches – fully randomised or balanced and controlled manner. With a lot of participants, the final spread of assignments should be similar between the two options. However, to avoid counting on a high number of participants, the second approach was preferred. As mentioned in the previous paragraph, people without phobia will act as a

control group. In other words, first, the participant is identified in which group they belong to (with or without phobia), and then is assigned with the prototype version with lowest number of participants yet.

To attain this level of control, it was decided to develop the entire survey in a website, designed for this sole purpose. In addition, this gives the flexibility to organise and analyse the data with the use of database. The selected webhost is Altervista, because in its free version HTML, CSS, PHP and MySQL can be used (Laudicina et al., no date). HTML and CSS were used for the organisation of the pages and the user interface (UI). PHP and MySQL were used to collect and store the data in the database. The calculations of the results from PRPSA and the evaluation of the experience from the prototype are done with PHP.

The website is organised in 6 pages:

1. Introduction

This page explains the purpose of the research and gives general information about the survey and its organisation.

2. Information about the participant

Step 1 contains questions regarding the participant (Figure 48). The information about age, gender, nationality and whether their job requires public speaking are used for understanding the profiles of the participants.

3. PRPSA

Step 2 is with all the questions from the PRPSA questionnaire.

4. Prototype experience

Step 3 page starts with setting up a context of the speech. The participant is joining a book club and at the first meeting they need to talk about their favourite book for about 5 minutes. The goal is to create a story, in which the audience is with no familiar people and there is a common interest with the speaker. Additionally, three questions are listed to help for the speech – which is your favourite book, why you like it and what did you learn from it.

Based on the results from Step 2, one of the 9 prototype versions is assigned. The corresponding YouTube video is embedded in the page. To simplify the transition to a mobile phone, in case the participant has a headset and can perform the speech with it, a QR code with the link to the same YouTube video is provided. When the participant clicks the button "Next", a pop-up is asking for confirmation that they have performed the speech.

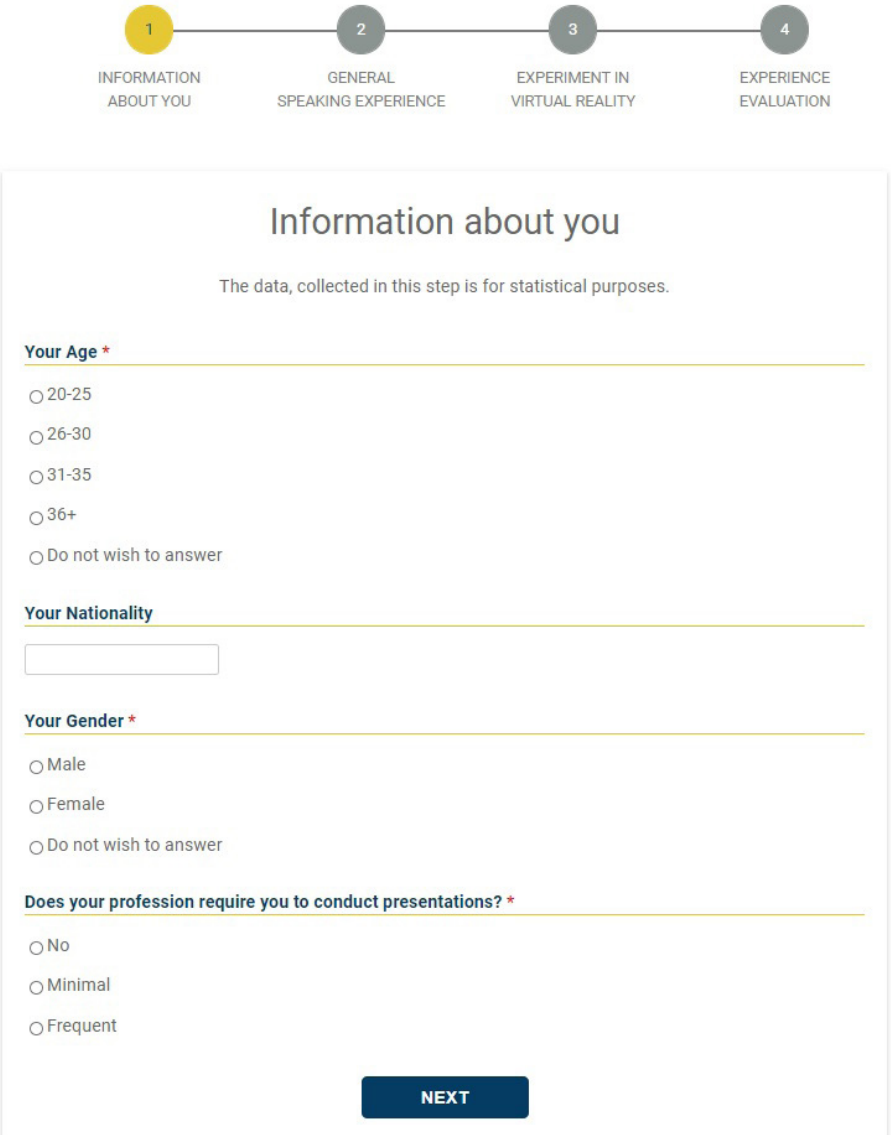


Figure 48. View from Step 1 in the survey website

5. Prototype experience evaluation

In Step 4, the selected 17 questions from PRPSA are listed. 5 additional questions are available. The first three of them are about the

mode, in which the speech was done – Full Screen or with a headset; whether they felt immersed in the virtual environment and how did they feel the reaction by the audience. The last two questions are optional text fields for feedback about the virtual reality experience and about the entire survey.

6. Submission confirmation

The last page is with confirmmation of a successful completion of the survey. The participant gets feedback for the evaluation from PRPSA.

The survey has 60 questions in total. The expected time for completing all the steps is around 15 minutes. To inform the participant about the progress, a step bar is available on top of the pages with questions (Figure 48). Yellow colour marks the current step, while blue is used for past one and grey for upcoming ones.

GDPR

As this survey collects data from people, it must be compliant with GDPR requirements. For this reason, at the first page of the website, there is information about how the collected data will be used and where it will be presented. It is mandatory for each participant to click on the check box to agree with the privacy policy. The default state of the check box is unchecked, otherwise, it is considered invalid for GDPR. Another requirement for compliance is to provide access to the user's data. One option could be my sending them their answers via email, which is the approach, used by Google Forms. However, even providing email address could generate doubts whether it is stored or not. Alternatively, a file can be made available for download with the answers. This is the approach, selected for this website. The file contains all the participant's data, including the time it took them to complete the survey and all the calculations performed on their individual data. With this, the survey is made GDPR compliant (How to make a GDPR compliant survey, 2018).

CONCLUSION

A standard questionnaire for public speaking anxiety is used. The survey is published in a website, made for the purposes of this research. The prototype is made available through a VR video in YouTube. It can be seen in full screen or with a VR headset on a mobile device. It is compatible with any operating system, any mobile device and any VR headset for a mobile phone.

2.4 ANALYSIS

"It is not an experiment
if you know it's going to work."

- Jeff Bezos

PARTICIPANTS

In total 28 participants took part in the survey in the period between 17th October and 1st November 2020. Not all of them shared their nationality, but among the ones who did, the list includes Italian, Bulgarian, Ukrainian, French, Chinese, Argentine and Indian. From these 28 participants, 15 are male and 13 are female. The age range is as it follows: 6 people in 20-25years, 10 in 26-30, 4 in 31-35 and 8 in 36+. 7 of the participants performed the prototype with a headset, while 21 did so in a full screen mode. From all, 21 shared that they did not feel immersed

in the virtual environment, while 4 felt so. It is good to point out that from these 4 participants, who felt immersed, 3 of them performed the speech with a headset in low or medium level of realism.

All 9 versions of prototype are with designed negative, positive or neutral audience reaction. According to the answers, all neutral audiences are detected correctly and only the positive high realism one. The rest versions are identified as mainly neutral. This could suggest that in high realism, the emotional reactions are detected better compared to low and medium realism.

The spread of participants for each prototype version is summarised in Figure 49:

	PROTOTYPE	WITH PHOBIA	WITHOUT PHOBIA
1	High Realism, negative audience	1	3
2	High Realism, positive audience	1	3
3	High Realism, neutral audience	1	2
4	Medium Realism, negative audience	1	2
5	Medium Realism, positive audience	1	1
6	Medium Realism, neutral audience	1	2
7	Low Realism, negative audience	1	1
8	Low Realism, positive audience	1	3
9	Low Realism, neutral audience	1	2

Figure 49. Number of participants for each prototype version

CALCULATION

The questionnaire about the evaluation of the emotional response is Personal Report for Public Speaking Anxiety (PRPSA). As clarified in the previous chapter, its aim is to calculate the level of anxiety of the person, based on questions about before, during and after giving a speech. There are 34 questions, all of which are to be answered in a 5-step scale from "Strongly Disagree" to "Strongly Agree". Each answer is given a point from 1 to 5 (Strongly Disagree =1, Disagree=2, Neutral = 3, Agree = 4, Strongly Agree = 5).

The formula for calculating the results is the following:

- **Step 1.** Add scores for items 1, 2, 3, 5, 9, 10, 13, 14, 19, 20, 21, 22, 23, 25, 27, 28, 29, 30, 31, 32, 33, and 34.
- **Step 2.** Add the scores for items 4, 6, 7, 8, 11, 12, 15, 16, 17, 18, 24, and 26.
- **Step 3.** Complete the following formula:
  PRPSA = 72 - Total from Step 2 + Total from Step 1

The correct calculation should lead to a score between 34 and 170. The higher the score is, the higher anxiety the participant demonstrated, therefore, it could be considered a sign of glossophobia. A score above 130 is considered high, under 98 is low and between 98 and 130 is moderate. The mean is reported to be 114.6, which is the value that we use as a border to divide the two groups of people. If above 114, a person is considered with a phobia, while under 114, is considered without. For even more precise results, participants' scores can be split in three groups – with phobia, without phobia and moderate.

From all 28 participants, 9 are above the mean of 114.6, while the rest 21 are under. 13 out of all 28 scored less or equal to 98 and 4 scored above 130. Therefore, we can conclude that 13 participants demonstrated confidence in giving a speech, while 4 have signs of glossophobia. The remaining 11 are considered moderate speakers. Counting all scores above 98 as a percentage, we can conclude that the ones demonstrating some level of anxiety are 86%. According to Fritscher, 77% of the entire population experience some anxiety when giving a speech (Fritscher, 2020). The proximity in the percentage could be considered a sign that the portion of participants in this survey are a good sample for the population.

For the calculation of the experiment with the prototype, PRPSA is partly reused. As mentioned in the previous chapter (2.3 Survey), only 17 out of 34 questions are selected for this calculation. The ratio between questions from Step 1 and Step 2 from the formula below is respected. The list of selected questions is the following: 3, 4, 5, 7, 10, 11, 16, 17, 22, 23, 24, 25, 27, 29, 32, 33, 34. Since the number of questions is divided by two, also the formula is changed – instead of 72, it is used 36. Therefore, the formula is:

PRPSA = 36 - Total from Step 2 + Total from Step 1.

For full list of questions from the survey, refer to Appendix A.

GRAPHS

For the purposes of this research, a few graphs are drawn. They are visualised with the use of polynomial trendline, which is one of the 6 most common trend lines for data analysis (Hayes, 2020). It is used, when the graph is to depict hills and valleys (Choosing the best trendline for your data, no date), which aligns with the purposes of the explored curves.

The first graph, is with all participants (Figure 50). The purpose of this one is to understand whether the uncanny valley effect is observed

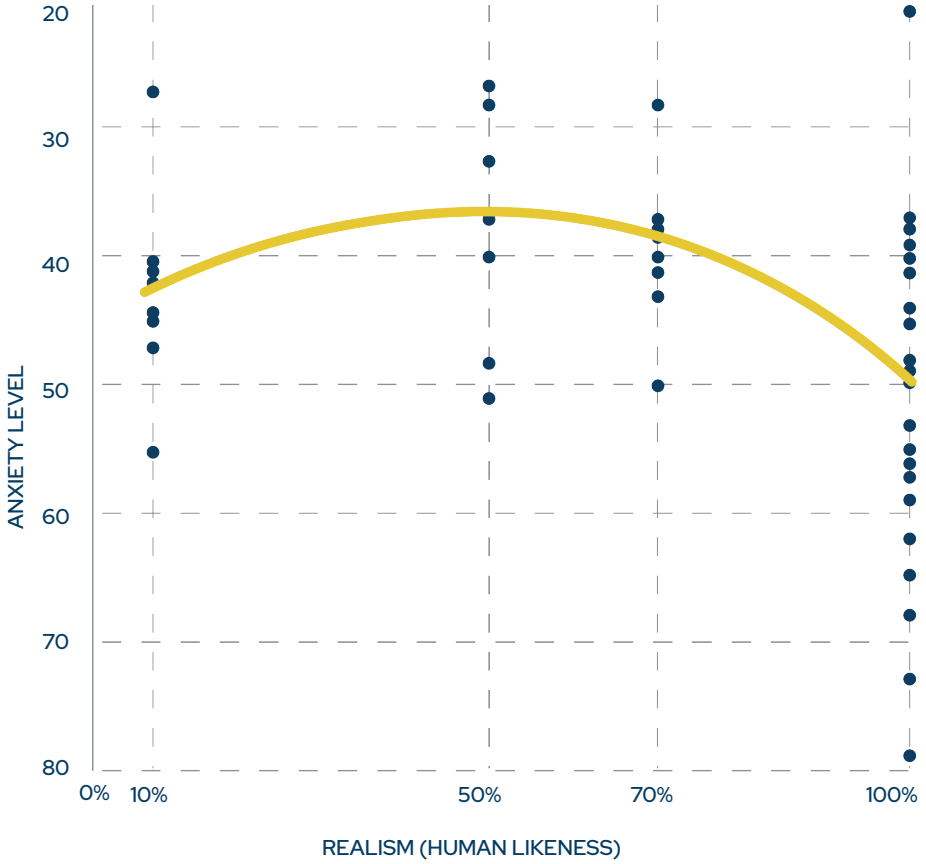


Figure 50. Graph with all participants and their emotional response for each prototype

or not. In the curve of the uncanny valley as we know it, there are two axis. The first one is about the level of realism, while the second one is the emotional response. With the use of PRPSA, the anxiety level is calculated and it can be considered the emotional response from the experiment. However, the higher the score is, it demonstrates more negative response, therefore, the axis should start from high to low scale.

The second graph is with the participants (Figure 51), who demonstrated confidence in giving a speech (under 114.6).

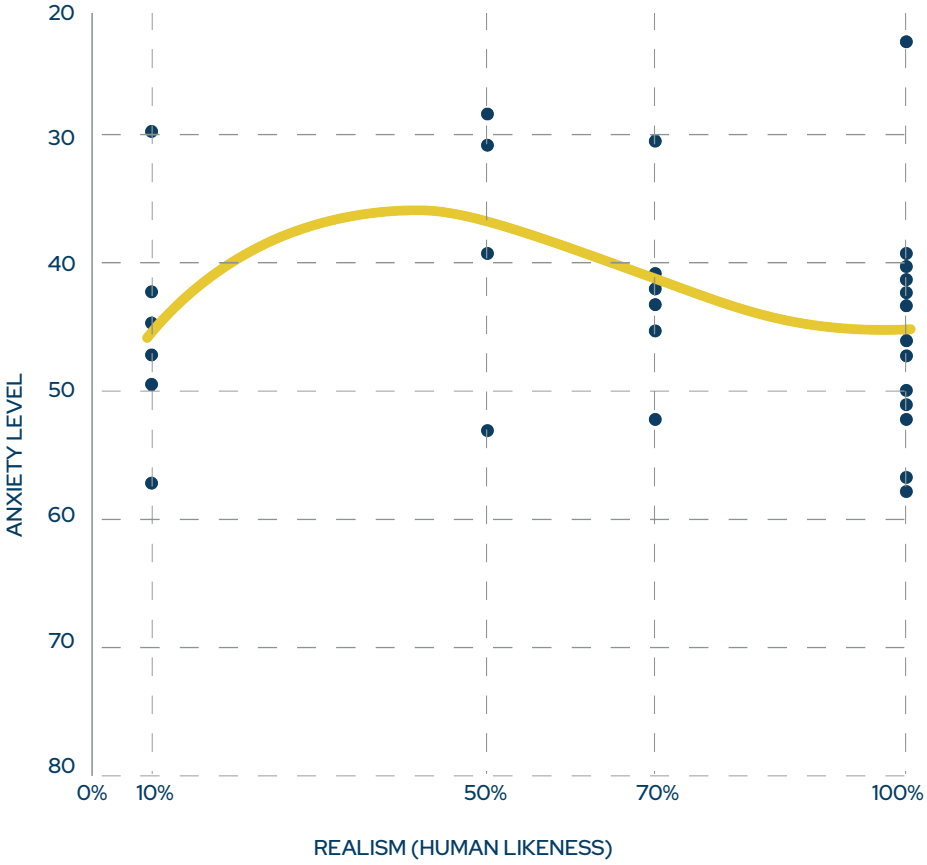


Figure 51. Graph of participants with confidence in public speaking

The third graph is for the participants with evidence of fear of public speaking (above 114.6) (Figure 52).

Additionally, graphs with particular answers were explored. For example, whether the participants used a headset and had potentially more immersive experience. Unfortunately, the number of participants, who performed the experiment in this mode, are 7, which is insufficient amount of data for building conclusions.

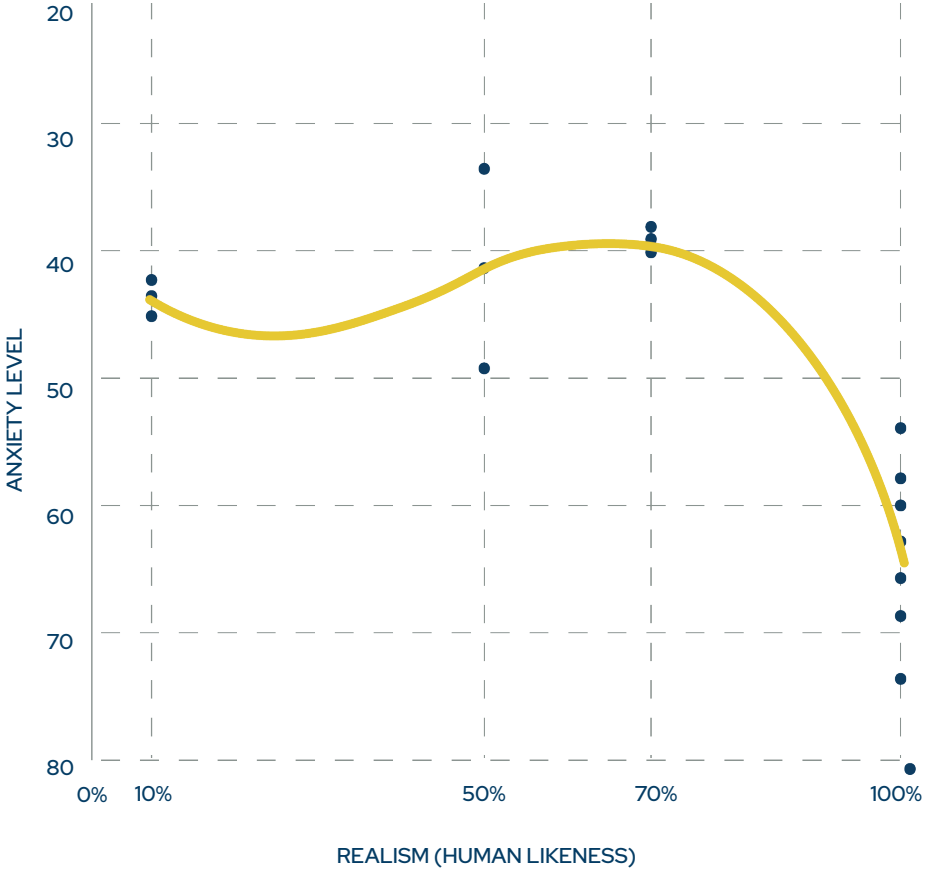


Figure 52. Graph of participants with lower confidence in public speaking

Another separation was based on confident, moderate and unconfident speaker criteria. However, these graphs show very similar illustration as the ones above.

On the x-axis for the realism, there are the 4 points from the prototype. The Low Realism (LR) is considered 10% realistic, Medium Realism (MR) - 50%, High Realism (HR) - 70% and Full Realism (FR) is 100%. The y-axis is for the anxiety level with scores from the PRPSA calculation. A possible way to calculate the "zero" on the y-axis is by using the mean, available from the formula for PRPSA, divided by two to keep the ratio from the changed formula. However, this information is less critical for the purposes of the research outcomes and it can be ignored.

CONCLUSION

28 participants took part in the survey. The scoring is calculated with the provided formula for Personal Report for Public Speaking Anxiety. With the results, graphs are drawn for all participants, the ones with confidence and the ones without confidence in giving speech.

2.5 DISCUSSION

"See now the power of truth; the same experiment which at first glance seemed to show one thing, when more carefully examined, assures us of the contrary."

- Galileo Galilei

The subject of the research is to investigate the emotional response in virtual reality (VR) and whether it differentiates for people with and without glossophobia. The analysis supports the theory that the uncanny valley effect alters in the presence of public speaking anxiety.

INTERPRETATIONS

The three main graphs (all participants (Figure 53), with (Figure 54) and without phobia (Figure 55)) demonstrate differences between each other. The curve with participants without phobia has similarities with the uncanny valley curve, observed in previous research (Figure 53). However, with this survey, the full valley depth is not detected. Possible explanation for this is that the level of realism was lower than the one, with which the bottom of the valley is hit. According to Tinwell (Tinwell et al., 2011), the uncanny valley is visible between 70 and 85% realism. In the prototype, the High Realism version can be evaluated as around 70%. Nevertheless, in the drawn curve from the survey, there is evidence that after certain level of realism (after 50%), the anxiety level goes up with the increase of realism. We can conclude that the results partly support the hypothesis about the uncanny valley, made by Masahiro.

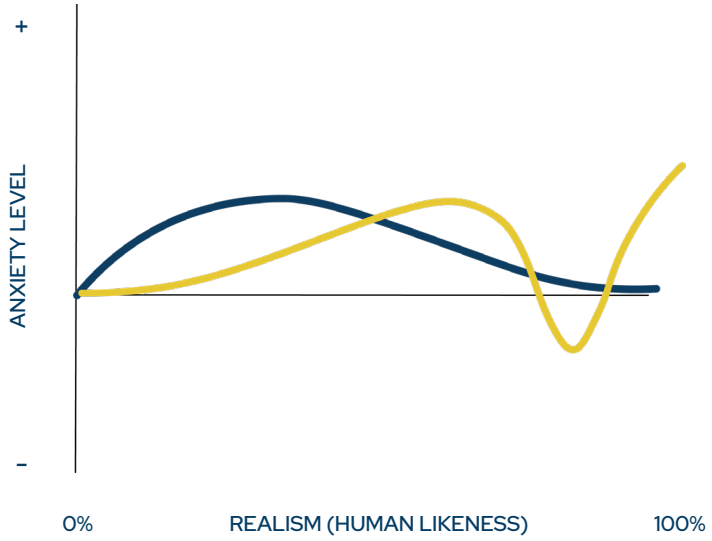


Figure 53. The original uncanny valley curve (yellow) and the curve with confident speakers from the experiment (blue)

The interest of the research is focused on the performance by participants with phobia in comparison with the ones without. For the first group, it is observed that the level of anxiety is lower at high level of

realism than at medium one (Figure 54). **In line with the hypothesis, the results suggest that there is no uncanny valley effect in virtual reality for people with glossophobia.**

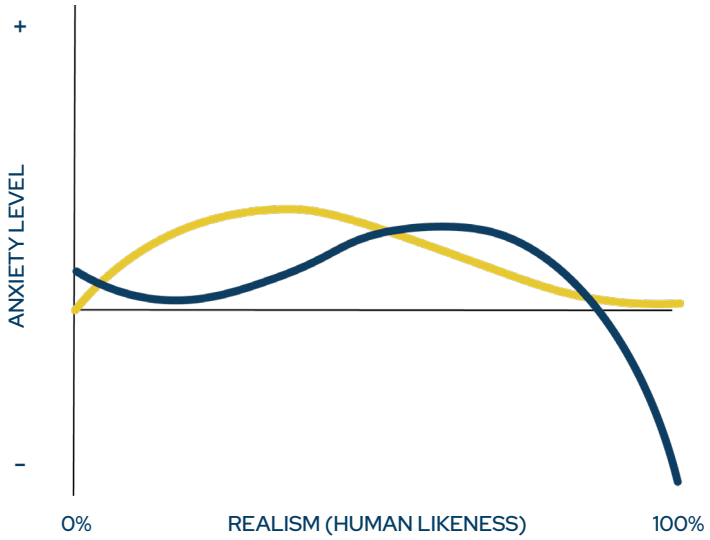


Figure 54. The curve with confident speakers (yellow) and the curve with speakers with phobia (blue)

In addition, another interesting observation is that the curve with all participants does not resembles the uncanny valley (Figure 55). As stated in Part 2, "2.1 Concept and Prototype", the researches about the uncanny valley so far have neglected the individual aspects in the participants, including whether they have a social phobia. The recorded result raises questions whether the existing experiments were performed with majority of the participants being from a certain group. Another possibility is that this survey puts people in a specific situation, which can trigger their anxiety more than in the other cases.

IMPLICATIONS

The emotional response and what could influence it are the key to the success of a design solution. On one hand, this research suggests that a VR with medium level of realism could be perceived more positively by people without social phobia. On the other hand,

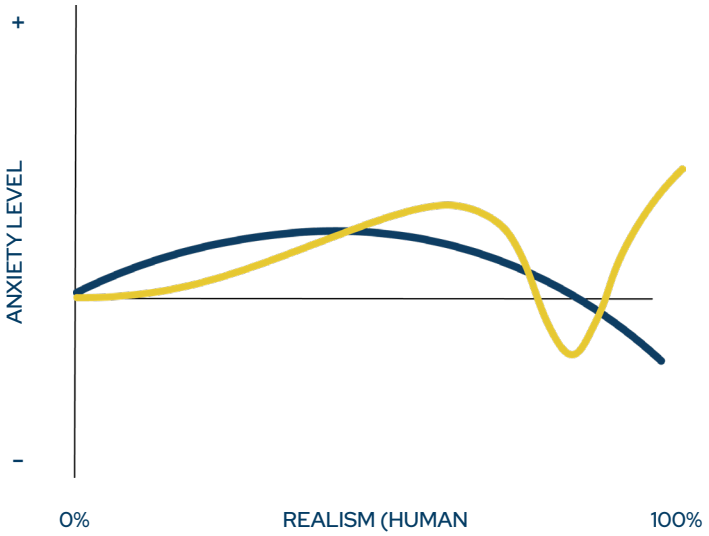


Figure 55. The original uncanny valley curve (yellow) and the curve with all participants from the experiment (blue)

it hints that higher level of realism is better emotionally perceived by people with social phobia, in particular fear of public speaking. **This research suggests that the level of realism is a variable, which can be manipulated by a designer in attempt to meet a certain design brief.** By understanding better the emotional response and the impact of the uncanny valley effect for different groups of people, a solution with more positive perception can be designed.

LIMITATIONS

The reliability of the research outcome is impacted by the conditions, in which the survey was conducted. Since the participants had to do it without supervision, it is hard to guarantee the significance of the collected data.

In the comparison between the uncanny valley curve and the one with participants without phobia, a difference to point out, is that the full realism results are lower than in the original curve. It is calculated by extracting a subset of answers from the PRPSA questionnaire and then compared to the experience from the VR prototype. Even though it has reasoning in doing such comparison, it is not as sufficient as it would be

to do evaluation on the same context and audience from the VR into a real scene. For this reason, performing this part of the experiment with real audience could give better outcome for comparison.

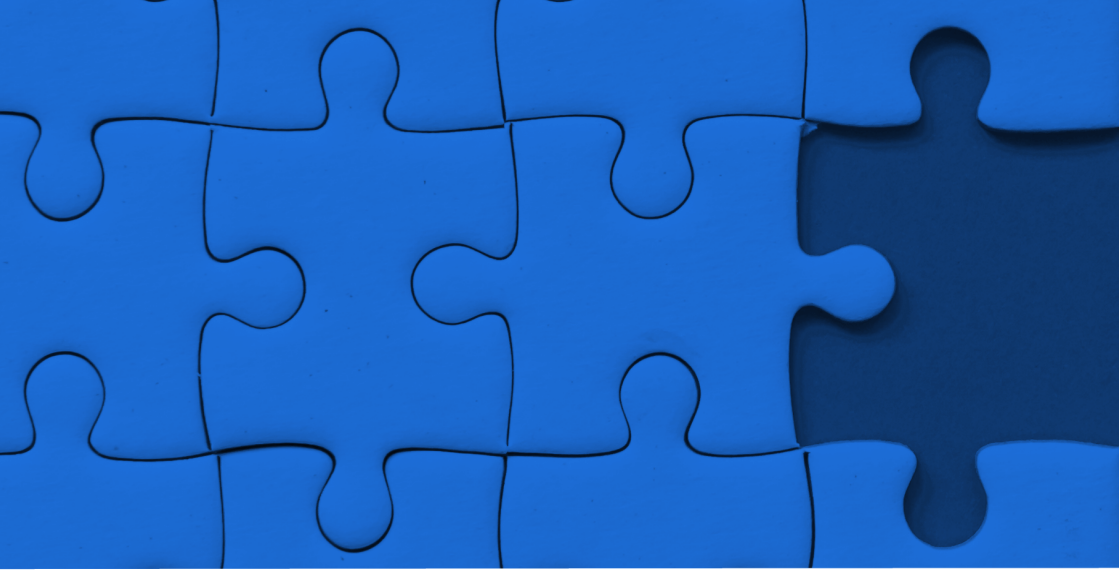
RECOMMENDATIONS

To confirm or refute the above-mentioned statements, it is recommended to perform the experiment in lab conditions. In addition, we suggest the participants to do the speech with a VR headset to give them a better feeling of immersion. Higher number of participants is often valid recommendation in order to simplify the pattern observation.

As stated in Part 1, "1.4 Phobias in Virtual Reality", all leading companies in the field of phobia treatment with virtual reality invest in producing VR with high realism. We know that there is also evidence that this treatment works. This could lead to a possible conclusion that Virtual Reality Exposure Therapy (VRET) is that effective due to the positive emotional response by the patients with social phobia. To verify the relation between positive response and effectiveness, further research could be to check patients with glossophobia in a longer term. This means to perform a series of exposures in VR and compare in which level of realism are observed quicker or better improvements of the phobia condition. Continuing this line, a further research could be to investigate whether medium level of realism is more effective for people without social phobia. Such research could have a serious value for the designers and developers of VR, since the majority of companies are aiming at the highest possible level of realism (Part 1, "1.6 Realism in Virtual Reality"). In other words, through the use of a social phobia in VR environment, we could make conclusions about what realism works better on a subconscious level.

CONCLUSION

The analysis from the survey are in support of the stated hypothesis. The results show difference in the anxiety levels for people with and without glossophobia. In particular, for people with phobia, the uncanny valley effect is not observed, while for people without phobia there are signs about the existence of the effect. This outcome contributes to design decisions about level of realism in VR and it can be selected, based on the targeted users.



2.6 CONCLUSION

"The end of a melody is not its goal:
but nonetheless,
had the melody not reached its end
it would not have reached its goal either.
A parable."

- Friedrich Nietzsche

This research aimed to investigate the emotional response in Virtual Reality environment for people with a social phobia, specifically fear of public speaking. The focus was on the uncanny valley effect, observed in people's reactions towards virtual characters in high level of realism.

The conducted trial, accompanied by a survey, supported the made hypothesis that the uncanny valley curve differentiates between people with and without social phobia. In particular, the results suggest

that there is no uncanny valley in people with fear of public speaking and their anxiety level is lowest at high level of realism – the opposite from the results of people without social phobia.

PHOBIAS

We, by design, experience fear or anxiety, which acts as a warning to us and helps to protect ourselves from dangers. However, once this anxiety becomes disproportionally high to the actual danger, it is called phobia.

There are three main categories of phobias – agoraphobia, specific phobias, and social phobias. The latter one generates fear or anxiety in social settings, because of negative judgement by others. Glossophobia, referred to also as fear of public speaking or public speaking anxiety, was selected as an example of a social phobia, due to the fact that it is the most common one, affecting 82% of all cases. It has a serious impact on people's quality of life, because its severity may lead to avoiding situations like job interviews or other career opportunities, requiring presentations.

The most successful treatment is the Exposure Therapy. This is the practice of putting the patient with phobia in the context, in which he needs to face the object of his fears. The exposure can be done in two main ways – in real environment (In-vivo Exposure Therapy) or by setting up the scene in the mind of the patient (Imaginal Exposure). Systematic Desensitization is when the in-vivo exposure is done in steps to increase the anxiety level, which the patient can tolerate. While In-vivo Exposure Therapy is effective, it could be harder to be achieved because it requires locations and other people's involvement. For example, aviophobia, the fear of flying, would require the patient and the therapist to take a plane together. In addition, it could be a challenge to control the real-life environment. This is why therapists apply Imaginal Exposure more often, in which they try to build the scene together with the patient through the use of words and imagination. The disadvantage in this method is that it counts a lot on the skills of the patient to feel into the imaginary setup.

PHOBIAS AND VIRTUAL REALITY

Virtual Reality is already successfully applied in fields like Education, Medicine and Entertainment. It is a technology that becomes more accessible from equipment point of view, as well as development.

In the past decade, it is also used for phobia treatment. This application is called Virtual Reality Exposure Therapy (VRET). Its advantages in comparison with the classical exposure therapies, are related to the simplified possibility to get the patient in a realistic environment with his cause of fear. It does not need to count on imagination, as in Imaginal Exposure, while at the same time it can be performed from the therapist's office instead of going to a specific place like in In-vivo Exposure Therapy. In addition, the VR environment can be configured to align with the steps, defined in Systematic Desensitization and updated by the therapist in real time during the exposure. VRET is time and cost effective. The purpose of such software tool is not to replace the therapist, but to accompany their work.

The Spanish start-up Psious is leader in the field of VRET, providing kits with VR headset, platform for the therapist to configure and follow the patient's progress, and a biofeedback sensor to give more information about the stress level during exposure session. It is reported that it takes between 3 and 5 sessions for a patient to overcome their phobia with VRET. The common between all VRET solutions on the market is that they try to replicate the real environment with photorealism.

THE UNCANNY VALLEY AND VIRTUAL REALITY

Masahiro Mori made a hypothesis that with the increase of realistic humanlike appearance of a robot, people tend to change their emotional response from positive to negative. Around 70-85% human likeness, the reaction becomes negative, causing the uncanny valley effect. With variety of experiments, researches support the hypothesis.

There are a few possible explanations for the effect, including that it is a defence reaction. Since something strange is noticed, it is considered a sign of sickness or other danger for us and, therefore, we are trying to avoid it. If we consider 0% of human likeness to be for a robot and 100% for a real human, we know what to expect from each one of these categories. But in the area, where these two are merging and we do not in which one to assign it to, it causes more cognitive effort for us and anxiety level rises.

The progress of VR technologies is in the direction of achieving photorealistic environments, especially in the game design field. Regardless of the high realism, this is not guaranteeing the feeling of presence, because realism is not the same as believability.

This leads to the translation of the uncanny valley hypothesis to virtual characters in VR. In fact, in a research, it is believed that the effect is even stronger with avatars. As William Bricken says, "Psychology is the physics of virtual reality". To produce feeling of presence, other elements are important, for example, whether an avatar is looking at you. The body produces reactions as if the VR environment is real because the brain takes a moment longer to remind us that this is not. By that time, we are already immersed.

In a new guideline about creating virtual characters to avoid the uncanny valley, a set of suggestions are listed. The main point is that the effect happens when there is an atypicality in an avatar at high level of realism. For example, too big eyes, while the rest is quite detailed and with regular proportions.

Even though, there are experiments exploring the uncanny valley effect in VR and with robots, they mainly focus on proving or refuting the hypothesis. To our knowledge, no research on the effect has been conducted on specific group of people.

HYPOTHESIS AND PROTOTYPE

We made the hypothesis that the presence of glossophobia impacts the emotional response in people and, therefore, the uncanny valley effect is either stronger or does not exist.

To prove this hypothesis, a prototype was developed. Three levels of realism are selected – at 10% (low realism LR), 50% (medium realism MR) and 70% (high realism HR). These are the main points that influence the graph of the uncanny valley. For each one, three versions are created with positive, negative and neutral reactions by the audience. All avatars are moving their bodies and faces to convey the reactions. For the positive audience, enjoyment and surprise facial expressions are implemented. For negative one, the expressions are contempt and disgust. Some of the body movements include breathing, blinking, shaking head in agreement or disagreement.

The prototype development was done with Unity3D. For HR and MR, the avatars were created with Adobe Fuse and animated with Mixamo. Once imported in Unity, the facial expressions were done with the use of blendshapes, allowing natural movements on the face. LR avatar was created with Blender and animated in Unity. The body and face movements are synchronised between all versions of the prototype to

avoid unwanted influence on the emotional reaction by the participants.

SURVEY

The survey was conducted online, due to constrains in organising it in lab conditions. No requirement on who can participate was applied. To make comparison in support of the hypothesis, people without phobia were needed as a control group. For the questionnaire, a standard one was used – Personal Report for Public Speaking Anxiety (PRPSA). It is commonly used in experiments, in which the participant needs to self-evaluate their speech performance. The questionnaire is used before and after the prototype to compare the real-life experience and the one in VR.

The prototype versions were uploaded as VR videos in YouTube. This was identified as the most efficient approach that does not require additional installations, while it fits all devices and Operation System.

A website was developed for the purposes of this survey. The main reason was because this way there is more control on the prototype version assignment, guaranteeing balance in all versions for each of the two groups of participants.

ANALYSIS AND DISCUSSION

In total, 28 participants took part in the survey, 9 of which demonstrated signs of phobia.

The graph with participants without phobia does not precisely replicate the uncanny valley curve, however, it reports more positive reaction in MR rather than in HR. This aspect is in line with the uncanny valley effect.

On the contrary, t**he graph of participants with phobia in high realism shows the lowest level of anxiety**. This revelation supports our hypothesis that the uncanny valley effect does not exist for people with fear of public speaking. In other words, we can conclude that the perception of avatars in a virtual environment depends on the user's individual characteristics, in particular whether they experience a social phobia.

As a multidisciplinary research, it delivers benefits both for design and psychology as separate disciplines and as combined.

In one direction, Clinical Psychology is provided with a tool in the form of a prototype, which can be used for formal experiments with a

strong scientific value. In order to produce analysis as a demonstration of a statement, there are requirements for the experiment. This includes establishing the number of participants in advance, approval from an ethical committee and performing the data analysis by following specific methodological and statistical procedures.

In the other direction, Interaction Design benefited from this research by building new knowledge about the emotional response in users, caused by virtual characters. By bringing understanding from psychology about the emotional reactions in people, designers are empowered to make decisions about the suitable level of realism for a target user group.

FUTURE WORK

The produced work so far is at a proof of concept stage. To elaborate further the hypothesis, a formal experiment in lab conditions is planned, with a scientific validation of the statement. The target is to meet the requirements for an experiment in the field of clinical psychology and perform evaluation with physiological feedback. The next steps in the research are led by experts in psychology with consultancy from designers. Therefore, the outcome can be used as a solid base for further investigation.

For a sequential research, we propose considering the long-term impact of the level of realism on phobia treatment to understand whether there is a connection between more rapid improvement and positive response to a VR. Such investigation could give information about the subconscious reaction in people and contribute to designing solutions that are not only perceived positively at that moment, but in long term as well.

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FIGURES

PART 1

PART 2

APPENDIX A: SURVEY

Survey website: http://publicspeakingexperiment.altervista.org

STEP 1: INFORMATION ABOUT YOU

1. Your Age*
   Answer options: 20-25 / 26-30 / 31-35 / 36+ / Do not wish to answer
2. Your Nationality
3. Your Gender*
   Answer options: Male / Female / Do not wish to answer
4. Does your profession require you to conduct presentations?*
   Answer options: No / Minimal / Frequest

STEP 2: PERSONAL REPORT FOR PUBLIC SPEAKING ANXIETY

All questions are to be answered in 5 options from Strongly Disagree to Stronly Agree.

1. While preparing for giving a speech, I feel tense and nervous.*
2. I feel tense when I see the words "speech" and "public speech" on a course outline when studying.*
3. My thoughts become confused and jumbled when I am giving a speech.*
4. Right after giving a speech I feel that I have had a pleasant experience.*
5. I get anxious when I think about a speech coming up.*
6. I have no fear of giving a speech.*
7. Although I am nervous just before starting a speech, I soon settle down after starting and feel calm and comfortable.*
8. I look forward to giving a speech.*
9. When the instructor announces a speaking assignment in class, I can feel myself getting tense.*
10. My hands tremble when I am giving a speech.*
11. I feel relaxed while giving a speech.*

12. I enjoy preparing for a speech.*
13. I am in constant fear of forgetting what I prepared to say.*
14. I get anxious if someone asks me something about my topic that I don't know.*
15. I face the prospect of giving a speech with confidence.*
16. I feel that I am in complete possession of myself while giving a speech.*
17. My mind is clear when giving a speech.*
18. I do not dread giving a speech.*
19. I perspire just before starting a speech.*
20. My heart beats very fast just as I start a speech.*
21. I experience considerable anxiety while sitting in the room just before my speech starts.*
22. Certain parts of my body feel very tense and rigid while giving a speech.*
23. Realizing that only a little time remains in a speech makes me very tense and anxious.*
24. While giving a speech, I know I can control my feelings of tension and stress.*
25. I breathe faster just before starting a speech.*
26. I feel comfortable and relaxed in the hour or so just before giving a speech.*
27. I do poorer on speeches because I am anxious.*
28. I feel anxious when the teacher announces the date of a speaking assignment.*
29. When I make a mistake while giving a speech, I find it hard to concentrate on the parts that follow.*
30. During an important speech I experience a feeling of helplessness building up inside me.*
31. I have trouble falling asleep the night before a speech.*
32.My heart beats very fast while I present a speech.*
33. I feel anxious while waiting to give my speech.*
34. While giving a speech, I get so nervous I forget facts I really know.*

STEP 3: PROTOTYPE VERSIONS

High realism, negative audience:
https://youtu.be/2fTzKYczDMg

High realism, positive audience:
https://youtu.be/TM9Sx-NtjI0

High realism, neutral audience:
https://youtu.be/Qo6HzrPHzv0

Medium realism, negative audience:
https://youtu.be/JT-rz0yW4TY

Medium realism, positive audience:
https://youtu.be/oi-St9vUaXI

Medium realism, neutral audience:
https://youtu.be/5gIIO3XTjfc

Low realism, negative audience:
https://youtu.be/r5lyIFMKjhE

Low realism, positive audience:
https://youtu.be/3AhMQy3xuTM

Low realism, neutral audience:
https://youtu.be/b_C-iXTd_pw

STEP 4: EXPERIENCE EVALUATION

1. In which mode did you perform the speech?*
   Answer options: Full Screen / With headset ("Watch in VR")
2. How did you feel the reaction by the audience?*
   Answer options: Negative / Neutral / Positive

3. I felt immersed in the virtual environment.*
4. My thoughts became confused and jumbled when I was giving the speech.*
5. I feel that I had a pleasant experience.*
6. I got anxious when I was thinking about the upcoming speech.*
7. Although I was nervous just before starting the speech, I soon settle down after starting and felt calm and comfortable.*
8. My hands trembled.*
9. I felt relaxed.*
10. I felt in complete possession of myself.*
11. My mind was clear.*
12. Certain parts of my body felt very tense and rigid.*
13. Realizing that only a little time remains in the speech made me very tense and anxious.*
14. I felt in control of my feelings like tension and stress.*
15. I breathed faster just before starting the speech.*
16. I did poorer because I was anxious.*
17. When I made a mistake, I found it hard to concentrate on the parts that follow.*
18. My heart beat very fast.*
19. I felt anxious while waiting to give my speech.*
20. I got so nervous and I forgot facts I really know.*
21. Feedback for the Virtual Reality experience
22. Feedback for the survey