InterM&Dia

Interaction as a Dialogue based on Materiality

PhD candidate: Sara Bergamaschi
Supervisor: Prof. Lucia Rampino

Chair of the Doctoral Programme: Prof. Luca Guerrini

InterM&Dia

Interaction as a Dialogue based on Materiality

PhD candidate: Sara Bergamaschi
Supervisor: Prof. Lucia Rampino

ABSTRACT

This thesis explores the field of interaction design by the industrial design perspective. The interaction is seen as a dialogue between two entities. Both, interaction and dialogue require the involvement of two actors who are in contact for sharing something. Typically, they share information but it is also possible to enrich this relationship with emotional factors (like feelings) and personal point of view (like thoughts and ideas).

Each dialogue – and, consequently, each interaction - is based on specific language. In the interaction design field, four languages were cataloged according to their "dimensions":

- *The 1-D language: based on words and poetry.*
- *The 2-D languages: painting, typography, diagrams, and icons.*
- *The 3-D languages: physical and sculptural forms.*
- *The 4-D languages: sound, cinema, and animation.*

The limit of this categorization is that languages are considered as separated, without any touching point. However, they can be used together to enrich the interaction between the system (products or digital interface) and the user. This thesis is based on the idea that these languages may be enriched transferring some features of one language to another. Particularly, this research is based on a number of philosophical studies on the use of words (1-D language) which suggest two ways of using them: as a codified language and as an empirical language.

Starting from phenomenological studies, these languages were defined in this thesis as:

- *Codified language: a form of expression based on conventions/symbols/codes shared by a group of people. This language is useful to be applied in dialogues where the contents of the information have to be clear and not misunderstood. For example, the traffic light informs users about their possibility to cross the street applying three colors which meanings have become conventional: green, red and yellow.*
- *Empirical language: a form of expression in which the contents of the dialogue are not completely established a priori, but meanings are individually created by the user during the interaction with the product itself. Empirical language can be used to create meaningful product experiences, like in the artistic and poetic fields.*

Since I am an industrial designer, this research focused on the 3-D languages. Historically, industrial designers are indeed familiar with the physical and sculptural forms of artifacts. Nevertheless, in this research, 3-D languages are not only intended as pure physical shape, but also as all that we can perceive through the human sensory apparatus (e.g. touch feelings, smell properties ...). In order to be more inclusive and to refer to all the five human senses (view, smell, touch, taste and hearing), this research intends "sensory language" as a language based on any kind of sensory stimuli. Nowadays, microchips have become so small that they can be embedded in traditional materials such as wood, glass, polymers, fabrics and even more, making such materials "smart". Thanks to these materials, products can now change their sensory features (i.e. shape, texture etc.) proactively and in a reversible manner, according to a specific

situation. Such changes can be designed with an informative intent, i.e. a mug that is able to change color to communicate that the temperature of the drink inside is getting higher or lower. Therefore, nowadays product designers have new material opportunities to work on; and the industrial design field can be enriched with new forms of material interaction, novel ways to convey meanings, and new shape possibilities: indeed, products are able to establish over time dialogues with users through their sensory features.

This research aims to explore if interactive products can establish meaningful dialogues based on sensory stimuli and how they can be designed according to codified and empirical languages. In this perspective, I have chosen to focus my research on a specific field to test the limits and the potentialities of these languages based on dynamic sensory features of industrial products. The field of resources conservation have disclosed some opportunities for such languages. Studies have demonstrated the importance to establish dialogues between the product and the user (mainly through smart meter based on screens) with the aim of informing and motivating users to change their behavior in order to be make sustainable choices in their daily life.

This research aims to contribute to achieve a "cross-fertilization" between features that traditionally apply to the alphanumeric language (1D language) and the sensory language (3D language). Indeed, the sensory language can nowadays exploits new opportunities coming from the development of smart materials and new technologies.

In order to test the real possibilities of such cross-fertilization, the Research-through-Design approach was applied and two prototypes have been created. "Glass of Water" explores the use of sensory language as a codified code through a the light, which decreases its brightness according to the amount of water consumed, so recalling a glass of water that is consumed. "F.E.E.L."(Feelings and Experiences for an Embodied Learning) investigates a sensory language that is responsive to the situation: this means that the sensory changes do not convey information through conventional symbols but they create a dialogue as a sort of "repartee" between the user and the product. Then, two prototypes were tested with users during three focus groups, which were organized with the aim of explore the interests, feelings and the engagement of the users as well as their understanding about the information conveyed through materiality instead of using alphanumerical language.

The two design concepts demonstrate that like words, also senses can be designed in order to either convey simple information (codified language) or to emphasize emotions (empirical language). The resulting concepts shown that designing for a codified language or for an empirical one have different implications into the design process and thanks to the results of three focus groups it is demonstrated that they can also influence the users' understanding.

The two design activities lighted up the importance - for the designer - to develop skills both in the products' technical feasibility and in the user investigation. The designer, who wants to embrace the sensorial language, has to develop skills about functional materials as well as on how to hybridate microprocessor to traditional materials; he/she has to be able to perform a user research and to gain knowledge on how to design for our senses, being aware that different senses can have different meanings. For instance, the sense of smell is strictly connected to people's memories while a vibration instinctively alarms the user.

From the users' point of view, it was observed that establishing a material dialogue through a codified code gives prominence to the message and to the communicative intent of the products. A codified language can be applied when we want the user to be conscious of the informative content, such as when the aim of the product is to make users aware of the amount of water consumed in a given situation. On the other side, applying an empirical language means to underline the experience of interaction with the product. Such experience is likely to be perceived as more engaging and attractive by the user, resulting in a possible fruitful strategy to motivate him/her to reduce his/her consumptions.

A Savy,

per la sua pazienza, il suo amore e la sua pazzia nell'avermi sposata

INDEX

PART 5: ANNEX

Journal Paper

BERGAMASCHI, S., LEFEBVRE E., COLOMBO S., DEL CURTO B., RAMPINO L.; Material and immaterial: new product experience; The International Journal of Designed Objects, Volume 10, Issue 1, March, 2016, pp.11-22. Article: Print (Spiral Bound). Published Online: January 8, 2016.

Conference proceedings

BERGAMASCHI S., COLOMBO, S., RAMPINO L.; Educational Experience In Interaction Design: A Case Study. In the proceedings of the conference INTED 2016.

BERGAMASCHI, S., RAMPINO L., COLOMBO S.; Engaging users through dynamic products for promoting water saving in a domestic environment. In the proceedings of Cumulus Mumbai 2015.

BERGAMASCHI, S.; Dynamic Products: an instrument for saving resources. Improve user's awareness through designing product experiences. In the proceedings of ICED2015.

COLOMBO, S., RAMPINO, L., BERGAMASCHI, S.; What are you telling me? How objects communicate through dynamic features; xCoAx 2013 conference, 27- 28 June 2013

INTRODUCTION

This thesis explores the field of interaction design by the industrial design perspective. The interaction is seen as a dialogue between two entities. In both interaction and dialogue two actors are involved and they are in contact for sharing something. Typically, they share information but it is also possible to enrich this relationship with emotional factors (like feelings) and personal point of view (like thoughts and ideas).

Each dialogue is based on language. For instance, the dialogue between two people is based on words. This thesis aims to give more insights to the industrial design area for inspiring the exploration of sensory language in the field of interaction design.

Moggridge (2007) categorized four languages (in the interaction design field) according to their "dimensions": 1-D, 2-D, 3-D and 4-D.

The 1-D language is based on words and poetry.

The 2-D languages refers to painting, typography, diagrams, and icons.

The 3-D languages refers to physical and sculptural form.

The 4-D languages include sound, film, and animation.

Figure 1. Scheme of the four languages

The limit of this categorization is that these languages are considered something *per se*, they have not touching points. However, they can be used together to enrich the interaction between the system (products or digital interface) and the user. I believe that these languages may be enrich transferring some features of one language to another. Specifically, this research is based on some philosophical studies (Merleau-Ponty, 1964; Philip, 1966) on the use of words (1-D language)

which suggest two ways of using them: the everyday language uses words in a codified way, to be clearer and not misunderstood (desfined in this research as codified language). In poetry and in the artistic field, words are used in an original and novelty way to create emotions and personal meanings in the reader (defined in this research as empirical language).

As an industrial designer, I focused my research on the 3-D language. Historically, the product designer is familiar with the physical and sculptural form of artifacts. This research considers the 3-D language not only as a physical shape; but (in my point of view) it also refers to everything we can perceive through the human sensory apparatus (e.g.: visual aspects, touch feelings, smell properties, etc…). In order to be more inclusive and to refer to all human senses (such as view, smell, touch, taste, and hearing), this research defines sensory language as an expression based on sensory stimuli. Nature is filled with beautiful examples of sensory language: tomatoes change their color according their ripening, or people blush in embarrassing situation. Nowadays, thanks to the development and the diffusion of functional materials, the miniaturization of electronics, processors and sensors, designers are able to simulate these changes and to communicate with users in more engaging ways. For example, Noi (Fig.2) is a concept for maintaining indoor climate in private homes: more the air is polluted, denser the surface texture becomes.

Figure 2 Noi by design-people

In our previous study, we have collected classified and analyzed 45 case studies (Colombo, Rampino & Bergamaschi., 2013). These case studies are representative of this sensory communication. They aimed to explore the potentialities and limits of the sensory language in comparison with the alphanumerical language largely used by digital interfaces. Moreover, in these previous studies (Colombo,

Rampino & Bergamaschi., 2013; Gorno, Colombo & Bergamaschi, 2013) emerged that designers apply the sensory language in an intuitive way and sometimes they are not conscious to design it. Industrial designers usually think and design physical feature in terms of usability of products, overlooking more 'soft' communication issues related to what a product says about itself, its functioning and feedback. Therefore, the richness of the materiality remain, for some aspects, unexplored and far from the practice of everyday design. For this reason, I believe research in this field is required to generate more knowledge to consciously design for sensory language.

OBJECTIVE

Moggridge (2007) claims that like films have taken more than one century to develop their spare language, likewise in the field of interaction design more investigations are due to find a way to merge the richness of all these languages: dialog, graphics, typography, 3D form, sound, film and animation. This research aims to be a tentative to transfer some properties of the 1-D language (such as the codified and the empirical usage of words) to the 3-D language based on the sensorial richness of the materiality of things in order to create another perspective for designing the sensory language.

THESIS OVERVIEW AND STRUCTURE

This PhD thesis investigates the possibilities of materiality as a medium to establish dialogues between the product and the user. For this reason, the first chapter aims to present the industrial design shift from the form to the dialogue over time made possible by the development of technologies and functional materials. Dialogues are based on language. Indeed, in this chapter, two kind of languages (apply to the verbal communication): the codified language and the empirical language are presented. The chapter 2 focused on the issue of product communication, and it is an overview of the potentialities and limits of the sensory language. In order to test the limits and the potentialities of codified and empirical language based on dynamic sensory features of industrial products the Chapter 3 explores the field of resources conservation. This field of application have disclosed some opportunities for such languages. Studies have demonstrated the importance to establish dialogues between the product and the user with the aim of informing and motivating users to change their behavior in order to be make sustainable choices in their daily life. Chapter 4 aims to present the hypothesis and the research questions of this research. Chapter 5 illustrates the methodology followed in order to answer the research questions. In detailed the study is carried on literature review, design

experiment and user tests. Chapter 6 and 7 presents and discuss two design activities aimed to apply the codified and the empirical languages. Finally, these projects have been explored by focus groups with potentials users. The findings and the process of focus groups are discussed in the Chapter 8. Concluding remarks are highlighted in Chapter 9, where the main contribution of the work is underlined, together with the open issues and future developments.

RELATED PUBBLISHES WORKS

Journal Paper

BERGAMASCHI, S., LEFEBVRE E., COLOMBO S., DEL CURTO B., RAMPINO L.; Material and immaterial: new product experience; The International Journal of Designed Objects, Volume 10, Issue 1, March, 2016, pp.11-22. Article: Print (Spiral Bound). Published Online: January 8, 2016**.**

Essay in a book

BERGAMASCHI, S.; Dynamic products: progettare nuovi dialoghi e nuove esperienze per favorire il risparmio di risorse; In Raimonda Riccini (a cura di), Fare ricerca in design. Forum nazionale dei dottorati di ricerca in design, Il Poligrafo, Padova 2016. ISBN 978-88-7115-976-8

Conference proceedings

BERGAMASCHI S., COLOMBO, S., RAMPINO L.; Educational Experience In Interaction Design: A Case Study. In the proceedings of the conference INTED 2016.

BERGAMASCHI, S., RAMPINO L., COLOMBO S.; Engaging users through dynamic products for promoting water saving in a domestic environment. In the proceedings of Cumulus Mumbai 2015.

BERGAMASCHI, S., LEFEBVRE E., COLOMBO S., DEL CURTO B.; Implemented design & engineering students skills through stimuli-responsive materials knowledge. In the proceedings of the conference EDULEARN15

BERGAMASCHI, S., COLOMBO S., RAMPINO L.; Teaching design & engineering students how to create pleasurable experiences through designing interactions with products. Abstract in the proceedings of the conference EDULEARN15

BERGAMASCHI, S.; Dynamic Products: an instrument for saving resources. Improve user's awareness through designing product experiences. In the proceedings of ICED2015.

GORNO, R., COLOMBO, S., BERGAMASCHI, S.; Enhancing product sensory experience: cultural tools for design education; E&PDE conference 2013, 5-6 September 2013.

COLOMBO, S., RAMPINO, L., BERGAMASCHI, S.; What are you telling me? How objects communicate through dynamic features; xCoAx 2013 conference, 27- 28 giugno 2013

v**Paper- Abstract accepted at conferences:**

BERGAMASCHI S., RAMPINO L.; Designing material interaction to Promote water saving. An

exploration of sensory language, Design for Next, Rome, 12-14 April, 2017.

BERGAMASCHI S., van DIJK J.; F.E.E.L.: Promoting Sustainable Behaviour Through Material Interactive Coupling, STS conference November 2016, Trento.

BERGAMASCHI S., COLOMBO, S., RAMPINO L.; Save Food. Designing artifacts that make users aware, paper accepted for the proceedings of the conference Understanding Food Design Conference, Milano, 8-9 ottobre 2015. (in press)

1. THE INTERACTION AS A DIALOGUE

INDUSTRIAL DESIGN: SHIFT FROM FORM TO INTERACTION

Conventionally, Design was born within the industrial revolution which defined it in relation to the mass production of goods. At the beginning of the industrial revolution, designers were commissioned to contribute on the aesthetics of industrial artifacts. In that period, design was also defined as art for industries and the designer was considered as an artist appointed to give shape to technology and to innovative products that has been developed by new industries. Against this idea of the design-artist, the slogan "Form Follows Function" was created. This movement was against ornament, decoration, and natural form. It promoted the creation of a new aesthetics linked to the industrial world more than recreate shapes linked to artisanship. At the beginning of the XX century, the Bauhaus school promoted geometrical and abstract forms designed to answer to the new needs of people and industrialized society. In this period, design becomes not only a matter of giving shape to objects but it was focused on ways of use and ways of living. Moving design closer to the issue of how object are used, designers started to investigate how a given design invites potential users to interpret its form; design faced disciplines like semiotic and semantic. As soon as the discussion about design came near to the notion of users, it became relevant to investigate their reactions, their experiences and the way they create meanings from the form of the object (Redstrom, 2006). Kazmierczak (2003, p. 45):

The position presented here redirects the perceived ground for design away from objects themselves, as independent from mind, toward the conceptual characteristics these object embody as a means for communication. It redefines designs from finite, fixed objects of aesthetic and practical consideration to semiotic interfaces enabling the reconstruction of meaning by receivers.

Following this evolution, objects can be seen as a medium for designers to convey meaning and messages that have to be interpreted and understood by the users:

The designer communicates by means of the product sign. The industrial designer should make a sign as clear and unequivocal as possible, so that the target group understands the message (Mono¨ , 1997, p. 51).

This idea enrich the role of the designer. The designer is not just someone able to shape things, but who is able to shape the perception of the users. During this evolution, the design move more closed to users growing in to a discipline related to the correspondence between product and user which is not only functional but it can be also linked to the status symbol of the users. Indeed, design tries to be more than a communication process, in which users decode messages that are conveyed through products,, it start to refer to the user's experience:

It is now becoming clear, in view of the large number of award-winning designs that have failed the test of use, that the design community's criteria for successful design differs radically from that of design users.. design itself needs to be redefined in terms of peoples' experiences, instead of in terms of objects. This static geometrical criteria of the design of the industrial era must be abandoned in favor of a focus on the dynamic, multisensory experiences of design users. (1993, p. 131) Mitchell (1993, p. xxiii)

Mitchell, point out the importance to address the multisensory experience that means that not only design the shape but also other senses (such as smell, touch, feelings, etc...) have to be considered during the design process. To enrich the product's experience and the ability of artifacts to establish riches dialogues, industrial design field faced the field of digital interfaces. After the evolution of computer, products that traditionally were mechanic were implemented with electronical system, like the telephone or the thermometer. The extreme of this evolution was the tendency to transfer the material qualities to the virtual world. Negroponte talked about the transition from atoms to bits exploring the tendency to dematerialize items that are typically physical. For instance a black and white photo can be virtually represented with bits: colors are represented by a series of "0" and "1" (the binary code). (Negroponte, 1995). He made also a step further, he envisioned the ability of computer to disappear, to become invisible, and integrate into clothes and even in food. (Negroponte, 1995).

Shortly after, Ishii introduced the notion of Tangible bits and he is became the father of Tangible Interaction (TI). TI is based on the idea of making bits physical and manipulable, that means that data can be connected with object and surfaces becominggraspable and directly controlled by hands and gesture. *"The entire world*

could become an interface". (Shaer and Hornecker, 2010)

Reconciling the division between physical and digital means not only crafting metaphorical relations, like GUIs, nor even enabling physical analogues for digital information, like TUIs [9, 11, 12] Complementing these approaches must be a design space for broadly imagining what kinds of new materials and relations between materials are possible at a range of depths—from interface to structure—and at a variety of scales—from objects to architectures. (Robles, E., & Wiberg, M. , 2010)

Thanks to the development, the diffusion of functional materials, and the miniaturization of electronics, processors and sensors, designers have more possibilities to design with the materiality of objects. This new materiality make products smart, dynamic, and interactive. Recent studies talked about the fourth dimension of products: the time (Vallgarda, 2009). These products are able to behave and to respond to the situation (the users, the environment or others external or internal condition). Thus*, "a domain which was once considered pure industrial design is faced with many interaction design challenges" (Djajadiningrat et al., 2004).*

INTERACTION AS A DIALOGUE

"An interaction is a transaction between two entities, typically an exchange of information" Saffer, 2009

According to Saffer, an interaction is an exchange of information between two subjects that can be two humans or the users and the product. The important aspect of interaction is that both the subjects have to be reactive and responsive to each other. Indeed, if we have a look on the dictionary interaction is defined as "*an occasion when two or more people or things communicate with or react to each other*" (http://dictionary.cambridge.org/dictionary/english/interaction).

This research aims to explore the interaction between user and the product. I assume that users and products can be related each other in a circle of influences: for instance, the object with its material features (such as shape, weight, color, and etc…) can affect the user's behaviors and thoughts, and vice versa.

There is the tendency to believe that interaction design born at the beginning of 1990 when Bill Moggriedge defined it. However, we can talk about interaction design since American Indians (or other tribal population) have built a system of communication like smoke signals, or Celts who used mound of stones "*carin*" to communicate over time (Saffer, 2007). The idea of interactive objects became relevant with the development of the computer science and the information technologies

that permitted to enrich the communicative content within the interaction. At this point, the definition of interaction design can be enrich; as Saffer claims quoting (https://www.quora.com/What-is-the-best-definition-of-interaction-design) Jodi Forlizzi and Robert Reimann in their 1999 presentation "Interaction Designers: What we are, what we do, & what we need to know,"* that interaction design is about "defining the behavior of artifacts, environments, and systems (for example, products)." This view focuses on functionality and feedback: how products behave and provide feedback based on what the people engaged with them are doing.

The concept of the transaction between two entities in an interactive relationship and the idea of having an exchange of information over time is also visible in the dialogue. Looking up "dialogue" on the dictionary it is defined as *"A conversation between two or more people"* (Oxford English Dictionary, 2016)). To converse means *"talk between two or more people in which thoughts, feelings, and ideas are expressed, questions are asked and answered, or news and information is exchanged"* (Cambridge, English Dictionary, 2016). Into these definitions it possible to find some correspondence between interaction and dialogue. Both require two actors who are in touch for sharing something. Typically, they share information but also it is possible to enrich this relationship with emotional factors (like feelings) and personal point of view (like thoughts and ideas). This sharing create a cycle of correspondences between actions and responses that is inherent to the human use of artifacts.

"L'interaction design possiede un comportamento temporale dialogico. Con questo intendo un dialogo umano, non nel senso di usare un linguaggio comune, ma nel senso di pensare a questi termini la sequenza e il flusso delle interazioni." Intervista con terry winograd, p.77 Preece, J., Rogers, Y., & Sharp, H. (2004). Interaction design. Apogeo Editore.

Going back to the field of interaction design, the word dialogue is quite common talking about the communication process between humans and computers. For example we are familiar with the terms dialog box, which is "a temporary window an application creates to retrieve user input. An application typically uses dialog boxes to prompt the user for additional information for menu items." (https://msdn.microsoft.com/it-it/library/windows/desktop/ms632588(v=vs.85).aspx). These tools establish dialogue with the users through 2d screens that use an alphanumerical language instead of exploring the richness of the material word. Thus, I want to investigate if it is possible to recreate this circle of correspondence using the

materiality of artifacts in order to bring back product's dialogues in the sphere of knowledge of industrial designer who traditionally works with material features of artifacts (such as shape, color, light, sound, etc...)

LANGUAGE AS THE BASE OF THE DIALOGUE

Nowadays, design becomes a matter of using the right language to generate a dialogue about the functionality, intended use of the object and to generate thoughts and meanings in the user's mind (Redstrom, 2006).

Dialogue, as a way for sharing ideas and information, require a common basis: the language. Language is defined as *the method of human communication, either spoken or written, consisting of the use of words in a structured and conventional way* (http://www.oxforddictionaries.com/definition/english/language). According to this definition clear dialogues have to be based on a set of rules and conventions. Discipline such as philosophy explored the role of language in human beings. Particularly philosophy defines language as a process, not merely for transferring information or sharing contents, to understand the surrounding world and ourselves. Language is not seen just a cognition process but it also involves our body to create knowledge:

"Languaging, acting, and perceiving are inseparably tied to constructive understanding. Language is the primary source of conceptions. It also presupposes the bodily participation of human beings. Language is spoken, written and communicated. It is a condition for understanding oneself as human being, understanding the understanding of other beings, and enacting this understanding in the face of one's understanding of others' understanding of reality." (Krippendorff, 2005 pp. 20- 21).

The Greeks, Plato in particular, gave importance to the language as the base of dialogue that was considered the only tool to establish truths. For Plato, language was a container of propositions not connected to observations but to a world of ideal types behind mere appearances. Modern philosopher, such as Karl Marx, Immanuel Kant or Bertrand Russell, put the human mind in the center of their theorizing. In 1953, Ludwig Wittgenstein claimed that "the meaning of words and utterances are not found in what they represent but in how they are used." *(Krippendorff, 2005,*

p. 21)

Language is not anymore the representation of the truth but it can be transformed and re-arranged according to intentions and situation.

Contemporary, Merleau-Ponty talked about the distinction between "langage parlè" e "langage parlant":

"le langage parlé, that is, the sedimented, spoken language that a priori establishes a relation between the signifier and signified, and le langage parlant, that makes itself in its practice. This is not defined by sedimented elements of an already constituted language. Laws, conventions and established meanings do not bind it." (Marti, http://alexandria.tue.nl/extra2/redes/marti2014.pdf)

Particularly, the *langage parlè* is the everyday language that we use for communicating with other people, for example when we write an email or simpler when we go to the supermarket and ask for goods to the shop assistant; the *langage parlant* is the language of art and poetry and it is strictly connected to the creative sphere.

In this research, this distinction of this two kind of language is explored with the aim to find out new possibilities for designer to design interactions able to effect experiences that are meaningful for the user.

From Language Parlé And Langage Parlant To Codified Language And Empirical Language

Merleau-Ponty, starting from the Phenomenology, assumed that the word is an appropriation of thought that become real and evident. Against assumptions of Descartes, He claimed that the mind and the body are not two separated entities. They cooperate in the creation of meanings. In this idea, poetry and painting are evidences of the creative expression in which what is not already clear in your mind becomes a real form of expression. Thus, the meaning of word are not in the word itself.

Merleau-Ponty distinguished two kind of language: the *langage parlè* e *parlant.* The first language is based on the registration of established meanings. Thus, it is based on originals verbal expression generated in specific situation and experienced by specific subjects. This circle, that refers to establish meanings. made possible the communication among people. The *langage parlant* is an intentional form of expression that actualize in words the experiences lived by the subject. This kind of language (compared to the previous one) can be considered as a novelty of expression that create individual meanings. For this reason it is considered the

poetic and artistic language.

Guided by the ideas of Merleau-Ponty, this research talks about codified language and empirical language as a new opportunity to create dialogues between the product and the user. Codified language refers to *langage parle*, it is a form of expression based on conventions, symbols and codes that can be share by a group of person. This language can be applied to establish dialogues in which the content of the information have to be clear and not misunderstood. For example the traffic light with three colors inform user about her/his possibility to cross the street.

Empirical language refers to langage parlant. In this form of expression the content of dialogue is not established by the designer, but the meanings are created by the user during the interaction with the product. Thus, the role of the designer is to design the experience and the meaningful interaction between the product and the user. Empirical language can be used to create meaningful and individual product experiences like in the artistic and poetic field.

it is now recognized that the humanist and the artist can also enlarge human understanding and that the very phenomena that eludes literal meaning is often revealed by poetic statement and by visual image. (Eisner, 1998, p. 101)

FINAL REMARKS

This research is based on the idea that the interaction between users and products can be seen as a dialogue between them, a dialogue that is able to grow over time and to influence the user and the product's behavior. Both actors (the user and the product) are able to transfer and receive information, influence feelings and thoughts in relation to each other. The creation of this user-product dialogue (able to evolve over time) is possible thanks to the progress in the field of computing technologies and the development of functional materials that give more capabilities to products in terms of: responsiveness, intelligence and ability to adapt to the surrounding (environment, users and context in general).

Dialogues are based on language. Indeed, this research is an attempt to transfer the *codified* and the *empirical* usage of words typical of the 1-D language to a 3-D language based on the sensorial richness of materiality, here defined as sensory language. The aim is to create novel perspectives for designing meaningful and engaging interactions, intended as a dialogue between the user and the product.

References

Cambridge english dictionary, 2016, “to converse” http://dictionary.cambridge.org/dictionary/english/conversation

Colombo S., Djajadiningrat T., Rampino L. ; Tangible, Smart and Dynamic Objects. How the New Aesthetics Affects Meaning and Experience; introduction at the proceedings of DesForM 2015

Djajadiningrat, T., Wensveen, S., Frens, J., & Overbeeke, K. (2004). Tangible products: redressing the balance between appearance and action. Personal and Ubiquitous Computing, 8(5), 294-309.

https://www.quora.com/What-is-the-best-definition-of-interaction-design retrivered 10.08.2016

Krippendorff, K. (2005). The semantic turn: A new foundation for design. Boca Raton: Taylor & Francis.

Marti P. http://alexandria.tue.nl/extra2/redes/marti2014.pdf

Marti P. The Subtle Body. Eindhoven, Eindhoven Technical University Library, 2014.

Merleau-Ponty M.. Eye and Mind. The Primacy of Perception. Northwestern UP, 1964, Ed. James E. Edie. Trans. Carleton Dallery. Evanston, pp. 159-190.

Moggridge, B., & Atkinson, B. (2007). Designing interactions (Vol. 14). Cambridge, MA: MIT press.

Negroponte, N., Filippazzi, F., & Filippazzi, G. (1995). Essere digitali. Milano: Sperling & Kupfer.

Oxford English dictionary, 2016, “Conversation”: http://www.oxforddictionaries.com/definition/english/dialogue

Philip L. E. Merleau-ponty and the Phenomenology of Language. Yale French Studies, no. 36/37. Yale University Press: 19–40.

Preece, J., Rogers, Y., & Sharp, H. (2004). Interaction design. Apogeo Editore.

Prentice, R. (2000). The place of practical knowledge in research in art and design education. Teaching in Higher Education, 5(4), 521-534.

Redström, J. (2006). Towards user design? On the shift from object to user as the subject of design. Design studies, 27(2), 123-139.

Robles, E., & Wiberg, M. (2010, January). Texturing the material turn in interaction design. In Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction (pp. 137-144). ACM.) Wiberg, M., & Robles, E. (2010). Computational compositions: Aesthetics, materials, and interaction design. International Journal of Design, 4(2)

Saffer, D. (2007). Design dell’interazione. Creare applicazioni intelligenti e dispositivi ingegnosi con l›interaction design. Pearson Italia Spa.

Saffer, D. (2009). Designing for interaction: Creating innovative applications and devices (voices that matter).

Shaer, O., & Hornecker, E. (2010). Tangible user interfaces: past, present, and future directions. Foundations and Trends in Human-Computer Interaction, 3(1–2), 1-137.

2. ESTABLISH DIALOGUES TROUGH MATERIALITY: THE CONTRIBUTION OF INDUSTRIAL DESIGN

INTRODUCTION

Industrial design is, traditionally, considered a discipline that works on the shape and the appearance of artifacts. The designer works with colors, forms, weight, lights, sound etc all material properties in order to create the desired product experience. Disciplines, out of the design field, have investigated how all these product properties are able to influence the user's perception and action. Product semantics explored how meanings can be conveyed by the product appearance. Product semantics has been defined as a systemic study of the meanings that emerge during human interaction with objects (krippendorff and Butter, 1984) or a vocabulary and methodology that can be used to design objects in view of meanings the users will attribute to them. Product semantics explores the "product language". Designer are able to convey meanings and information designing the appearance of artifacts, for example, a handle communicate how it can be grasp or a car with its shape, colors etc. can express the idea of fastness. However, messages conveyed through the materiality of object are "static" they are not able to evolve over time. The invention of computers brought new possibilities to industrial design. With small digital screen on the product surface designers have been able to enrich the communicative intent, and to convey information adaptable to the context and the use. However, computer lost the tangibility, the richness and the multisensoriality of physical and tangible material. At the beginning, it was focused on virtual and digital interfaces. Digital screens became tools to communicate with users, which were able to transmit more complex and univocal information, since they were based on the verbal language. Some studies (Fitzmaurice, Ishii, & Buxton, , 1995; Ishii & Ullmer, 1997; Holmquist, Schmidt, & Ullmer, 2004) have found these virtual and digital interfaces too limited and have invented other forms of interaction whit the aim to involve a larger part of the human sensory apparatus. These investigations brought to develop new materials (that are implemented with sensors and electronics) that can hybrid the richness of materiality (in terms of sensory stimulation) and the richness of computer (in terms of dynamicity and responsibility). These materials have been defined as computational composites (Vallgårda, 2013; Vallgårda, and Redström, 2007). Computational composite have four main properties: reversibility, accumulation, computed causality, and connect

ability.

This chapter wants to be an overview of what traditionally product designers means as "convey meanings through the materiality of products". This chapter takes into consideration studies from different disciplines, such as the semantic field. Moreover, in this chapter the materiality is explored by two point of view: static and dynamic. Since, materiality can be static (that is not able to change over time) or dynamic (that is able to adapt itself according to certain situation and return to an initial phase).

ESTABLISH DIALOGUE THROUGH PRODUCTS

The product itself with its features can transmit several information or meanings through its appearance. For example if one is looking a car he first recognize the category of the object observed (e.g. "it is a car", than looking to its appearance one can recognize when it is designed (e.g. it is from the 90s); it's cost (e.g. it is an expensive car); its brand (e.g. Volkswagen); and then its performances (e.g. it is a sporty car). With its appearance, the product can transmit two different kind of messages (Colombo, 2016):

- Intrinsic information, which refer to the product mode of use, its functionality and its character.
- Extrinsic information, which refers to situations or phenomena that are external to the product itself, and that refer to events that transform over time (like the temperature of a room, the person's biometric parameters, the stock exchange oscillations, and so on).

Intrinsic information can be considered static since they do not change, substantially, during the product's life. Instead, the second kind of information can be considered dynamic, since they refer to something external to the product that can change over time. For example the temperature communicate by a thermometer.

Intrinsic and extrinsic information can be conveyed through products by three main channel (as krippendorff and Butter, 1984):

- information displays
- graphic elements fixed to product surface
- product form, shape and texture

This elements use two kind of languages the alphanumerical language and the sensory language. The sensory language is tied to the product's materiality since

it is based on sensory properties of artifact. That means that objects are able to send messages to users using their visual, tactile, auditory, olfactory and gustatory features. Sensory language is implicit since it is not based on conventions that make the message univocal (Colombo, 2016). The sensory language, also called "product language" (Gros, 1984; Steffen, 2010). That was describe by Ellinger as:

"Product language includes very heterogeneous forms of expression such as dimension, form, structure of the physical surface, movement, quality of material, means of fulfilling function, colors, and the graphic design of the surface, sounds and tones, taste, smell, temperature" from the book "theory and practice" by Bernhard E. Bürdek p.285

On the contrary, information displays and graphic elements can enrich their communicative content using the alphanumerical language based on words and numbers. Moreover, the dynamicity of displays can give to products the possibility to convey changeable and extrinsic information. Once again, we are at the boundaries between products and technologies, between industrial design and interaction design. Thus, an overview about the languages adopted by interaction design is due to better understand how the sensory languages (strictly connected to industrial design) can be merge with the languages used in the filed of interaction design to create new opportunities for interactive products.

Moggridge (2007) categorized four languages (in the interaction design field) according to their "dimensions": 1-D, 2-D, 3-D and 4-D.

The 1-D language includes words and poetry. It is the language used in the dialogue boxes of computer systems. This kind of language show some limits such as: "are the words in a menu the most accurate encapsulations of the action they denote? Are they too abrupt and imperious, or too cloyingly conversational?

The 2-D languages refers to painting, typography, diagrams, and icons. This language is typically used in the artistic field. This language can make the message more clear and more engaging. Computer interfaces used the 2D language in the icons, that are simplified images that stand for a larger idea of things.

The 3-D languages refers to physical and sculptural form. As presented in the next paragraphs, this language is typical of industrial design. This language of form and appearance is largely explored in the "product semantic". Designers use this language to make thing clear (if there is an handle, we are meant to grab it), but sometimes also to play with expectations that when they are avoided can raise surprise in the user.

The 4-D languages include sound, film, and animation. Moggridge (2007) compares

this language with films that have can put together all these factors to create a complex story that can be understood by every one.

Convey information through sensory static features

"The product can possess a multi-layered, […] which is far more comprehensive than normal verbal language." Theodor Ellinger (1966), from the book Theory and practice by Bernhard E. Bürdek, p.285.

Product form has always been considered as a communication means: products convey messages to users through their sensory properties (visual, tactile, auditory, etc.). For product form I mean both tangible quality like three-dimentional shape of the product itself, it is material property (color, texture, weight etc.) and a sort of intangible qualities like sound, smell, light. As Vallgårda (2014) pointed out: "The notion of physical refers more to what we can perceive through the human sensory apparatus than anything solely tangible." Desmet (2012) also defined product form as product appearance. Product appearance can convey several messages and meanings (Crilly et al., 2004; Demirbilek & Sener, 2003; Ehrnberger, Räsänen, & Ilstedt, 2012; Krippendorff, 2005; Norman, 2002; Salvendy, 2012; Creusen & Schoormans, 2005) such as:

- Functional and ergonomic: how product should be handle and use.
- Product personality: e.g. the product gender or character
- Semantic interpretation: describe the proportion of the product's value that is attributed to its utility. It refer to how the product appearance makes sense to the viewer in respect to the consumer's personal, cultural and sensory experience.

Symbolic association : the ability of a product's appearance to communicate messages, like luxury, richness, friendly, expensive, rude or the association to a certain social group.

Products can trigger three kind of resposnses: cognitive, emotional, and hedonic (Schifferstein & Hekkert, 2011).

Cognitive responses refer to the assignment of a particular meaning through product physical features, like a language the signifier and meaning are linked, and the user must interpret the sign to disclose the sense. Firstly, the user who perceives the product features understand the product (this process is called Semantic interpretation), and then associate it to personal or social significances (Symbolic association) (Crilly et al. 2004).

Hedonic response refers to the perception of pleasant or unpleasant feelings. Pleasure can arise from different elements of the product: product sensory features, functionality, social potential, or symbolic values (Colombo, 2016). Pleasure can be trigger primarily by product's sensory features. The materiality of products may stimulate one or more sensory modalities, generating pleasant sensations (Desmet and Hekkert, 2007; Norman, 2005; Ramachandran, 1999). However, pleasure is not just connected to sensory perception. Jordan, (1992; 1997; 2000), identifies other classes of pleasure aroused by products:

- psycho-pleasure (e.g. interacting with a usable, ergonomic and functional product, which conveys perceptible affordances, can be a source of pleasure),
- socio-pleasure (it emerges as a result of the evaluation of the stimulus according to its ability to strengthen or weaken interpersonal relationships; it is also connected to how the product can affect the social position of its owner),
- and ideo-pleasure (results from a reflection over the meanings or values carried by the product).

Emotions are the last response. During the interaction with products users create a wide range of emotions, connected to product appearances, functions, behaviors and associated meanings (Desmet, 2003). Desmet (2003) proposes a classification of the emotions elicited by products. He has created five categories: surprise, instrumental, aesthetic, social and interest emotions. Moreover, scholars divided emotions as the result of the cognitive process or as automatic reactions. Desmet and Hekkert (2007) affirm, "an emotion is thus the result of a cognitive, though often automatic and unconscious, process". On the contrary, Picard (1997) claims that, according to Damasio's theory on primary emotions, "there are certain features or stimuli in the world that we respond to emotionally first, and which activate a corresponding set of feelings (and cognitive state) secondarily". Therefore, there are two kinds of emotion. One is uncontrollable, visceral and primitive, and is connected to the mere perception of basic sensory stimuli in the environment (thus also to product sensory features). The other one stems from the cognitive elaborations of the stimulus, its recognition, interpretation, and the associated symbolic value. Such cognitive processes give rise to what is called "secondary" emotion.

These three responses to product features (cognitive, affective and hedonic) are interrelated and mutually affect each other. According to Crilly et al. (2004), they all are at stake in the communication process, because they compose the overall

psychological user response to the product, which is followed by the behavioral reaction (i.e. the action the user takes as a result of the communication process).

Convey information through sensory changeable features

"Every material change over time, but in this case the change comes from within and is not necessarily a consequence of the surrounding environment, just as the change may be reversible it is not decay; it is active behavior"

Vallgarda & Sokoler, 2010

Thanks to the hybridization of computers and traditional materials (defined by Vallgarda, (2013) as computational composite) and the diffusion of functional material (such as shape memory materials, thermochromics materials, piezoelectricity etc.), sensory properties (shape, colour, sound, smell, texture, surface, etc.) of artifacts can be transformed over time, becoming dynamic (e.g. a kettle which indicates that water is boiling by showing a texture on its surface. Fig.1).

Fig. 1 One by Vessel Ideation is a kettle that uses a thermochromic ink to tell the user when the water boils, by a texture appearing on the surface.

Nature is filled with beautiful examples: tomatoes change their color according their ripening, people blush in embarrassing situation,… these natural changes are consequences of something else: tomatoes becoming red to communicate that they

can be eaten, blushed cheeks give information about the emotional state of a person.

Nowadays, products can be designed to change some of their features to create more engaging dialogues based on the sensory language.

In recent years studies explored changeable features in products calling them temporal form (Vallgarda, 2015) or dynamic products (Colombo).

Temporal form (in interaction design) is the pattern of the state changes that computer will produce. (Vallgarda, 2015)

Dynamic products are artefacts showing dynamic sensory features that change proactively and in a reversible manner over time, activating one or more user's sensory modalities." (Colombo, 2014)

The first definition bordering the interest of this changeable materials in the computational field that means that at the base of the changes there are processors, such as: Arduino, Lilypad, Rasberry and so on. An example can be Plank (Vallgarda, 2013). PLANK is composed by pine planks (each board is 2m long and 8mm thin) a microphone, a motor, a contraction structure, and an Arduino board. PLANK translates the sound waves into a weave (a central bend) that gradually builds up in the PLANK. When silent, the PLANKS return to its outset independent on how far out it got.

The definition of dynamic products is more general on the point of view of technologies that allowed the changes and talk about dynamic sensory features as the base for such products.

In this research, I explore the sensory dynamic features as physical qualities (e.i. light, sound, texture, weight, shape, etc.) that change proactively and in a reverse manner over time, which actively transform artifacts appearance in response to either external stimuli, users' interactions or automatic pre-programmed schemes. These changes can be based on both processors and functional materials.

From the product design point of view, the possibility to create dynamic features gives to designers additional material to work with:

Designing such products and systems requires an aesthetic that goes beyond traditional static form aspects. It requires a new language of form that incorporates the dynamics of behavior (Ross and Wensveen 2010).

As pointed out by Ross and Wensveen, designer must to reason up this new aesthetics in order to explore dynamic features as a new language. Few studies explored the potentiality of this dynamic sensory features as a new way to communicate with users, (Colombo, 2016, Colombo at al. 2013, Colombo &

Rampino, 2013) dynamic sensory features can be a language through which it is possible to convey information and messages to users in a more intuitive and less conventional way than using verbal and iconic language. The advantage is that the communication, even if less complex, can become more engaging for users, and the interaction with products more pleasurable. Tests with users have demonstrated that the emotional content of these dynamic products seems to be very high and stems from their capacity to surprise and delight users' senses (Colombo, 2014: Vallgarda, 2015).

Ambient display: physical environment as an information display

A suitable example of information conveyed through the materiality and the physical space are in the field of HCI, which developed ambient display.

Ambient display use the physical environment that surrounding the user for the interaction between the user and the system.

"information is moved off the screen into the physical environment, manifesting itself as subtle changes in form, movement, sound, color, smell, temperature, or light" (Wisneski et al., 1998).

Nature is filled with subtle, beautiful and expressive ambient displays that engage each of our senses. The sounds of rain and the feeling of warm wind on our cheeks help us understand and enjoy the weather even as we engage in other activities. Similarly, we are aware of the activity of neighbors through passing sounds and shadows at the periphery of our attention. Cues like an open door or lights in an office help us subconsciously understand the activities of other people and communicate our own activity and availability.

Ambient display shows digital information through subtle changes in the user's physical environment such as variations of light, sounds, or movements. They capture natural interactions of the user with physical devices such as switches, buttons, or wheels and translate them into digital commands (Gross, 2002; Gross, 2003:Wisneski et al., 1998). Usually, the information which wants to be conveyed by these systems is related to events like human presence in a room or to "natural phenomena, such as atmospheric, astronomical, or geographical events" (Wisneski et al., 1998).

Ambient display can be considered as inspirational of this research with the industrial design perspective.

FINAL REMARKS

Product language, based on product sensory features, plays an important role during the interaction with products. Even if sensory language is able to convey several information, the interpretation of product sensory features cannot be univocal, as

above stated, but it make sense within groups of people belonging to the same culture or to the same historical period (Crilly et al., 2004). As Fernaeus et al. (2008), quoting Schutz (1967), state:

"Schutz provides an explanation to our ability to share understanding based on the fact that we share a common life world. We can thus assume that other persons have got similar experiences as ourselves, and thus will make sense of certain phenomena in a similar way as we do. Inter-subjective sense making is also an activity that takes place over time. By interacting with each other and sharing a common environment we create common experiences that makes it easier for us to communicate and agree on the meaning of symbols and language that is meant to describe properties of the world." (Fernaeus, Tholander, & Jonsson, 2008)

Designers can create a sharable and common sensory language among certain group of people only if those people share experiences and common environments. Other interesting point is that this implicit language creates meanings in users through the interaction and over time. This idea is at the bases of the presented empirical language that emphasize the creation of those meanings through personal and individual experiences.

Exploring languages in the interaction design field is an issue also for Moggridge (2007), who stated:

After twenty years of drawing on existing expressive languages, we now need to develop an independent language of interaction with "smart systems and devices". Moggridge, 2007, pag. XVIII

This assumption motivates this research to explore the issue of language and to contribute to find out other inspirations for product designers who want to design novel form of dialogue between users and products. I assume that is can be possible exploring unusual possibilities offered by the new materiality of things.

References

Bürdek, B. E. (2005). Design: History, theory and practice of product design. Walter de Gruyter.

Colombo, S. (2016). Dynamic Products: Shaping Information to Engage and Persuade. Springer.

Colombo, S., Rampino, L., & Bergamaschi, S. (2013). What Are You Telling Me? How Objects Communicate Through Dynamic Features. xCoAx2013, 129.

Colombo, S., Rampino, L. (2013) Beyond Screens. Exploring product dynamic features as communication means. DeSForM 2013

Crilly, N., Good, D., Matravers, D., & Clarkson, P. J. (2008). Design as communication: Exploring the validity and utility of relating intention to interpretation. Design Studies, 29(5), 425-457. doi:http://dx.doi.org/10.1016/j.destud.2008.05.002

Crilly, N., Moultrie, J., & Clarkson, P. J. (2004). Seeing things: Consumer response to the visual domain in product design. Design Studies, 25(6), 547-577. doi:http://dx.doi.org/10.1016/j.destud.2004.03.001

Demir, E., Desmet, P. M. A., & Hekkert, P. (2009). Appraisal patterns of emotions in human-product interaction. International Journal of Design, 3(2), 41-51.

Demirbilek, O., & Sener, B. (2003). Product design, semantics and emotional response. Ergonomics, 46(13-14), 1346-1360. doi:http://dx.doi.org/10.1080/00140130310001610874

Desmet, P. M. (2008). Product emotion. Product experience, 379-397.

Desmet, P. M. (2012). Faces of product pleasure: 25 positive emotions in human-product interactions. International Journal of Design, 6(2)

Desmet, P. M., & Hekkert, P. (2007). Framework of product experience. International Journal of Design, 1(1), 57-66

Desmet, P.M.A. (2003) Multilayered model of product emotions. The Design Journal, 6 (2), 4-11

Fernaeus, Y., Tholander, J., & Jonsson, M. (2008). Towards a new set of ideals: Consequences of the practice turn in tangible interaction. Proceedings of the 2nd International Conference on Tangible and Embedded Interaction, 223-230.

Fitzmaurice, G. W., Ishii, H., & Buxton, W. A. (1995). Bricks: Laying the foundations for graspable user interfaces. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 442-449.

Gros, J. (1984). Reporting progress through product language. Innovation, the Journal of the Industrial Designers, Society of America, , 10-11.

Gross, T. (2003). Ambient interfaces: design challenges and recommendations. Human computer interaction: theory and practice, 68-72.

Gross, T. (2002, Jan. 9-11). Ambient Interfaces in a Web-Based Theatre of Work. Proceedings of the Tenth

Euromicro Workshop on Parallel, Distributed, and Network-Based Processing - PDP 2002, Gran Canaria, Spain. 55-62.

Holmquist, L. E., Schmidt, A., & Ullmer, B. (2004). Tangible interfaces in perspective. Personal and Ubiquitous Computing, 8(5), 291-293.

Ishii, H. (2008). Tangible bits: Beyond pixels. Proceedings of the 2nd International Conference on Tangible and Embedded Interaction, xv-xxv.

Jordan P.W., (1997) Putting the pleasure into Products. Iee Review, Vol. 43, Issue 6, 249 – 252

Jordan, P.W. (2000) Designing Pleasurable Products, London, Taylor & Francis

Krippendorff, K. (1989). On the essential contexts of artifacts or on the proposition that "design is making sense (of things)". Design Issues, 5(2), 9-39.

Krippendorff, K. (2005). The semantic turn: A new foundation for design. Boca Raton: Taylor & Francis.

Krippendorff, K., & Butter, R. (1984). Product semantics: Exploring the symbolic qualities of form. Innovation: The Journal of the Industrial Designers Society of America, 3(2), 4-9.

Mahlke, S. (2007). Aesthetic and symbolic qualities as antecedents of overall judgements of interactive products. In People and computers XX—Engage (pp. 57-64). Springer London.

Moggridge, B., & Atkinson, B. (2007). Designing interactions (Vol. 14). Cambridge, MA: MIT press.

Norman, D. A. (2002). The design of everyday things Basic books.

Norman, D. A. (2005). Emotional design: Why we love (or hate) everyday things Basic books.

Picard, R. W. (1997). Affective Computing, Studies In Health Technology And Informatics, 136 (321), 292- 318, MIT Press.

Picard, R.(2000) Affective Computing. Cambridge, MA: The MIT Press.

Ramachandran, V., & Hirstein, W. (1999). The Science of Art. A Neurological Theory of Aesthetic Experience. Journal of Consciousness Studies, 6 (6-7), 15-51

Ross, P. R., & Wensveen, S. A. (2010). Designing behavior in interaction: Using aesthetic experience as a mechanism for design. International Journal of Design, 4(2).

Salvendy, G. (2012). Handbook of human factors and ergonomics, John Wiley &

Sons.

Schifferstein, H. N., & Hekkert, P. (2011). Product experience. Elsevier.

Schutz, A.The phenomenology of the social world. 1967.

Steffen, D. (2010). Design semantics of innovation. Product Language as a Reflection on Technical Innovation and Socio-Cultural Change. Department of Art and Design History, Bergische Universität Wuppertal, Germany.

Vallgårda, A. (2014). Giving form to computational things: developing a practice of interaction design. Personal and Ubiquitous Computing, 18(3), 577-592.

Vallgårda, A., & Redström, J. (2007, April). Computational composites. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 513-522). ACM.

Vallgårda, A., & Sokoler, T. (2010). A material strategy: Exploring material properties of computers.

Vallgarda, A., Winther, M., Mørch, N., & Vizer, E. E. (2015). Temporal form in interaction design. International Journal of Design, 9(3).

Weiser, M. (1991). The computer for the 21st century. Scientific American, 265(3), 94-104.

Weiser, M. (1993). Hot topics-ubiquitous computing. Computer, 26(10), 71-72.

Wensveen, S. A. G. (2005). A tangibility approach to affective interaction, Doctoral Thesis, TU Delft.

Wisneski, C., Ishii, H., Dahley, A., Gorbet, M., Brave, S., Ullmer, B., & Yarin, P. (1998, Feb. 25- 26). Ambient Displays: Turning Architectural Space into an Interface between People and Digital Information. Proceedings of the First International Workshop on Cooperative Buildings: Integrating Information, Organisation, and Architecture Workshop - CoBuild›98, Darmstadt, Germany.

3. DESIGN FOR SAVING RESOURCES: AN APPLICATION FIELD FOR THE CODIFIED (SENSORY) LANGUAGE AND THE EMPIRICAL (SENSORY) LANGUAGE

INTRODUCTION

In previous chapters, the relationship between design and dialogues is presented underlining limitations and possibilities of product sensory language. New materiality of things, like computational composites (Vallgårda, 2014; Vallgårda, and Redström, 2007), can enrich and overcome some limits of static sensory features of products (e.g. the difficulty to express extrinsic information and their inability to change over time). This new materiality makes products features: dynamic, responsive and adaptable to the situation. Therefore, nowadays product designers have new material opportunities to work on; and the industrial design field can be enriched with new forms of material interaction, novel ways to convey meanings, and new shape possibilities: indeed, products are able to establish over time dialogues with users based on their dynamic sensory features.

This research aims to explore if interactive products can establish dialogues based on sensory stimuli and how they can be designed according to codified and empirical languages. With the aim to add knowledge in the interaction design field. In this perspective, I have chosen to focus my research on a specific field to test the limits and the potentialities of codified and empirical language based in a real situation. As this chapter will present, the field of resources conservation have disclosed some opportunities for such languages. Studies have demonstrated the importance to establish dialogues between the product and the user (mainly through smart meter) with the aim of informing and motivating users to change their behavior in order to be make sustainable choices in their daily life. In this chapter an overview of the possible application of sensory language (codified or based on the experience) is presented.

THE IMPORTANCE TO SAVE FOOD ENERGY AND WATER

Water, food and electricity are fundamental for life and they are at the base of human progress. Nevertheless, such resources are mostly wasted in our daily life. A study of Italian householder carry out during Expo 2015 claims that food, water and electricity are perceived by interviewees as the most resources

wasted by humans (see fig.1).

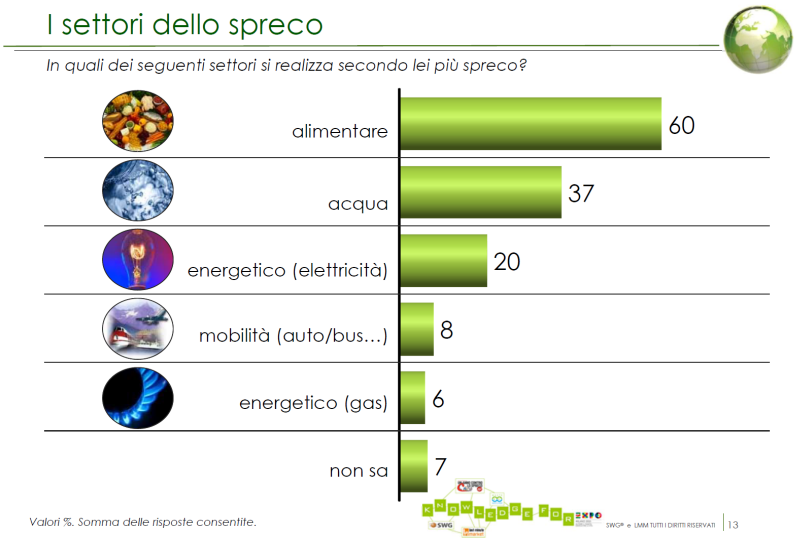


Figure 1. http://www.lastminutemarket.it/media_news/wp-content/uploads/2014/05/Knowledge-for-Expo-Rapporto-2014.pdf in the picture the results of Italian families.

These results motivate this research to focus only on these three resources. Indeed, it demonstrate that there is a common sense and awareness about food energy and water wastage, which are at the base of the user's motivation for changing his/her behaviors.

How much Food Energy and Water is wasted?

It is estimated that 8% of worldwide water is used for household purposes (WBCSD, 2009). The amount of water needed for basic household activities (i.e. cooking and cleaning, excluding gardening) has been estimated at around 50 liters per person per day (Gleick, 1996). But the real amount of water used in residential areas differs greatly region by region. The World Water Council declares that the highest use of water is in residential areas of North America and Japan where thedaily consumption of water is around 350 liters; followed by Europe, with 200 liters of water per person every day. At the other extreme, in the residential areas of Sub-Saharan Africa people use not more than 20 liters of water per day (WBCSD, 2009). The excessive use of water in the domestic context of developed Countries strongly depends on the users' behavior. In several circumstances, an improper behavior is one of the causes of the waste of such a precious resource.

Talking about food, the Institution of Mechanical Engineers claimed that four million tons of food were produced in 2012, of those, more than half was wasted (http://www.expo2015.org/magazine/it/economia/quanto-cibo-si-spreca-nel-mondo--in-europa-e-in-italia.html retrivered 9.11.2015).

It has been observed that, merely in Europe, every year89 million tons of food are wasted, 80% of which would be still consumable (European commission, 2010; Waste Watcher, 2014). Food is wasted at all stages of the food chain - from farm to fork, by producers, processors, retailers, caterers, and consumers. Several investigations were performed to better understand this phenomenon. British studies declare that 60% of domestic food waste can be avoided and this would allow families to save 565 € (on average) every year (http://www.lovefoodhatewaste.com/about_food_waste).

The domestic food waste is strictly related to the awareness and attitudes of individuals (http://www.expo2015.org/magazine/it/economia/quanto-cibo-si-spreca-nel-mondo--in-europa-e-in-italia.html retrivered 9.11.2015; European commission, 2010). In most cases, such wastage is due to the careless behaviors adopted by users: food left on plates, leftovers from cooking, bad advertising that encourage users to buy much more than the necessary, food that is not consumed in time (expired food), or food that is not conserved properly. (http://www.expo2015.org/magazine/it/economia/quanto-cibo-si-spreca-nel-mondo--in-europa-e-in-italia.html retrieved 9.11.2015; European commission, 2010).

Domestic electricity consumption is the second cause of waste in Europe, representing 27% of the all usage; whereas energy used for public transportations is 30% (Bertoldi and Atanasiu, 2009). As a paradox, lighting was the first service offered by electric utilities and it continues to be a major source of electricity consumption (Herring, 2006).

This research explores also the relationship between wastage and user's behaviors. The importance of user's behavior to prevent resources' wastage is underlined also by their definitions: *"Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behavior."* (Parfitt et al., 2010).

"*Energy conservation is reduced energy consumption through lower quality of energy services, […] Often it means doing without to save money or energy. It is strongly influenced by regulation, consumer behavior and lifestyle*

changes." (Herring, 2006).

Water conservation is "*Water management practices that improve the use of water resources to benefit people or the environment."* (Alberta Water Council's Water Conservation, 2007).

Thus, this research investigates how dialogues have to be set in order to lead users to change or adapt their behavior to save resources.

INFORMING USERS AS A STRATEGY FOR SAVING

In developed countries resources (such as food, energy and water) are quite obvious. As an example, a person just opens the faucet and water falls down as a continuous, endless flow. The same things happen to energy. Some studies investigate how to make such resources more visible and perceptible (Lockton et al., 2014; Backlund et al., 2007).

"with oil, you can see the level going down, piles of logs you see them going down but with electricity, you just don't realise how much you're using. I was blissfully unaware". Kidd, A., & Williams, P. (2008).

For this invisibility of such resources and the consequent user's unconsciousness, several studies (most of them carried out in the field of energy conservation) suggest to provide users with information about the amount of consumption to enhance consumer awareness and to encourage more sustainable behaviors (Darby, 2006; Darby, 2010; Fitzpatrick and Smith, 2009; Fischer, 2008).

The first study on the effectiveness of giving feedback about energy conservation was performed in the 1970 (Darby, 2006). For one week researchers gave feedback about the energy consumption writing on a post-it the amount of electricity used the day before and sticking it, each morning, on the kitchen's window of participants. As a result, researchers observed that informing householder about the amount of electricity consumed and related it to the ideal amount of daily energy consumption, helped users to change their behaviors.

In the last decades, thanks to the development and the diffusion of computers for domestic purposes, digital interfaces become the common way for giving feedback to users. Studies shows that in-home displays giving feedback on real-time and historic usage help users to understand and manage their electricity better, achieving savings in the range of 5–15% (Darby, 2006). Moreover it is demonstrate that such display have an enduring impact on users' behaviors. The information convey

through them lead householders to change habits and investment in efficiency measures (Darby, 2006; Rossini, 2009), even if only used for short periods.

Smart meters

The need of having an informing display evolved in the concept of smart meter defined as:

"Advanced meters that identify consumption in more detail than conventional meters and communicate via a network back to the utility for monitoring and billing purposes." (Climate Group, 2008, p. 85)

Taking the definition a little further, the literature shows general agreement that a fully smart meter is one that can (1) measure and store data at specified intervals, and (2) act as a node for two-way communications between supplier and consumer and automated meter management (Darby, 2010). The diffusion of smart metering systems has been a crucial issue for institutions. The European Union declares in Article 3 of a Directive 2009/72:

. . . customers are entitled to receive all relevant consumption data . . . to promote energy efficiency, Member States shall strongly recommend that electricity undertakings optimise the use of electricity, for example by providing energy management services, developing innovative pricing formulas, introducing intelligent metering systems or smart grids, where appropriate . . ..(European Commission, 2009)

As an example, UK government declared that most householders will have smart meters installed between 2016 and 2020 (GOV.UK, 2015). These smart meters are able to record consumption and communicate this to suppliers and consumers with the aim to manage resources in a more efficient way. Several country, like: Italy, Sweden, the Netherlands, the United Kingdom, Australia, Canada, California, and Northern Ireland, have already introduced smart meters into the domestic environment. Some of these system not only refer to energy consumption but also gas and water. This diffusion was also possible thanks to the European investments that found projects like SmartH2O (Fig. 2). SmartH2O is an ICT platform that aims to use information as a strategy:

- to raise the awareness of water consumers on their current water usage habits and their lifestyle implications and to stimulate them to reduce water use,

- to understand and model the consumers' current behavior, based on historical and real-time water usage data,
- to predict how the consumer behavior can be influenced by various water demand management policies: water savings campaigns, social awareness campaigns, to dynamic water pricing schemes. (http://smarth2o.deib.polimi.it)

Figure 2. SmartH2O. source: http://smarth2o.deib.polimi.it/wp-content/uploads/2014/04/flyer.png

Thanks to smart meters, suppliers receive a much more actual and accurate overview of energy consumption, that means that they are able to monitor and examine the energy use. Collecting these data, the grid operator can predict electricity flows more accurately and use this knowledge in network and maintenance planning (van Gerwen, et al., 2006). Users can benefit from these systems as they have direct feedback on the amount of their consumption leading them to be more aware about the consequence of their behaviors (in terms of resource used).

Yet, householders sometimes perceive smart meters as an invasion of privacy, and as an extra cost for families that have to pay for an unwelcoming piece of equipment (Darby, 2010).

Kidd and Williams (2008), in an in-depth study of ten Welsh householders, pointed out that 'understanding consumption is a tricky cognitive problem':

"Most people will not devote much time or effort to studying numbers and graphs and the drama of seeing consumption readings jump up and down in response to kettles and hairdryers can distract people from identifying appliances which contribute a larger load over a longer period of time." Kidd and Williams, 2008.

Moreover, in this study has been emerged that users are fascinating and attracting by the changes of the display itself instead of the numbers on the screen:

"In our trial, much of the impact which the smart meters had was a result of the eye-catching jumps in wattage when the user switches a device on or off. These have a shock element which stimulates behavioural change. Media reviews of other smart meters suggest this phenomenon is common (at least at the novelty stage)." Kidd and Williams, 2008.

Other ways to give feedback

"the majority of work on influencing energy use through behaviour change concentrates on numerical, visual feedback displays" Lockton, 2014.

Smart meters and digital displays have shown some influence on behavior, (Froehlich et al. , 2010, Kim et al. 2009; Darby, 2006) but a more detailed investigation shows that the situation is complex: numerical feedback may not take account of the realities of household life (Fogg, 2009; Lockton et al., 2014; Daae and Boks,2015) or people's understanding of units and quantities (Bowden, 2014), nor link people to wider understanding of the energy system (Niedderer et al., 2014). Another limit of visual displays is that they require the householder to look at the display (often a small LCD, or a web page) regularly, to understand the consumption trend. To overcome such limits, studies (carried out in different domain, such as: interaction design, aesthetics of interaction, ambient display, and visualization of data) have explored more sensorial ways (such as change in color, in light, in form) to give information about the amount of the resources' consumption. That means that they use the sensory dynamic language instead of using alphanumerical one. Some of them have proposed colored environment light-based systems for displaying electricity use, such as DIY Kyoto's Wattson and Ambient Devices' Orb. A suitable example is the Project "Static!" by Interactive Institute of Sweden that investigates interaction design as a means of increasing householders' awareness of how energy is used and for stimulating changes in energy behavior. As a results, more than 10 projects were development with the aim of making energy visible and tangible to all senses and to supporting reflection on how the energy is used over time (http://dru.tii.se/static/research.htm).

Power Aware Cord (Fig. 3) is one of the prototype development within this research program. *"Power-Aware Cord' is a re-designed electrical power strip in which the cord is designed to visualize the energy rather than hiding it. The current*

use of electricity is represented through glowing pulses, flow, and intensity of light. Expressing the presence of energy through light can inspire people to explore and reflect upon the energy consumption of electrical devices in their home" (http://dru.tii.se/static/research.htm).

Figure 3. Power Aware Cord.

Source: https://www.tii.se/sites/default/files/pub/tii.se/upload/groups/powerc.png

Another example is Powerchord (Fig. 4) a project by SusLab, Royal College of art. It explores the concept of "Making the invisible audible". In this project, researches have tried to overcome the invisibility of energy designing auditory stimuli. Powerchord is a device based on an Arduino board that plays a variety of birdsong of different intensities in response to the instantaneous power readings from multiple household appliances, providing a form of ambient feedback intended to fit with the soundscapes of everyday domestic life (Lockton, 2010).

Figure 4. Powerchord.

Source:http://static1.squarespace.com/static/560d2ab3e4b09013d3d0a710/t/560e989ce4b0291997a01728/1443797155189/!!!powerchord_screenshot1+copy.jpg?format=750w

These two examples are part of a collection of case studies. As mentioned at the beginning of this thesis, in previous researches (Colombo at al., 2013, Colombo, 2014 e 2016, Colombo & Rampino, 2014), my research of group and I explored the communication based on dynamic sensory features.

As a result 45 case studies were collected classified and analyzed (Colombo et al. 2013, Colombo and Rampino, 2013). Twelve of which (fig. 5) referring to the saving resources field: 7 products aim to save energy; 4 products aim to save water; 1 product aims to save food.

Mettere una tabella con foto!

This datum confirm the interest of product designers and researchers to explore the sensory language in this field. Even if in these projects there is not any mentions about codified and empirical languages, we can observed that some of them can be classified according to this distinction. For instance, Water Pebble gives real-time feedback about the water consumed during a shower using a codified code. It changes its color from green to red (as a traffic light) to communicate to the user that the consumption is getting unsustainable. The light changes are explored by other 4 projects and they are used in a codified way. The others 8 projects communicate with users through some changing in shape (4 projects), in sound (3 projects) and in weight (1 project). In these project we can observe a tentative to design for the empirical language. However, these changes and the consequent

experiences are (in mostly of the cases) linked to the time as a sort of a countdown. For instance, My Shower (Fig. 5) is a Green Warrior (Fig., designed by Elisabeth Buecher, is a shower curtain, which inflate after four minutes spent under the water, taking over the space and discouraging long water-wasting showers. This project is a tentative to design for an empirical language creating an uncomfortable situation that force users to save water but the fact that is repeated over the time it can be considered as sort of codified language that is less intuitive and conventional (as the usage of traffic light colors).

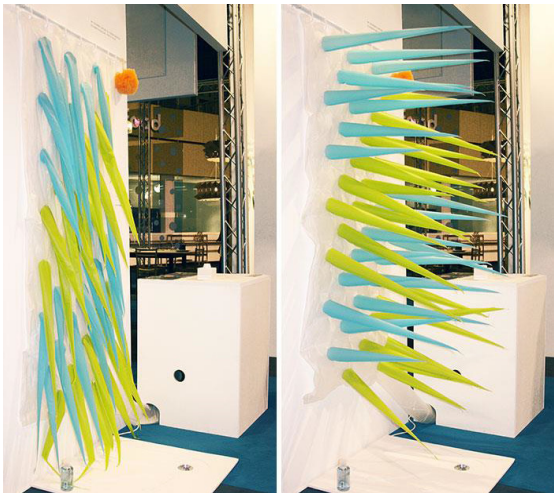


Figure 5 My shower is a green warrior

These case studies give some ideas of the potential use of the sensory language to convey information about food energy and water consumptions. As critique, in these projects there is not a wide exploration of the senses and the message to convey: it is not clear which rules and constrain they have used to guide the concept phase and the reason why they decided to refer to one sense instead of another. These projects are an exploration of the aesthetic and the appearance of the product instead of an exploration of the creation of dialogues (based on the interaction between the product and the user) that can create meanings in the users. Most of these projects lack information about the user's responses. This research wants to go further providing exploration about the possible translation of environmental messages from alphanumerical language to sensory language through to two strategies: codified messages and empirical one.

FINAL REMARKS

Previous studies (most of them carried out into the energy field) showed the importance to establish a dialogue as a tool for helping users to be more aware

about their consumption and, at the same time, how it can be effective to lead householders to be more sustainable in their daily life. Numerical data provided by digital interfaces, can give more accurate feedback to users. Yet, some users find them not so clear and they have some difficulty to link such numbers to their behavior. Such information can be designed as more intuitive and visible using the sensory language, such as using ambient light. Ham and Midden (2010) demonstrated that conveying information through light is more effective than numerical feedback. Lighting feedback can have stronger persuasive effects than alphanumerical feedback (approximately 27%). Also, Ham and Midden (2010) concluded that for participants processing alphanumerical feedback, doing an additional cognitive task that led to slower the understanding of the data transmitted.

Moreover, it was demonstrated the importance to fascinate, engage and attract users during the interaction with these systems through unusual sensory experience. This field seems to be interesting for the aim of this study. Indeed, it shown the contrast between alphanumerical language (mostly used in In-Home Display) and the sensory language. This research aims to go deeper in the exploration of the sensory language and its possible application, on one hand, as a codified language and on the other hand, as more empirical one. In the following parts, this research focuses on water saving because it is one of the most critical scenario. The energy field has been discard since it was largely explored by previous researches, even if, the results archives in these studies has been taken into consideration. As I mentioned above these resources have the similar qualities, like to be imperceptible to the user meanwhile they are used, so it seems possible to transfer findings in energy or food field to water saving.

References

Alberta Water Council's Water Conservation (2007). Conservation, Efficiency and Productivity Final Report, January 2007

Backlund, S., Gyllenswärd, M., Gustafsson, A., Ilstedt Hjelm, S., Mazé, R., & Redström, J. (2007). Static! The aesthetics of energy in everyday things. In Proceedings of Design Research Society Wonderground International Conference 2006.

Bertoldi, P., & Atanasiu, B. (2009). Electricity Consumption and Efficiency Trends in European Union'. European Commission, Joint Research Centre. Institute for Energy, Renewable Energy Unit EUR, 24005.

Bowden, F., Lockton, D., Brass, C., & Gheerawo, R. (2014). Drawing Energy: Exploring the Aesthetics of the Invisible. In IAEA Congress 2014: Congress of the International Association of Empirical Aesthetics.

Climate Group. 2008. Smart 2020: Enabling the Low Carbon Economy in the Information Age, Report by The Climate Group on behalf of the Global eSustainability Initiative (GeSI). (available at: http://www.gesi.org/LinkClick.aspx ?fileticket=tbp5WRTHUoY%3D&tabid)

Daae, J., & Boks, C. (2015). A classification of user research methods for design for sustainable behaviour. Journal of Cleaner Production, 106, 680-689.

Darby, S. (2006). The effectiveness of feedback on energy consumption. A Review for DEFRA of the Literature on Metering, Billing and direct Displays, 486, 2006.

European Commission (2010). Preparatory study on food waste across EU 27. Bruxelles, Belgio:http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_ report.pdf

Fischer, C. (2008). Feedback on household electricity consumption: a tool for saving energy? Energy efficiency, 1(1), 79-104.

Fitzpatrick, G., & Smith, G. (2009). Technology-enabled feedback on domestic energy consumption: Articulating a set of design concerns. Pervasive Computing, IEEE, 8(1), 37-44.

Fogg, B. J. (2009, April). A behavior model for persuasive design. InProceedings of the 4th international Conference on Persuasive Technology (p. 40). ACM.

Froehlich, J., Findlater, L., & Landay, J. (2010, April). The design of eco-feedback technology. In Proceedings of the SIGCHI Conference on Human Factors in

Computing Systems (pp. 1999-2008). ACM.

Gleick, P. H. (1996). Basic water requirements for human activities: Meeting basic needs. Water international, 21(2), 83-92.

Herring, H. (2006). Energy efficiency-a critical view. Energy, Volume 31, Issue 1, January, pp. 10-20.

http://dru.tii.se/static/research.htm

http://smarth2o.deib.polimi.it

http://www.expo2015.org/magazine/it/economia/quanto-cibo-si-spreca-nel-mondo--in-europa-e-in-italia.html retrivered 9.11.2015

http://www.lastminutemarket.it/media_news/wp-content/uploads/2014/05/Knowledge-for-Expo-Rapporto-2014.pdf Retrivered 29.06.2016

http://www.lovefoodhatewaste.com/about_food_waste

Kidd, A., & Williams, P. (2008). The Talybont trial: exploring the psychology of smart meters. Brecon, Wales, The Prospectory.

Kim, T., Hong, H., & Magerko, B. (2009, April). Coralog: use-aware visualization connecting human micro-activities to environmental change. In CHI›09 Extended Abstracts on Human Factors in Computing Systems (pp. 4303-4308). ACM.

Lockton, D., Bowden, F., Brass, C., & Gheerawo, R. (2014). Bird-wattching: exploring sonification of home electricity use with birdsong. In Conference on Sonification of Health and Environmental Data.

Moggridge, B., & Atkinson, B. (2007). Designing interactions (Vol. 14). Cambridge, MA: MIT press.

Niedderer, K., MacKrill, J., Clune, S., Evans, M., Lockton, D., Ludden, G., ... & Hekkert, P. (2014). Joining Forces: Investigating the influence of design for behavior change on sustainable innovation.

Ross, P. R., & Wensveen, S. A. (2010). Designing behavior in interaction: Using aesthetic experience as a mechanism for design. International Journal of Design, 4(2).

Vallgårda, A. (2014). Giving form to computational things: developing a practice of interaction design. Personal and Ubiquitous Computing, 18(3), 577-592.

Vallgårda, A., & Redström, J. (2007, April). Computational composites. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 513-522). ACM.

van Gerwen, R., Jaarsma, S., & Wilhite, R. (2006). Smart metering. Leonardo-energy. org, 9.

Waste Watcher - Knowledge for Expo Rapporto 2014 - Executive Summary Andrea Segrè, presidente Last Minute Market Maurizio Pessato, presidente SWG. http://www.lastminutemarket.it/media_news/wp-content/uploads/2014/05/Knowledge-for-Expo-Rapporto-2014.pdf

WBCSD Water Facts & Trends. Retrieved 2009-03-12. http://www.wbcsd.org/home.aspx

WRAP, about food waste: http://www.lovefoodhatewaste.com/about_food_waste

Ham, J., & Midden, C. (2010, June). Ambient persuasive technology needs little cognitive effort: the differential effects of cognitive load on lighting feedback versus factual feedback. In International Conference on Persuasive Technology(pp. 132-142). Springer Berlin Heidelberg.

4. HYPOTHESIS AND RESEARCH QUESTIONS

HYPOTHESIS AND RESEARCH QUESTIONS

This research aims to contribute to achieve a "cross-fertilization" between features that traditionally apply to the alphanumeric language and the sensory language. The general objective of this study is to transfer the concepts of "codified language and empirical language" to the design of changeable sensory features, to make products able to create meaningful and engage dialogues through their materiality. Indeed, thanks to functional materials and integrated microprocessors, the materiality is now able to establish dialogues over time with the users by sensory language instead of the alphanumerical one. This shift give new opportunities to industrial designer who can fascinate surprise and engage users designing an unusual conversation. I decided to focus this exploration on codified (sensory) language and empirical (sensory) language in the field of saving resources (in particular saving water) that has shown interesting insights.

Critical Findings

From literature review and preliminary research, three critical elements have been outlined, which have been assumed as starting point of this research work. These elements can be synthesize as follows:

• to explore the ability of changeable sensory feature to establish meaningful dialogues over time.

• to adopt the concept of codified (sensory) language and empirical (sensory) language for investigating new ways of expression in order to give more instruments to the interaction design field.

• to evaluate these typologies of languages in a real context in which establish dialogues between the user and the product have been perceived as advantageous, such as the saving resources context.

Hypothesis

The starting hypothesis to be verified during the course of this PhD thesis,

stemming from previous research in nearby fields, is that product designers are now able e to create meaningful and engage dialogues between the product and the users through the materiality of the product itself. Moreover, since studies on emotions give evidence of the power of positive emotions to influence user's behavior (Fredrickson and Cohn, 2010), it also wants to be investigated if and how these dialogues may be able to engage users. The positive engagement can lead, day by day, the user to be more sustainable (saving resources in the domestic context).

The main hypothesis of the study is the following: the changeable dynamic features can be designed following two principles: the code (codified language) and the experience (empirical language). These languages can be the base for establishing meaningful dialogues between the user and the product through the materiality of the product itself. Dialogues that can be designed to motivate users to adopt sustainable behaviors in their daily life.

Research questions

In the light of the analysis made so far, this thesis aims to answer the following questions:

• How can dynamic sensory features be designed in order to establish product-user dialogues? Which are the implications in the design process?

• What are the implications from the product designer's point of view? Is it necessary to gain new knowledge?

• What are the implications from the user's point of view? When the concepts of codified and empirical languages are transferred to the sensory language; are they perceived as different languages? If yes, which is the language perceived as more attractive, engaging and interesting?

Since the research questions concern a few different elements, a set of different research actions will be performed in order to give answers to each of the critical aspects identified. All these actions are based on two design activities aimed to explore the design and the users' response implications.

5. METHODOLOGY

RESEARCH THROUGH DESIGN

The knowing is in the action. We reveal it by our spontaneous, skilled execution of the performance; and we are characteristically unable to make it verbally explicit. Nevertheless, it is sometimes possible, by observing and reflecting on our actions, to make a description of the tacit knowing implicit in them. (Schon 1987, p. 25)

This research applies the research through design approach. Schon (1987) introduced the idea of design as a reflective practice in which researcher is able to make explicit the knowledge that otherwise would remain implicit and complex to communicate. Some years later, Archer, 1995, talked about 'action research' defined it as '*'systematic enquiry conducted through the medium of practical action; calculated to devise or test new, or newly imported, information, ideas, forms or procedures and generate communicable knowledge'*. In this approach *'the research activity is carried out through the medium of practitioner activity. There are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact something, calculated to explore, embody or test it'*.

Research through design is similar to Archers' 'action research'. It is applied in this research with the aim to produce two kind of knowledge: Knowledge on products and knowledge on the process of designing these products. The aims of this approach is to design products to explore implications of theory in context.

This research follows three steps:

1. Theoretical investigation with the aim of creating the base for the design activity.
2. Practical activities with the aim of putting into practice the knowledge generate with the theoretical investigation and generate knowledge about the design process.
3. Test with users with the aim of exploring the user's understandings.

Theoretical investigations

Theoretical investigations are set in order to understand how it is possible to create an effective dialogue in order to lead and motivate householders to reduce their water consumptions. As it was mentioned in previous chapters, dialogues require the involvement of two actors who are in contact for sharing something. Typically, they share bits of information, but it is also possible to enrich this relationship with emotional factors (like feelings) and personal points of view (like thoughts and ideas). Thus, this first part focus on the inquiry of the possible content and information that have to be exchange in such dialogues in order to be effective.

Such as in the codified language the informative content has to be translate from words to sensory stimuli, a literature review was performed with the aim of answer to the followed questions:

Which is an effective way to establish product-user dialogues in order to help users to be more sustainable in their daily life? Which are the information that has to be convey? Have previous studies investigated any features of information to lead users be sustainable? Are there any guidelines to design/ translate such information for the sensory language?

Practical activities

During the research, two different design activities were performed with the aim of exploring diverse aspects of this investigation. The design activities were organized in order to assess the insight coming from the theoretical investigations. These design activities focused on the development of a product that establish dialogue with users in order to influence their water consumption. The first design activity was held at Politecnico di Milano with the aim of exploring the concept of *"codified language*". During the design process the insights coming from the literature review were applied. Specifically, the three resulting features of information were taken into consideration during the concept phase. As a result a prototype was developed. The last design activity aims to investigate the concept of *"empirical language*". This activity was held at the University of Twente in collaboration with Dr. Jelle van Dijk. During the development of this project the user-center design approach was applied to understand experiences and feelings perceived by the users during showering. Since the aim of the project was to redesign the user experience inside the shower in order to make it personal and meaningful for the user.Hence,we asked to 4partecipants to fill diaries and to make videos for collecting enough information

about their usual routine in terms of mood, their emotions and their behaviors. As a result a raw prototype was developed.

Diaries

Diaries are designed to capture the "little experiences of everyday life that fill most of our working time and occupy the vast majority of our conscious attention" (Wheeler & Reis 1991, p. 340).

A fundamental benefit of diary methods is that they permit the examination of reported events and experiences in their natural, spontaneous context, providing information complementary to that obtainable by more traditional designs (Reis 1994).

Test with users

This third research activity aims to involve users with the objective of evaluate the users' understanding about the codified and the empirical language; and their responses about the prototypes. Three focus group were organized in order to present: (i) the theme of saving resources, (ii) the concept and (iii) the prototypes to the users to collect feedback and insights about the projects. Focus groups were first used in the field of marketing to evaluate potential customer response to new products. Nowadays, they are being adopted in other domains to identify user needs and feelings that might be missed through other methods of assessment. In this research, focus groups not serve as a usability test but it is used as a method to explore the interests, feelings and the engagement of the users as well as their understanding about the dialogues established through the sensory language instead of using alphanumerical language. Studies pointed out that designers can benefit from taking part in a focus group sessions (Bruseberg and McDonagh-Philp, 2002):

* observing sessions (Wilson and Callaghan, 1994),

* providing responses to users' questions during the sessions (Sato and Salvador, 1999),

* actively taking part in the discussion (Caplan, 1990; Sato and Salvador, 1999),

* working directly with users in participatory workshops (Fabius and Buur, 2000; Burns and Evans, 2000),

* acting as a focus group moderator (MERCI, 1997).

I have taken part to these activities as a focus group moderator. The moderator has to keep the discussion on track without inhibiting the flow of ideas and comments. She also must ensure that all group members contribute to the discussion and must avoid letting one participant's opinions dominate (Nielsen, 1997).

During the focus group, I want to guide the discussion through four keys aspects:

- Awareness of the water consumption issue
- Acceptance of the product
- Understanding about sensory language. Particularly, it is important to observe if users perceive that the product changing its sensory features is establishing a dialogue with them.
- User's response in terms of: fascination, novelty factor and engagement. Since studies on emotions give evidence of the power of positive emotions to influence user's behavior (Fredrickson and Cohn, 2010), it also wants to be investigated if these dialogues may be able to engage users and consequently to support behavioral changes.

Focus Group

"A focus group consists of individuals, who have been assembled to discuss a particular issue or concern. A moderator, who leads the group through a number of topics and activities, guides the discussion. The synergy between the participants (the interaction through sharing and comparing of ideas) is one of its distinctive characteristics. Participants stimulate and encourage each other." Definition by Kinnaird and Romero, 2010.

Focus group is a technique useful for exploratory purposes in which open-ended questions can be examined. As a result, designer can achieve qualitative information that consists in experiences, opinions, ideas, and motivation rather than 'figures and facts' (Morgan, 1998a). It is not suited to gain quantitative or generalized information. Mazza and Berre (2007) summarized the advantages of using focus group as follows:

- Focus groups provide qualitative data more quickly, and they are more cost-effective than other methods.
- • Researchers may interact directly with participants and obtain rich data in the participants' own words. This also gives them the opportunity to

clarify the responses, follow up questions, and receive contingent answers to questions.

- • Focus groups allow respondents to react to other group members, and to generate new ideas that might have not been uncovered in individual interviews.
- However, focus group have some limitations:

  • Responses from group members are not independent of one other. Also, the small number of participants may limit the generalization of the research;

- • A dominant member of the group may bias the result, and more reserved members may be hesitant to talk;
- • The open-ended nature of the responses make the analysis of the result difficult.

Focus groups require a certain number of representative users. Because a flowing discussion and various perspectives are needed. Typically, it is better to run more than one focus group, because the outcome of any single session may not be representative and discussions can get sidetracked. To overcome such limit, I have decided to run three focus group:

- One to gain information about the codified language
- One in order to achieve insights about the empirical language
- And the last one to compare the two prototypes and have more feedbacks about the comparison between empirical and codified language. This third focus group was organized as a control test.

I have chosen to involve four participants for each focus group (e.g. the focus group organized in the FlexibEL project, Colombo, 2016).

References

Archer, B. (1995). The nature of research. Co-Design Journal, 2(11), 6-13.

Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. Annual review of psychology, 54(1), 579-616.

Bruseberg, A., & McDonagh-Philp, D. (2002). Focus groups to support the industrial/product designer: a review based on current literature and designers' feedback. Applied ergonomics, 33(1), 27-38.

Burns, A.D., Evans, S., 2000. Insights into customer delight. In: Scrivener, A.R., et al. (Eds.), Collaborative Design. Proceedings of Codesigning, 2000, UK, 11–13 September. Springer, London, pp. 195–203.

Caplan, S., 1990. Using focus group methodology for ergonomic design. Ergonomics 33 (5), 527–533.

Colombo, S. (2016). Dynamic Products: Shaping Information to Engage and Persuade. Springer.

Fabius, B., Buur, J., 2000. The story of the size of a screw: experiments in collaborative design learning. In: Scrivener, A.R., et al. (Eds.), Codesigning, 2000 Adjunct Proceedings, Coventry, 11–13 September. Springer, London, ISBN 0 905949 93 5.

Kinnaird, P., & Romero, M. (2010). Focus Groups for Functional InfoVis Prototype Evaluation: A Case Study. Beyond Times and Errors: Novel Evaluation Methods for Information Visualization, BELIV.

Mazza, R., & Berre, A. (2007, July). Focus group methodology for evaluating information visualization techniques and tools. In Information Visualization, 2007. IV›07. 11th International Conference (pp. 74-80). IEEE.

MERCI, 1997. Focus groups in ReLaTe. The MERCI project (Multimedia European Research Conferencing Integration), Work Package 4, Final Report, http://www-mice.cs.ucl.ac.uk/multimedia/projects/merci/wp4/6.4.2-focusgroups.html.

Nielsen, J. (1997). The use and misuse of focus groups. Software, IEEE, 14(1), 94-95.

Sato, S., Salvador, T., 1999. Playacting and focus troupes: theatre techniques for creating quick, intense, immersive, and engaging focus group sessions. Interactions. New Visions Human–Comput. Interaction 6 (5), 35–41.

Schon, D. (1987) Educating the Re□ ective Practitioner (San Francisco, CA,

Jossey-Bass).

Vallgårda, A. (2009). Computational composites: understanding the materiality of computational technology. IT University of Copenhagen, Innovative Communication.

Van Den Hoven, E., Frens, J., Aliakseyeu, D., Martens, J. B., Overbeeke, K., & Peters, P. (2007, February). Design research & tangible interaction. InProceedings of the 1st international conference on Tangible and embedded interaction (pp. 109-115). ACM

Wheeler L, Reis HT. 1991. Self-recording of everyday life events: origins, types, and uses. J. Personal. 59:339–54

Wilson, K., Callaghan, T.R., 1994. Handheld computer terminals: starting off right first time. People and technology in harmony. Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting, 24–28 October, Nashville, Tennessee. Human Factors and Ergonomics Society, Santa Monica, CA, pp. 355–359

6. EPLORATION OF SENSORY LANGUAGE AS CODIFIED LANGUAGE

INTRODUCTION

"We mean by code, for instance, a verbal language such as English, Italian or German; visual systems, such as traffic signals, road signals, card games, etc; and so on.' Umberto Eco.

"Nel linguaggio parlato usiamo significanti (leggeri come parole) per veicolare significati, che si riferiscono a concrete [..] esperienze del mondo." Socco, C. (1996). Semiotica e progetto del paesaggio. Seminario, organizzato.

As mentioned above, the first design activity focused on the exploration of a language that makes a correspondence between a signifier and significant. This correspondence is called in the field of semiotics as "code" (Socco, 1996). Specifically, Lachman et al.'s (1979, p. 68) defined the "code" as: "a set of specific rules or transformations whereby messages, signals, or states of the world are converted from one representation to another, one medium of energy to another, one physical state to another." Codes, in short, specify how information is to be converted from one form to another. (Durgee, 1986). Indeed, in the first part of this chapter I focused my attention on the exploration of literature in order to find out a set of requirements for codifying clear, effective and understandable dialogues. Moreover, this literature research aims to find new possibilities to convey messages through product dynamic features that can be more engaging than the usage of the most common codified code like the change of color from green to red that recalls a traffic light; such as the project "Upstream" by Carnage Mellon university (Fig. 1). It communicates the amount of water consumed in the shower changing color from green (as the shower is lasting as usual) to blinking red (when the time of shower overcome the 200% of usual); passing through yellow (if the time is between the 100% and 150% of usual) and red (when the time is between 150% and 200%).

Fig. 1 Upsteam project (Kuznetsov and Paulos, 2010).

In Upsteam project the numerical language and the sensorial language were compared. Researchers build up two prototypes: one with a screen and the other with a light. As a limit this, study does not explore how numerical language can be codified through dynamic sensory features. Indeed, the researchers decided to apply codified code that are not unusual but they are quite common in our daily life experience; such as traffic light.

The objective of this initial investigation is to verify if and how it is possible to translate messages from words to senses in order to find out a set of parameters that can lead and inspire product designers in the concept phase. The resulting parameters have not been conceived as a simple set of requirements to follow but opportunities for the application of the sensory language. Moreover, these requirements are compared to the possibilities and the limitation of using a sensorial language to convey information through the materiality of the product itself. In the second part of this chapter the design activity is describe in order to light up the implication of using such suggestions in the design process.

DEFINITION OF A SET OF SPECIFIC RULES

In order to create a grammar (as a set of basic parameters) for designing dialogues between the user and the product using a codified language a literature review have been performed. Even if this investigation focus on the role of the industrial designer and the exploration of the materiality and the tangible aspects of products, in this initial phase studies performed in the field of digital interfaces, persuasive technologies and interaction design were also considered. Since there are several studies in these field that have already investigated the importance of giving feedback on consumption, and some of them tried to give some suggestion to

designers who is facing this matter that can be translated in my research field. I also decided to take in consideration only studies that report results about users' investigation and users' responses, since I am interested to explore the effectiveness of the information content, the user's response and the user understanding of the content of the dialogue. As a result, 12 studies were selected[1]. At the end of this research I observed that to make users aware of their resource consumption in a domestic context, three features of the information are important in order to design an engaging and effective dialogue.

They have been defined as: metrics (related to the unit of measure), frequency (related to the timing of the data: when and how many times is necessary to give information to users) and representation (related to the shape of the data). It was also argued that such dimensions might be integrated into dynamic products, to make them effective media for conveying information about user's consumption.

Metrics

Different studies, most of which carried out in the field of energy conservation, tested the effectiveness of giving numerical data to users, such as the amount of CO2 emitted, the cost over energy and the amount of energy used (Darby, 2006; Jacucci et al., 2009; Fitzpatrick and Smith,2009; Ham and Midden, 2010). In these studies, it was observed that giving information about financial savings is not effective overtime (Darby, 2006; Jacucci et al., 2009). It was also observed that numerical data could lead ordinary people to misinterpretations or to an incomplete understanding of the information (Fitzpatrick and Smith, 2009; Strengers, 2011) Indeed, pure quantitative information related to specific dimensions (e.g. the consumed energy in kW/h), which are used in the scientific field, are often difficult to understand for ordinary people. Knowing the amount of CO2 emitted is not sufficient per se to understand if one's behavior is environmentally friendly or not.

"On the ecoMeter it says 2.7 tonnes per day. What is a tonne? ... What is two tonnes? There's no description"

"We're pretty intelligent, but it's still gobbledygook"

that are two of the interview reported into the study conduced by strangers (2011)

Nota 1. Fischer, C. (2008); Fitzpatrick, G., & Smith, G. (2009); Ham, J., & Midden, C. (2010, June); Jacucci, G., Spagnolli, A., Gamberini, L., Chalambalakis, A., Björkskog, C., Bertoncini, M., & Monti, P. (2009); Kim, T., Hong, H., & Magerko, B. (2009, April); Kuznetsov, S., & Paulos, E. (2010, April); Lachman, R., Lachman, J., and E. Butterfield (1979); Petkov, P., Goswami, S., Köbler, F., & Krcmar, H. (2012, October); Strengers, Y. A. (2011, May); Fogg, 2009; Lockton et al., 2014; Daae and Boks,2015; Bowden, 2014.

one interview form the study of upsteam report: ""I turned on my shower, and it [the display] started turning. I found it interesting but it had no effect."

Often qualitative data can give users less precise but more understandable feedback about their behavior.

"You can see what colour it is so you can tell whether you're doing right or wrong" that are two of the interview reported into the study conduced by strangers (2011)

Sensory language is able to communicate with users in an intuitive way, using sensory stimuli instead of the alphanumerical language. Therefore, transmitting qualitative data is one of the peculiarity of this language. Designers can take advantage of changeable features for conveying qualitative information instead of quantitative ones.

Figure.2 Tio ghost concept by Tim Holley. It makes children aware of the amount of energy consumed by changing color from green to red and by changing the facial expression.

Frequency

Regarding frequency, it was observed that the feedback is more effective when it is given frequently and over long time, instead of inform users only when something is changing (in a good or in a bad way) during the usage of resources (Fitzpatrick and Smith, 2009; Fischer, 2008). That means the importance of the information to be continuously accessible to users.

Moreover, it was observed that users' appreciate to have historical details about consumption, because this allow them compare their usage in a given period of time, such as day by day or week by week.

On a sensory language point of view, changeable features can be designed for giving frequent and immediate feedback about the resources' usage, since the changes can be fast and immediate.

Figure.3 Water pebble gives real-time feedback about the water consumed during a shower. It changes its color from green to red to communicate to the user that the consumption is getting unsustainable.

As a disadvantage, dynamic sensory features of products are not able to convey complex information, such as comparative feedback over a period or several information organized in a hierarchical order, as interfaces do. More accurate reflections have to be made regarding this matter. Previous studies had shown that the information that can be conveyed through dynamic sensory features has to be simple (such as "now, your consumption of water is sustainable" or "you are being sustainable!"); comparison feedback could add complexity to dynamic products; thus, it is more appropriate to convey frequent feedback (Colombo, 2014).

Representation

Some studies (Jaccucci et al., 2009; Petkovet al., 2012; Kim et al., 2009) investigated the role of shaping information as an instrument for leading people to decrease their consumptions in a more conscious way.

Analyzing the motivations behind the resource-saving behavior, some researchers observed that giving users positive messages rather than showing them the negative effects of their behaviors can be a fruitful strategy (Jaccucciet al., 2009; Petkovet al., 2012). For instance, it is good to show users that they are good resources savers.

To make the consumption more understandable, the designer should find different ways to shape information. Metaphors can help designers represent data in a

more understandable and engaging way, for instance by showing the consequences of users' sustainable (or unsustainable) behaviors. Thanks to metaphors, messages conveyed by products could be easier to understood and immediate. Test with users showed that the messages conveyed by metaphors can lead users to be sustainable over a long period of time (Kim et al., 2009).

Designers can take advantage of the evocative potential of sensory language. Designers can shape the product's aesthetics and the dynamic sensory stimuli (such as visual, tactile, hearing, or olfactory stimuli) in a consistent way, to create cognitive associations with the message conveyed (Fig.4). This way, they can create strong metaphors (Colombo, 2014). Metaphors can remind users some concepts, ideas, and values; for instance, if the designer wants to convey messages related to nature, sensory features might be metaphorically connected to this world, by conveying the information through sounds and aromas that remind it.

Figure.4 E-plant by Paolucci, Viola, Perna and Incarnate provides easy energy consumption information using the metaphor of the plant.

"GRAMMAR" IN PRACTICE

The design activity described aimed to put into practice suggestions and insights coming from previous studies about dynamic sensory features and the characteristics

of information. In order to understand if the knowledge generated in previous investigations could support designers during the design process, a design activity was performed. The activity lasted three weeks and it aimed to generate concepts of products able to convey information through their materiality about the user's water consumption. During the design process, the three information features (metrics, frequency and representation) were taken into consideration in designing a dynamic product able to make users aware of the importance of saving water in their domestic life.

Concept generation

At the beginning of the design process two concepts were generate.

Concept 1

The first concept is an accessory for the shower, which makes user aware about the consumed water. It takes inspiration from water drops. As the water is used during the shower, the accessory changes its shape from flat to texturized. 3D concentric circles appear on the surface, resembling the shape of falling of drops in water.

Figure.5 Concept 1: inspiration

Figure.6 Concept 1

Concept 2

The second concept takes inspiration from a study carried out by Gleick (1996), in which he estimated the basic water requirement for humans needs. Thanks to this investigation, it is possible to presume the basic amount of water (50 liters per day) that has to be consumed in the bathroom (35 liters per person per day) and in the kitchen (15 liters per person per day).

This concept consists of a set of products that shown dynamic sensory features. The set is composed by little spheres that can be connected to all the faucets of the house, and by a dynamic tangible painting.

The spheres are conceived as meters of the water consumption for all the faucets in the house (from the kitchen to the bathroom/s). The aim of these elements is to tell users the correct amount of water they should use, by means of a blue light (Fig. 8). The spheres change their brightness according to the amount of water used. As soon as the user turns on the tap, the spheres gradually lose their brightness to show users that the amount of water suitable for the kitchen or the bathroom activities is decreasing until ending (the light turns off).

Spheres remind users that they have not an unlimited quantity of available water.

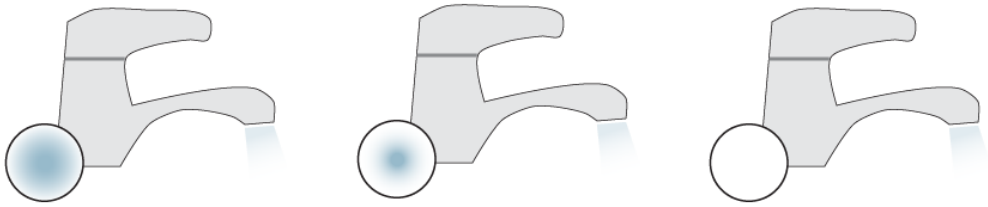


Figure.7 Concept 2

The set is also composed by a dynamic physical painting. The painting displays information about the total amount of water used in the house during the day. The amount of water needed for basic household activities (i.e. cooking and cleaning, excluding gardening) is around 50 liters per person per day (Gleick, 1996). Based on this datum, the painting changes its 3D texture to show that the water consumption in the house exceeds the suggested limit. At the beginning of the day, the picture is completely flat. When the user overcomes the limit of 50 liters per person, a geometrical and abstract texture appears. This texture becomes more and more visible as the water consumption increases. This material changes are inspire by the natural pattern of the arid soil (fig.8)

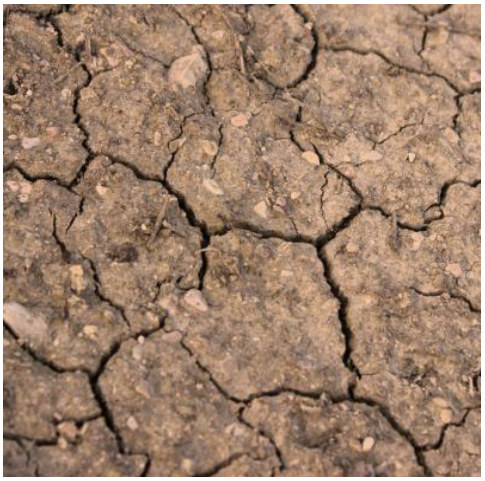


Figure.8 Second concept: inspiration for the painting

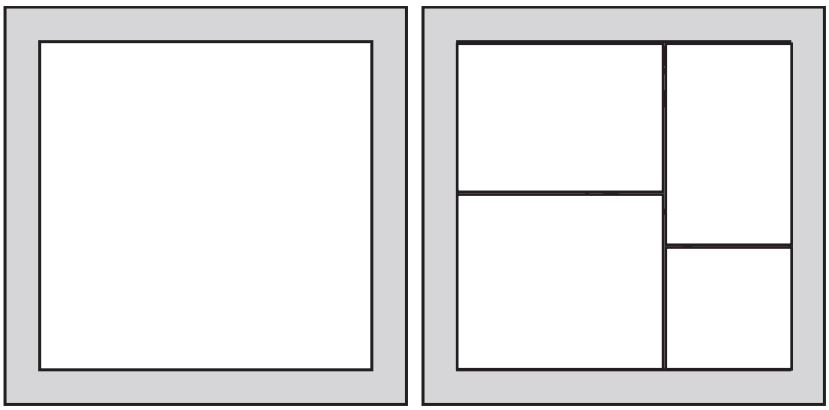


Figure.9 Second concept: dynamic painting

DISCUSSION ON THE CONCEPT PHASE

Inspiration

The inspirations for the solutions are variable. The inspiration for the Concept 1 derived solely from the natural world. In the Concept 2, two different inspirations can be found. The first is conceptual: the spheres' lights follow the water availability in continuous downfall. Indeed, the light changing from intense to off means that keeping on using more water than necessary will eventually deplete all the water reserves of the planet. The second one is more direct: the painting, by changing its texture, shows the real consequences of the excessive use of water, that is the earth dried up and no longer fertile.

Consistency with the features of information

The concepts show correspondence with the three information features. All two concepts return qualitative, instead of quantitative, information (metrics). Moreover, they give to the user the ability to access the information frequently, because the message is displayed without interruptions (frequency). Finally, they deliver the message either by using a cognitive or sensory analogy with nature. It should also be noted that the Concept 2 explores the possibility to have two messages tied together. One is immediate and results from the user's action, while the other one gives an overview of the household's consumption. This concept highlights the difficulty to display two different messages by the same dynamic product. Indeed, to resolve

such difficulty, two separate objects were designed. As a disadvantage, the second concept gives negative feedback when the consumption overcome the sustainable limit. However, this negative message is not designed in order to showing them the negative effects of their behaviors (such as a real pattern of an arid soil) but it create an abstract geometrical pattern.

Sensory media

The last analyzed parameter is the variability of the sensory stimuli used to convey the message. The sensory map (fig.10) summarize the possible transformations in products appearance.

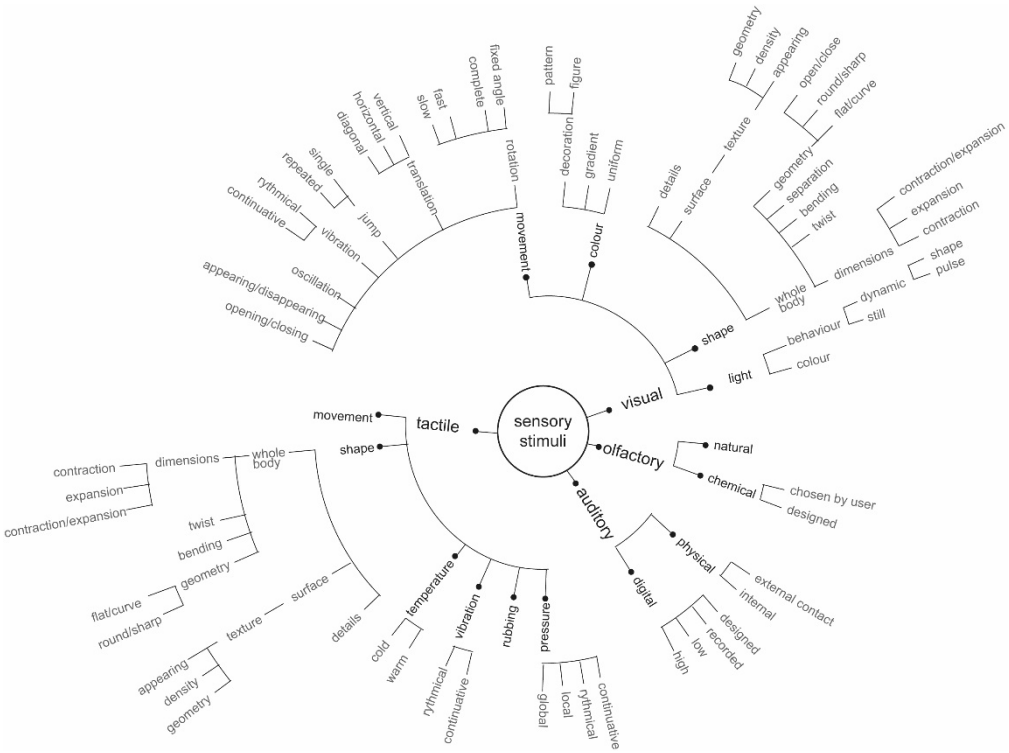


Fig. 10 Sensory Map by Colombo and Rampino 2013

The concept 1 and the concept 2 explore visual stimuli with the exception of concept 1 in which the change of texture can be also perceived by the sense of touch. Concept 2 explores the change of light in terms of behavior. Studies (Ham and Midden, 2010) demonstrated that conveying information through light is more effective than numerical feedback. Lighting feedback can have stronger persuasive effects than alphanumerical feedback (approximately 27%). The sense of smell was discarded

since it is strictly connected to people's memories (Cavalleri 2009). Previous studies (Colombo, Rampino and Bergamaschi 2013; Colombo and Rampino 2013) showed that, in olfactory products, the fragrances used to communicate messages are chosen by the user: by choosing one's favorite fragrance, one can more easily remember the information the product wants to convey. For instance, the case of Scent of Time (fig.11), in which every hour releases a different fragrance chosen by the user.

Figure.11 Scent of Time by Hyun Choi

Another reason that guide the choice to discard the use of aromas to convey messages is that during showering the users is unconsciously involve in a smell experience: the shampoo, the shower gel and other products that we use in the shower already contribute to spread aromas in the bathroom. The risk is that the massage may be overlook by the user.

PROTOTYPE DEVELOPMENT

In this phase I decided to focus on Concept 2, which convey more information and it refer to the whole consumption in the house, similarly to in-.home display. Thanks to the collaboration with Polifactory (a making space at Politecnico di Milano) it was possible to develop one sphere. The dynamic painting remain as a concept it was not develop as a physical prototype. The spheres project was called *"Glass of Water"*.

Prototype description

Glass of water prototype is based on an Arduino board that control the brightness of the sphere's light. To recall the idea of water inside container I chose to use a blue

LED (Fig. 12).

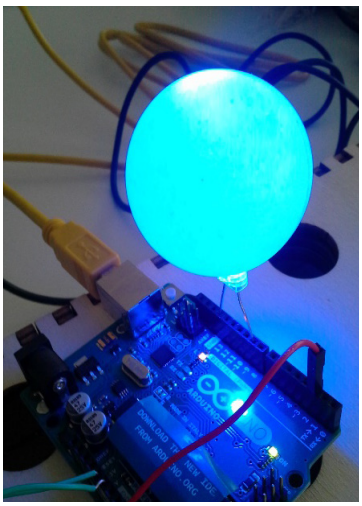


Figure. 12 Glass of water

When the faucet is not used the light is tuned off (Fig.13) as soon as it is turned on it gives information about the water remained. When the consumption of water exceed the 50 liters, the light does not react anymore.

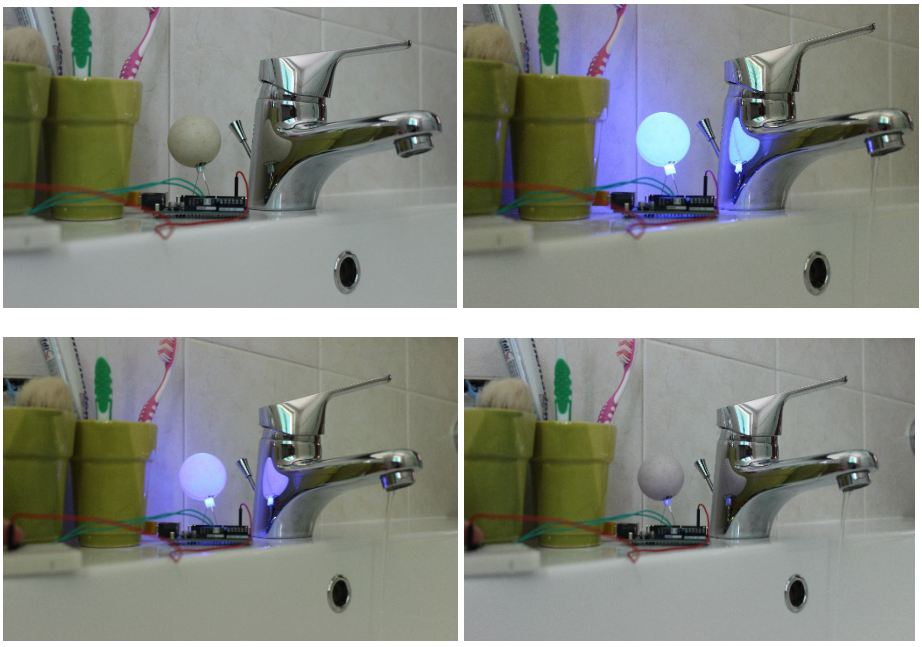


Figure. 13 Glass of water storyboard

Glass of Watre's prototype is not conceived as a Pre prototype series but it is a research prototype in which the intent is to be demonstrative of the research. This raw prototype aims to be representative of the language; its functionality is

simplified: it is not implemented with sensors to measure the real amount of water used. There are simple systems that can be already used to detect water consumption, for instance glass of water can be based on a Bluetooth platform able to receive data from the meter; or it can be based on cheaper system that used microphones, like the Upsteam project (Kuznetsov and Paulos, 2010).

FINAL REMAKS

This design activity aims to investigate new possibilities to convey messages through product dynamic features that can be more engaging than the usage of the most common codified code like the change of color from green to red that recalls a traffic light. A literature research helps to find out a set of parameters that can inspire the designer to translate numerical feedback in sensory stimuli. Using a sensory language may be a fruitful strategy to emotionally engage users that are continuously surrounding by cognitive stimuli (this hypothesis has to be verified during the test with users).

As a result of the first design activity, two concepts were developed. Those are the evidences that is possible to codify messages through sensory language that not recall common experiences. However, some issue remains:

- Which are the implications from the user's point of view? Is the message codified by sensory stimuli still clear and immediate?
- Do user prefer common codified language instead of novel codification?

Studies in the semiotic field also underline another (general) limit of codify messages: *Decode and Encode messages is not a univocal process, it is influenced by culture, background and others personal and social factors* (Crilly et al., 2004).

To answer these questions, a prototype have been developed, which will be tested with users through focus groups.

References

Cavalleri, Rosalia. Il naso intelligente, cosa ci dicono gli odori. Roma: Editori Laterza, 2009 (Italian text)

Colombo S., Rampino L. (2013). Beyond Screens. Exploring product dynamic features as communication means. In proceedings of DeSForm 2013 (pp. 71-84).

Colombo S.. (2014) Sensory Experiences. Informing, Engaging and Persuading through Dynamic Products. Phd Thesis, Politecnico di Milano, 2014

Colombo, S., Rampino, L., & Bergamaschi, S. (2013). What Are You Telling Me? How Objects Communicate Through Dynamic Features. xCoAx2013, 129. Lachman, R., Lachman, J., and E. Butterfield (1979), Cognitive Psychology and Information Processing, Hillsdale. B.J.: Lawrence Erlbau

Darby, S. (2006). The effectiveness of feedback on energy consumption. A Review for DEFRA of the Literature on Metering, Billing and direct Displays,486, 2006.

Durgee, J. F. (1986). How consumer sub-cultures code reality: a look at some code types. NA-Advances in Consumer Research Volume 13.

Fischer, C. (2008). Feedback on household electricity consumption: a tool for saving energy?. Energy efficiency, 1(1), 79-104. C. FISCHER. Feedback on household electricity consumption: a tool for saving energy? «Energy efficiency» 1(1), 79-104.

Fitzpatrick, G., & Smith, G. (2009). Technology-enabled feedback on domestic energy consumption: Articulating a set of design concerns. IEEE Pervasive Computing, 8(1), 37-44.

Gleick, P. H. (1996). Basic water requirements for human activities: Meeting basic needs. Water international, 21(2), 83-92.

Ham, J., & Midden, C. (2010, June). Ambient persuasive technology needs little cognitive effort: the differential effects of cognitive load on lighting feedback versus factual feedback. In International Conference on Persuasive Technology(pp. 132-142). Springer Berlin Heidelberg.

Jacucci, G., Spagnolli, A., Gamberini, L., Chalambalakis, A., Björkskog, C., Bertoncini, M., ... & Monti, P. (2009). Designing Effective Feedback of Electricity Consumption for Mobile User Interfaces. PsychNology Journal, 7(3), 265-289.

Kim, T., Hong, H., & Magerko, B. (2009, April). Coralog: use-aware visualization connecting human micro-activities to environmental change. In CHI›09 Extended Abstracts on Human Factors in Computing Systems (pp. 4303-4308). ACM.

Kuznetsov, S., & Paulos, E. (2010, April). UpStream: motivating water conservation with low-cost water flow sensing and persuasive displays. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1851-1860). ACM.

Lachman, R., Lachman, J., and E. Butterfield (1979), Cognitive Psychology and Information Processing, Hillsdale. B.J.: Lawrence Erlbau

Petkov, P., Goswami, S., Köbler, F., & Krcmar, H. (2012, October). Personalised eco-feedback as a design technique for motivating energy saving behaviour at home. In Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design (pp. 587-596). ACM.

Socco, C. (1996). Semiotica e progetto del paesaggio. Seminario, organizzato.

Strengers, Y. A. (2011, May). Designing eco-feedback systems for everyday life. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2135-2144). ACM.).

Crilly, N., Moultrie, J., & Clarkson, P. J. (2004). Seeing things: Consumer response to the visual domain in product design. Design Studies, 25(6), 547-577. doi:http://dx.doi.org/10.1016/j.destud.2004.03.001

7. EPLORATION OF SENSORY LANGUAGE AS EMPIRICAL LANGUAGE

INTRODUCTION

The second design activity was focused on the empirical language. This thesis defines *empirical language* a form of expression in which the dialog meanings are individually created by the user during the interaction with the product itself. Empirical language can create meaningful product experiences, like in the artistic and poetic fields.

This second activity was held at the University of Twente in collaboration with Dr. Jelle van Dijk and it last four months.

During the development of the concept, we retained useful to apply the principles of Embodied Interaction. The field of Embodied Interaction explores relationships between action and perception in the physical world, and investigates how designed artifacts can be tools for creating personally meaningful experiences (Hummels et al., 2008). Paul Dourish (2004) defined it as "the creation, manipulation, and sharing of meaning through engaged interaction with artifacts". According to the theories of Embodied Interaction, there is a link among physical properties of the objects, the user's actions on, or with, the product, and the creation of meanings in the user's mind (Hummels and van Dijk, 2015). In phenomenological terms, material properties of the world become taken up as elements sustaining stabilities in action-perception loops, which govern a persons' skilled, routine-like dealing with the world (Dreyfus, 1991 ; Merleau-Ponty, 1962; Ingold, 2000). This circle opens a new space for designers: creating dialogues using the material properties of artifacts is not just convey information though 3D shapes; it could be a strategy for creating dialogues between bodies and the world, between users and products, that encourage reflection-on-action and the creation of new meanings (Figure 2).

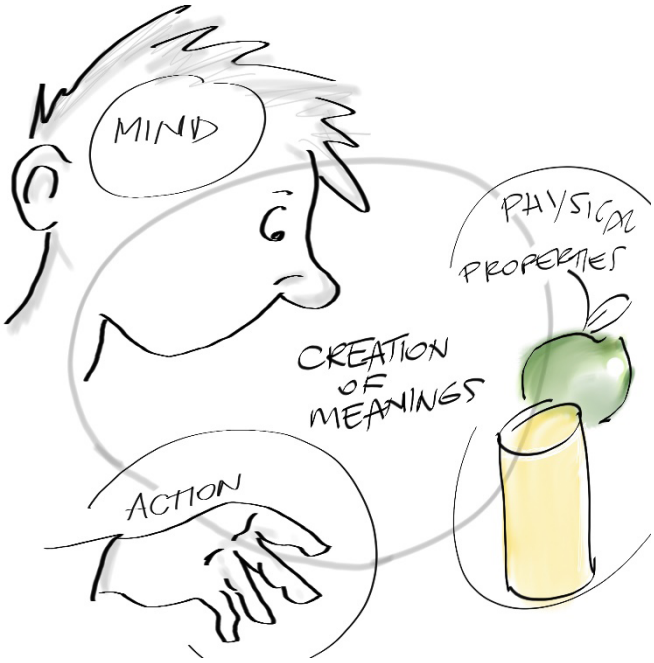


Figure 2. Influence of the physical properties of the objects on the user's actions on, or with, the product, and the creation of meanings in the user's mind. (Image based van Dijk, van der Lugt and Hummels, 2014).

Human behaviors are not driven (solely) by internal decisions making on previous knowledge and beliefs. From an Embodied Interaction point of view, the interaction between the body, the brain and the environment, forms its ultimate ground (Dourish, 2004; Clark, 1998; van Dijk, van der Lugt and Hummels, 2014). As phenomenologist Merleau-Ponty (1962) stated: *"The relationships between my decision and my body are ... in movement*". This means that to change behavior has perhaps less to do with influencing mental models, rather than with influencing the affordances of 'the embodied situation', affecting how this situation over time co-evolves with the development of skills and routines (Dreyfus, 2002; Gibson, 2003). In other words, on the embodied perspective, habitual behaviors are formed and transformed during the interaction between the body and the environment, in the course of action itself, and this is where persuasive interactive technology should have its impact (van Dijk, van der Lugt and Hummels, 2014; See also Hermsen, 2016).

As the field of Embodied interaction suggests, this design activity aims to create meaningful experiences affecting the user's behavior day by day. Moreover, with this project, it was investigate how pleasurable experience could be designed as a fruitful strategy for activating an "unconscious learning process", in which users are not forced to do what is recommended by the system but to act according to the affordances created by evolved action-perception couplings. Due to the complexity

of the circle of influences, it was decided to focus only on the water consumed into the shower, and it was decided to involve the touch sense provided by the shower tray (easiest to explore compare to other parts of the shower that involves more intimate sphere during the interaction, for instance the whole body).

Before starting to design product experiences an investigation of usual shower experience was performed in order to explore in the real context the users' behaviors and feelings perceived during the shower. In more details, three short tests with users were organized in order to gain some insights on: (i) users' behaviours, (ii) tactile feelings and (iii) users' emotional experiences. Involving users in exploring these three aspects of the embodied experience was made difficult by the fact that showering is a private and intimate situation. Finding volunteers was not always easy. The focus of this project was to create engaging and meaningful tactile experience provided by the design of an interactive shower tray, which is able to effect users' behaviors, influenced them 'in the situation'. Video recording was used as a tool for exploring the users' feet behavior in the shower and the interaction with the shower tray. A one-week diary was used as a tool to keep track of the user's experiences and feelings during the shower. Both videos and diaries gave us insights about the context of use through pictures and words. At the end of this phase, we collected 4 videos and 4 diaries.

ITERATION 1. COUPLING TO THE USER'S MOVEMENT IN THE SHOWER SPACE

In order to better understand user's feet behavior in the shower, videos were recorded of naturally occurring movement whilst showering. Four participants took part to this exploration (two male and two female, aged between 23 and 30). During the first meeting, the aim of the study was presented to participants. The researchers gave three simple recommendations: (i) the movements in the shower had to be the most natural as possible, to take care of it the camera point to both (ii) feet and (iii) the shower tray. Plastics covers, as a protection for the camera, were assigned to all participants and they were asked to film their feet using a mobile phone.

Intermediate reflection

As a results, four videos were recorded. Observations showed that users have the tendency to move the feet up and down as they are doing short steps (Figure 3a), and sometimes, move their feet as if 'putting out a cigarette' (Figure 3b).

Figure 3a. Short Steps *Figure 3b. Putting out a cigarette*

Three people had their feet in the same orientation, only one tester use to walking around the shower tray.

These explorations guided us towards the following intermediate decisions:

- make a system that changes shape in a vertical direction.
- create some spherical zone on the floor.
- Create a pattern that can be perceived with different feet's orientation.

ITERATION 2. COUPLING TO THE TACTILE EXPERIENCE

During the phase of the idea generation, a short test was set up involving two potential users, one male (30 years old) and one female (27 years old). The aim of this experiment was to observe users' feet behavior providing different touch stimuli:

- Using a pattern made by soft spheres (Figure 4a)
- Using a patter made by little hard spheres (Figure 4b)

Figure 4a. Soft spheres

Figure 4b. Little hard spheres

These samples have the same dimensions (400 x 400 x 10 mm). They differ for the material and the touch feeling of the sphere. The two participants were asked to make a video of their feet in the context of use. As the previous observation, plastics covers were assigned to participants and they were asked to film their feet during the shower. During the tests, the samples were covered by the same plastic bag, in order to not affect any visual perception. After each shower, users were interviewed and they were asked to describe their experience.

Intermediate reflection

Both testers agreed that the little sphere annoyed them during the shower. They found not way to interact with the sphere in a pleasurable, or interesting way. One of the testers said "every time that I was moving I perceived the little balls as needles that sting under my feet". Videos underlined that users have the tendency to move less the feet when the texture of the tray were not perceived as comfortable. About the soft spheres, one tester said: "I felt it as comfortable". The second tester said: "at the beginning I perceived it as annoying […] but as soon I leave the shower I felt a pleasurable pressure under my feet". During a free conversation, the second tester claimed that she had the tendency to press the plastic bag as soon as she saw it swelling.

This experiment add other insights for the project:

- Using soft material is perceived as more pleasurable.
- Little and hard sphere are perceived as annoying.
- Parts that come up could invite users to interact with the system.

ITERATION 3. COUPLING TO EMOTIONAL EXPERIENCES WHILE SHOWERING

In order to explore the users' experience, participants were asked to fill a diary for

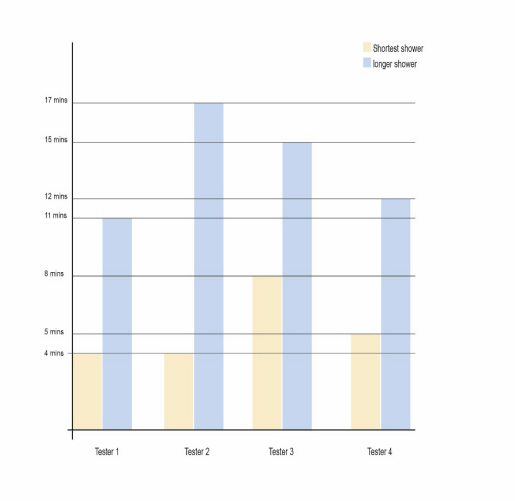
one week. The diary was made by seven short questions per day. At the beginning of the diary participants were asked to describe their self and the place in which they live (they were asked to make a deep description of their bathroom(s) and if it was possible to attach one pictures of it (them)). These questions aim to have more information about the user and to explore the context of use. For each day, participants were asked to take note about the duration of the shower; if there were some external motivation that force them to quit showering (such as. someone was calling them; they ran out of hot water; etc..); users were asked to express their feeling before and after the shower using the facial expression by EmoCards (Desmet et al., 2001). As a last question, researchers asked to summarize all their feeling during the shower using a draw, or a picture (they could searched it in google or they could take a photo), and to describe it with few words.

Intermediate reflection

As a results four diaries were collected. Participants are two male and two female aged between 23 and 27. Two of them share the flat with roommate, one with her family and one lives alone. Only one user has two bathrooms, one with the shower and one with bathtub, but he declared to prefer having shower. One participant have only one bathroom with the bathtub, but she declared to have shower every evening: "it is faster and more practical".

The time spent into the shower varies from 4 to 17 mins (Table 1).

Table 1. Time spent into the shower in the usual users' routine.



About feelings, participants declared that having a shower help them to feel better. After the shower, they feel positive sensations; like: calm, pleasure and relax. How-

ever, diaries highlight two different situations in which users have showered. The first situation is to rest and relax (for example after a working day), the second is to wake up and collect energy for the day. Pictures chosen by the users underline these two circumstances (Figure 5).

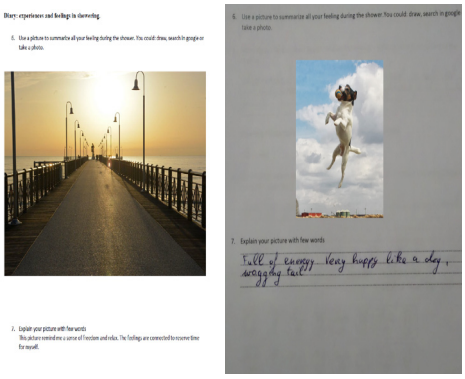


Figure 5. Pages of diaries (the photo credits are unknown, the pictures were selected and download from the users themselves)

In the first scenario users spent more time into the shower, in the second one, registered showers were the shortest.

As external motivation that force users to quit showering were noted:

- They feel cleaned enough.
- Other people that need the bathroom.
- They felt that they were late.
- Sustainable motivation, such as I do not want to waste water.
- Economical issue, such as they want to save money.

The analysis of the data coming from diaries give more insights for the idea generation:

- The time spend into the shower has a personal meaning and it is important for users
- When researchers asked about external motivation some participants talk about his/her internal motivation, as it is more important than external one.
- The new design has to take into consideration the two scenarios: shower as relax moment or a tool for collecting energy for the day.

THE CONCEPT: F.E.E.L.

During all iterations, we were guided by the principle of Embodied Interaction that behaviors can be transformed during the interaction between the body and the environment, in the course of the action itself. We sought to design a tool that, in use, would create personal, meaningful experiences within a person's routines that eventually would lead to more sustainable behavior. This means our concept is not simply an information device giving feedback about water use. Instead, we aimed to create an artifact that fits with the user's routines and over time is able to transform this routine.

Thanks to the users' observations, useful insights were gained referring to: (i) the shape of the shower tray, (ii) the materials' selection, (iii) the design of new behaviors and scenarios. These suggestions were conveyed into F.E.E.L. (Feelings and Experiences for an Embodied Learning). F.E.E.L. is a squared shower tray that change its shape in order to create a new routine into the shower (Figure 6).

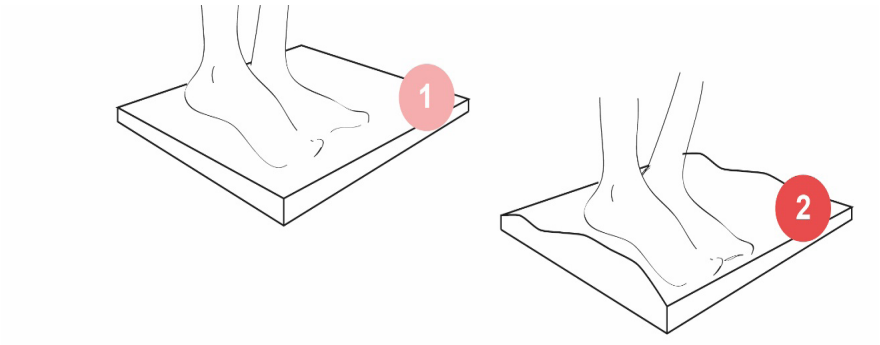


Figure 6. F.E.E.L.: in the situation 1 it is in the flat mode, in the situation 2 it is in the interactive mode.

F.E.E.L. is composed by an external structure and some soft "pins". These pins pop up randomly according different rhythms, creating each time a novel tactile experience as a sort of feet massage.

As mentioned above, the tests with users underlined two different scenarios:

- Users take a shower as a short refresh activity
- Users take a shower to relax and pamper themselves

According to these two scenarios, F.E.E.L. is designed to change its shape in a fast and more marked way in the first minutes of the shower (for the average amount of time that users usually spend for a short shower). Then, it decreases the speed of its movements over time until stopping at the achievement of the maximum average time usually spend under the shower.

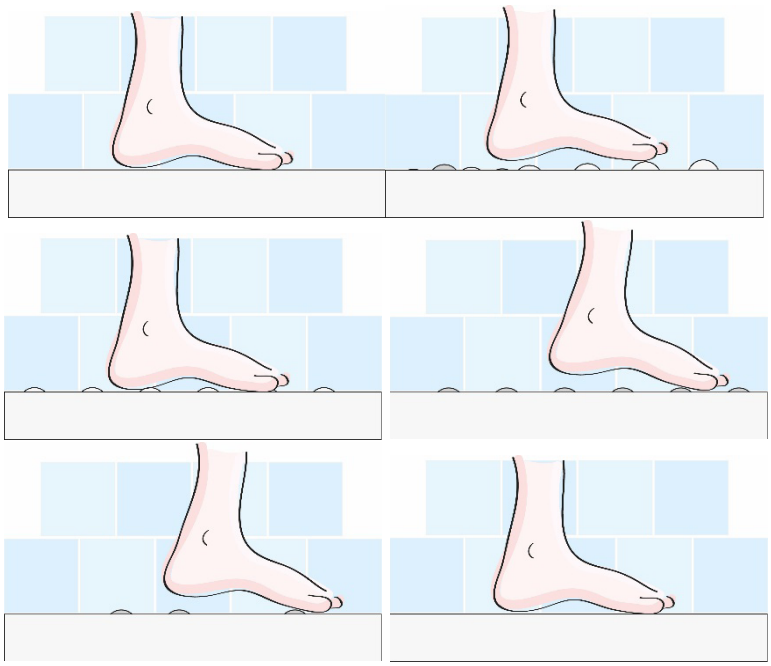


Figure 7. F.E.E.L. 's storyboard

With the aim of creating personal experiences, F.E.E.L. is provided with a smart system able to recognize the person (who is standing on it) and to measure how long a person spends in the shower in the two modes. These data are fundamental to understand the user's routine and to program the behaviors of the new shower tray in terms of rhythms and the velocity of the pins. At the beginning, the pins behave according to the usual routine of the user moving fast during the fast and refresh mode, and to move slowly and randomly in the relaxing mode. Overcame the usual time spent into the shower, F.E.E.L. will not change its shape anymore (e.g. Figure 8 refers to the usual routine of the test 1 observed during the diaries). In any case, pins stop to move as soon as the user quit the shower.

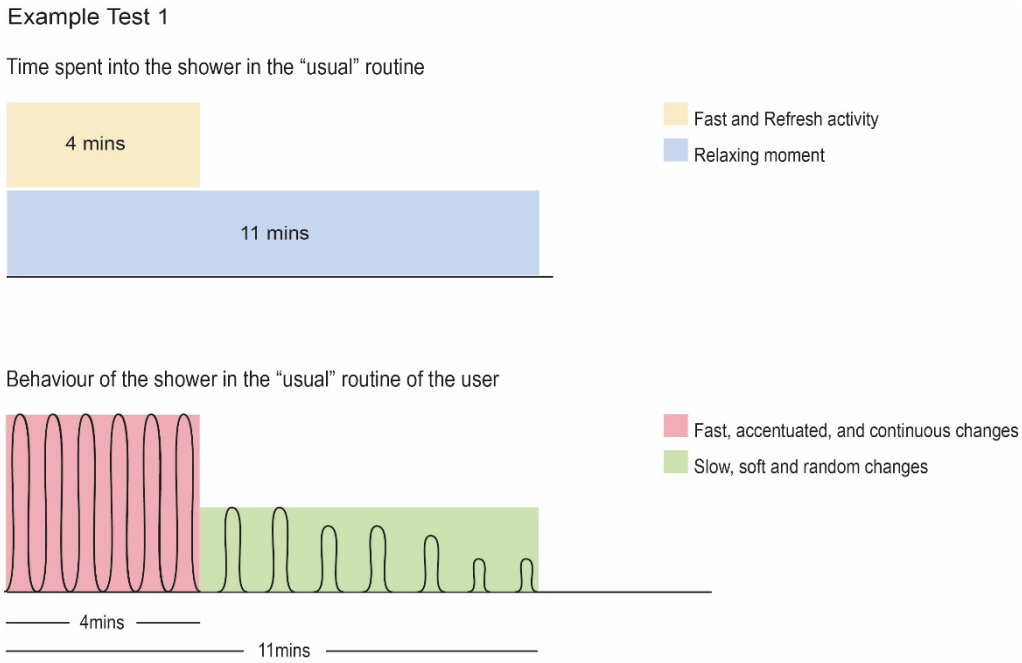


Figure 8. Relationship between the usual routine of the tester 1 and the changes of F.E.E.L.

In order to lead users to decrease the time spent under the shower (and consequently the usage of water), the system will decrease the duration of the stimuli over time, in an imperceptible way (we can measure it in seconds) (figure 9). Indeed, it is important that the user perceive always the same experiences during the shower.

Figure 9. Over time the simulations become shorter creating a new routine.

Over time, F.E.E.L. creates a dynamic coupling between the user's action and the responsive shower floor. As the user influences the system (e.i. in the rhythm of the changes and in duration of the stimulation), the system influences user's experience of time. A relationship is formed between actual time spent in the shower and the temporal pattern of tactile stimuli provided by the floor. Day by day, this relationship will be perceived as the usual routine, eliciting a kind of 'deja-vu'. In other words, the user subconsciously links the experience of continuously and fast rhythm of the pins to a fast shower routine, and slow, soft and random changes to a longer one. Subsequently, when the system gradually reduces the duration of each pattern of stimulations (Figure 9), the user is in a subtle way guided to decrease the time spent in the shower (Figure 10).

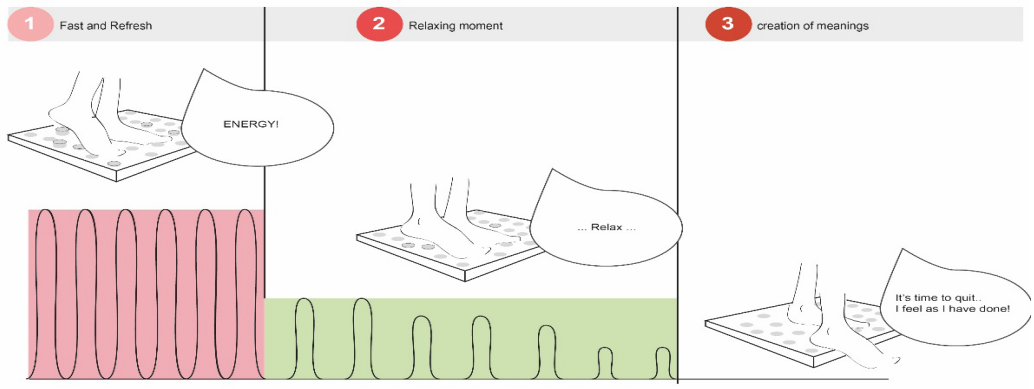


Figure 10. the three phases of the users' experience provide by the changes of F.E.E.L.

PROTOTYPE DEVELOPMENT

Thanks to the collaboration with the University of Twente, it was possible to develop a raw prototype representative of the system, in terms of: shape, tactile feedback and dimensions.

Prototype description

The prototype is made by wood, steel and soft material. The general measure of the prototype is 40*40*5 cm (W*H*D). The structural box is made in wood and it was divided in four parts in order to make it more resistance to the weight. Each part measures 40*10*5 cm (W*H*D) and it has twelve hole for pins. Wood pins are moved by a cam system made by a cylinder of steel and laser cut wood (Fig. 10).

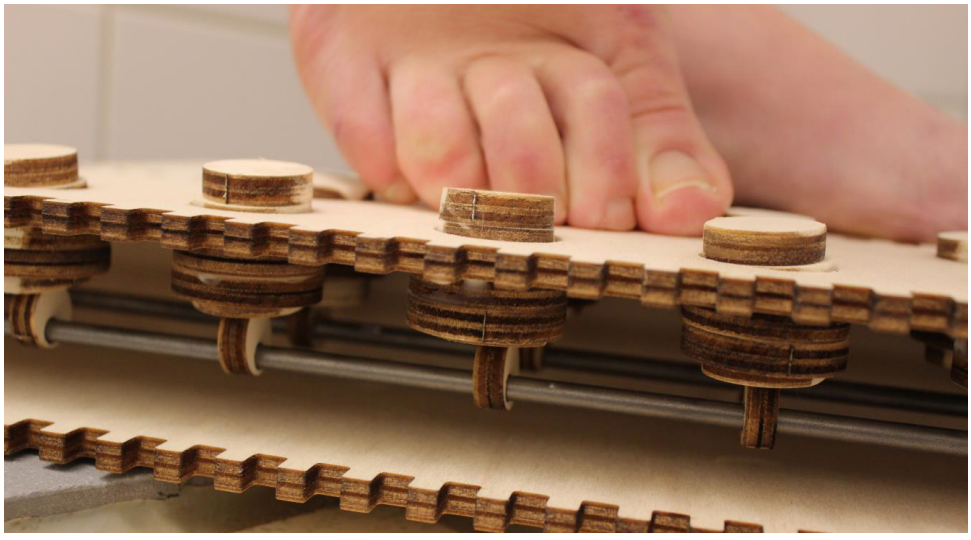


Figure. 10 F.E.E.L. prototype

This raw prototype aims to be representative of the language; its functionality is simplified. Thus, the prototype has not been already implemented with electronic devices. It has to be moved by someone. This manual control give more flexibility to the system.

LIMITATION OF THE STUDY

A limit of this study is the small amount of testers who participated to the user's exploration. That was influenced by the context of this research. The fact that we want to explore such intimate and private space make harder to find volunteer willing to join the research activities proposed. Even when we proposed to make a diary (as a method of observation that is less intrusive than the others), we could not involve a significant number of participants.

FINAL REMARKS

The concept of FEEL aims to investigate new forms of interaction (conveyed through the shower tray) able to create meaningful dialogues that could lead users to be more sustainable day by day. F.E.E.L. activates an unconscious learning process, and this process is evoked through the empirical language based on product's materiality. The learning process is based on what we have come to call, a sense of deja-vu instead of based on the cognitive passage of information. If we talk about interaction as a story, every time in which we interact with F.E.E.L., it is telling us the same story in the same way: now you have just started, now you are in the middle of showering, and now you are about finished. Yet with each run (on each next day), this story unfolds imperceptible faster. Thus, every time (in which user is showering) he/she is part (or better the protagonist) of the same tale and when the changes stop the user feel (unconsciously) as there is not role to play. This process is supposed to be slow. Firstly, the user has to create his/her personal meaning of the changes, and then the stimuli can become shorter over time. In other words, before reduce the narrative time, the user has to create own personal meaning about the object, its changes and the action on it. In this case, the materiality of the product play an important role: it is the narrator. Indeed, F.E.E.L. dialogues with the user through changing its shape. No symbols, no metaphors and no alphanumerical languages were used. There are no grammar rules; the user with his/her sensibility is able to make sense of the experience that he/she has perceived as in the artistic and the poetic field. In this sense, F.E.E.L. proposes a new model

of dialogue that is not based on information, data, symbol and metaphors (i.e. Kim et al, 2009; Petkov et al, 2012; Darby, 2006). In the field of industrial design and art performances, shape-changing system are not completely new as a strategy for leading people to decrease their water consumption into the shower. Particularly, the projects "My Shower is a Green Warrior" (Figure 10) and the "Eco drop" (Figure 11) inspire us during the exploration of these systems. Compared to these concepts, the innovative aspects is that F.E.E.L. does not change its shape to discourage users to have long showers, but to help them to perceived that the moment of quit the shower is arrived. F.E.E.L. does not forced users to do what is recommended by the system, but to act according the affordances created by evolved action-perception couplings.

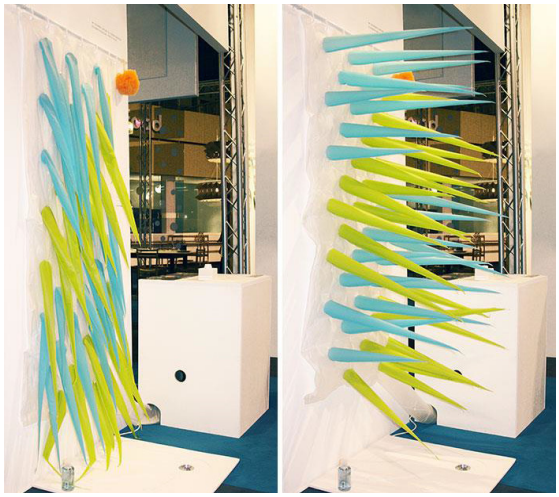


Figure 10. My Shower is a Green Warrior, designed by Elisabeth Buecher, Is a shower curtain which inflate after four minutes spent under the water, taking over the space and discouraging long water-wasting showers. Source: http://www.elisabethbuecher.com/22.html

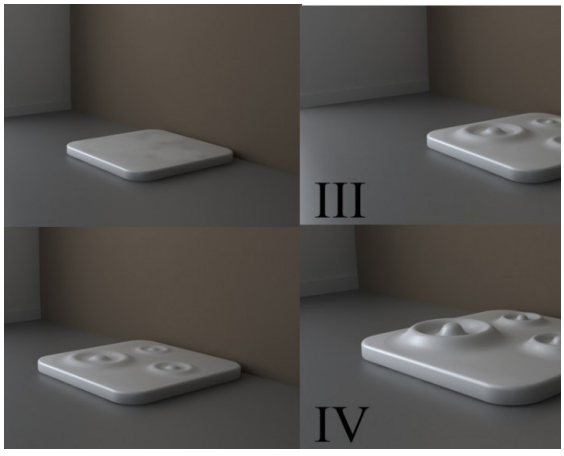


Figure 11. Eco Drop Shower, designed by Tommaso Colia, is a shower tray that pop up some

circle in order to force users to quit the shower and go out. Source: http://tommasocolia.com/

However, some opened questions remain:

- Which are the implications from the user's point of view? Is the dialogue based on *empirical language* understandable by the users?
- Is the *empirical language* able to engage, attract and fascinate users?

To answer these questions and gain information about the users' perspective, the raw prototype was tested with two focus groups.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior (pp. 11-39). Springer Berlin Heidelberg.

Bergamaschi, S., Rampino L., Colombo S.; Engaging users through dynamic products for promoting water saving in a domestic environment. In the proceedings of Cumulus Mumbai 2015.

Chaiken, S. (1980). Heuristic versus systematic information processing and the use of source versus message cues in persuasion. Journal of personality and social psychology, 39(5), 752.

Clark, A. (1998). Being there: Putting brain, body, and world together again. MIT press.

Colombo S. (2014). Sensory Experiences. Informing, Engaging and Persuading through Dynamic Products. Phd Thesis, Politecnico di Milano.

Colombo, S., Rampino, L.(2013). Beyond Screens. Exploring product dynamic features as communication means; Design and semantics of form and movement (DeSForM 2013)

Colombo, S., Rampino, L., Bergamaschi, S.; What are you telling me? How objects communicate through dynamic features; xCoAx 2013 conference, 27- 28 giugno

Darby, S. (2006). The effectiveness of feedback on energy consumption. A Review for DEFRA of the Literature on Metering, Billing and direct Displays, 486, 2006.

Darby, S. (2010). Smart metering: what potential for householder engagement? Building Research & Information, 38(5), 442-457.

Desmet, P. M. A. and Hekkert, P. (2007). Framework of product experience. International Journal of Design, 1, 57–66.

Desmet, P., Overbeeke, K., & Tax, S. (2001). Designing products with added emotional value: Development and appllcation of an approach for research through design. The design journal, 4(1), 32-47.

Dourish, P. (2004). Where the action is: the foundations of embodied interaction. MIT press.

Dreyfus, H. L. (1991). Being-in-the-world: A commentary on Heidegger's Being and Time, Division I. Mit Press.

Dreyfus, H.L. (2002). Intelligence without representation: Merleau-ponty's critique of mental representation. Phenomenology and the Cognitive Sciences, 1, 367-83

Fischer, C. (2008). Feedback on household electricity consumption: a tool for saving energy? Energy efficiency, 1(1), 79-104.

Fitzpatrick, G., & Smith, G. (2009). Technology-enabled feedback on domestic energy consumption: Articulating a set of design concerns. Pervasive Computing, IEEE, 8(1), 37-44.

Fogg, B. J. (1999). Persuasive technologie301398. Communications of the ACM, 42(5), 26-29.

Frayling, C. (1993). Research in art and design.

Gibson, E. and Pick, A. (2003) An ecological approach to perceptual learning and development. Oxford: University Press.

Gleick, P. H. (1996). Basic water requirements for human activities: Meeting basic needs. Water international, 21(2), 83-92.

GOV.UK. (2015). GOV.UK. Retrieved from https://www.gov.uk/government/publications/2010-to-2015-government-policy-household-energy/2010-to-2015-government-policy-household-energy#appendix-7-smart-meters

Hekkert, P. (2006). Design aesthetics: principles of pleasure in design. Psychology Science, 48, 157–172.

Hekkert, P., & Schifferstein, H. N. (2008). Introducing product experience. Product experience, 1-8.Hengeveld, B. J. (2011). Designing LinguaBytes: A tangible language learning system for non-or hardly speaking toddlers (Doctoral dissertation, Technische Universiteit Eindhoven).

Hermsen, S., Frost, J.H., Renes, R.J., & Kerkhof, P. (2016). Using Feedback Through Digital Technology to Disrupt and Change Habitual Behavior: A Critical Review of Current Literature. Computers in Human Behavior, 57, 61-74. DOI: 10.1016/j.chb.2015.12.023

Hummels, C. C. M., Overbeeke, C. J., Appleby, R. S., Frens, J. W., & Wensveen, S. A. G. (2008). The power of embodiment for design and vice versa. Form+ Zweck, 22, 6.

Hummels, C., & van Dijk, J. (2015, January). Seven Principles to Design for Embodied Sensemaking. In Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction (pp. 21-28). ACM.

Ingold, T. (2000). Making culture and weaving the world. In Matter, Materiality and

Modern Culture, ed. P. M. Graves-Brown. London: Routledge, pp. 50-71.

Kim, T., Hong, H., & Magerko, B. (2009, April). Coralog: use-aware visualization connecting human micro-activities to environmental change. In CHI'09 Extended Abstracts on Human Factors in Computing Systems (pp. 4303-4308). ACM.

Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., & Wensveen, S. (2011). Design research through practice: From the lab, field, and showroom. Elsevier.

Marcus, A., & Jean, J. (2009). Going green at home: the green machine. Information Design Journal, 17(3), 235-245.

Merleau-Ponty, M. (1962). Phénoménologie de la perception (English translation Phenomenology of perception, New York.

Petkov, P., Goswami, S., Köbler, F., & Krcmar, H. (2012, October). Personalised eco-feedback as a design technique for motivating energy saving behaviour at home. In Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design (pp. 587-596). ACM.

Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion (pp. 1-24). Springer New York.

Stienstra, J.T., Bruns, M., Wensveen, S.A.G. & Kuenen, C.D. (2012). How to design for transformation of behaviour through interactive materiality. Proc. of NordiCHI 2012, October 14-17, Copenhagen, Denmark, New York: ACM.

van Dijk, J., van der Lugt, R., & Hummels, C. (2014, February). Beyond distributed representation: embodied cognition design supporting socio-sensorimotor couplings. In Proceedings of the 8th International Conference on Tangible, Embedded and Embodied Interaction (pp. 181-188). ACM.

World water council Water Crisis. Retrieved from http://www.worldwatercouncil.org/library/archives/water-crisis/

8. TEST WITH USERS: FOCUS GROUPS

INTRODUCTION

Three focus groups with potential users were organized in order to collect feedback about the two projects.

The first focus group aimed to present the concept “Glass of water” (codified language) to the users . The second one aimed to collect feedback about the concept F.E.E.L. A third focus group was held to present both concepts in order to let the potential users to compare both the languages. Each focus group involved four people (two men and two women, aged 25-36). Our choice was to involve people with different backgrounds. None of the testers was a designer, since the aim of this activity is to gain feedbacks from non-expert people. Moreover, I decided to involve people who lives alone and who already manage his/her consumption. In general, each focus group lasted at least 40 mins (10 mins of presentation by a facilitator plus a 30 mins discussion). All of them followed the same scheme: each focus group started with a brief presentation aimed to introduce the concept/s to be discussed. During the session, videos and pictures were shown in order to describe the concepts in the real context. At the end of the presentation, participants were invited to discuss together. The discussion was guided by five open questions aimed to investigate the following aspects: (i) their awareness about the topic, (ii) the engagement that users perceived with the concept, (iii) potentialities and limits of the concept and (iv) how the concept could fit in their daily life.

The questions were:

• Are you aware about your daily water consumption?

• Do you think are you wasting water? If yes, do you have any strategies to save this resource?

• Do you think that the messages conveyed /experiences elicited by the products are clear or meaningful for you?

• Do you think that this concept can help you to save water? Which are the positive and negative characteristics that you perceive?

• How may the concept fit with your daily life? Can you image to have it at home?

In this chapter, the three focus groups and the main findings were presented and discussed.

FOCUS GROUP 1: "GLASS OF WATER"

Participants

Four people were involved two men and two women, aged from 25 to 35. In this activity were involved people with different background (there were a nurse, an engineer, a biologist and a computer technician). None of them is a designer since the aim of this activity is to gain feedback from ordinary people who is not familiar with designing sensory language.

Performance

The section was organized in two different step: the first one was focus on the issue of water wastage and the second one focused on the concept.

As first, a brief presentation about the water consumption and the importance to save water was made. At the end of the presentation, participants were invited to discuss about their water consumption and their daily life behavior. The discussion was guided by the two open questions aimed to investigate their awareness about this topic and if they have any "strategies" to save water. After the discussion, the concept "glass of water" was presented. During the session the prototype was on the table available to all participants, with the aim to invite them to interact with the prototype in order to figure out their scenario of use. At the end of the presentation, participants were invited to discuss about the concept. The discussion was guided by open questions aimed to investigate the following aspects: the clarity of the communicative content, potentialities, limits of the concept, and how the concept could fit with their daily life. The focus group lasted 50 mins (15 mins presentations and 35 mins of discussion).

Focus group results

The results can be divided in three themes: the consciousness of the participants about the issue of saving resources, the acceptance of the concept and the communicative intent.

Water saving awareness

At the end of the first discussion, the participants' awareness about the issue of saving water emerged. This awareness is motivated by different aspects, such as environmental issue, conservation of this resource for next generation and (only for one person) the money saving. All participants claim that they already know some "strategies" to save water, like have short shower or close the tap meanwhile they are brushing their teeth. However, they state that not always they observe these suggestions especially meanwhile they are showering.

Concept evaluation

In general, the concept "Glass of Water" has been positively assessed, participants say comments like:

"It is good!"

"I like the idea to have something that makes my water consumption more visible!"

All people agreed on the fact that this concept can be useful to help users to become aware about the importance to saving water and to motivate them to make more sustainable choices. As limit, they agreed that (after the first period of training) the system has to be implemented with more accurate information to let user control their choices (e.i. having information about the amount of water used to clean the vegetables or to have data about how often they wash their hands). In general, testers like to have one sphere to each tap, even though it can be perceived as annoying during the installation.

Communicative intent

During the discussion about the communicative intent of "Glass of Water" three main issue were highlight:

- Message
- Numbers vs Light
- Brightness vs codified colors

As first, Participants discussed about the message conveyed through the light. One participant claimed that if the intent of the project is to give prominence to the fact that the user is consuming much more than 50 L per day, it is better to have only one light in the house (like in the corridor). This light can be seen by the user only in the evening before going to sleep. On the contrary, the other three participants agreed on the fact that is more useful and clear to have one sphere on every tap, so the message is more visible and it can be linked to the activity that they are doing.

For them, the spheres make the water consumption more visible and it can be a good strategy to motivate users to take care about their behaviors.

Participants discussed also about the importance to have qualitative or quantitative information. Three people agreed on the fact that numbers are stressful and less significant. One participant claim that he prefers to have numbers in order to know exactly how much water he is consuming. However, he claim that having numerical data can be significant only if the person is already conscious about water wasting. Otherwise, qualitative data are more effective for an initial learning.

The last point discussed was the stimulus used to convey the message. Participants stated that they like the usage of light as a medium to convey information. However, they found the limit that the change of the brightness is not so immediate, and during the day, it is less perceptible. As soon as one participant suggest changing colors (like green and yellow), all participants agreed. They said that using colors the change is more visible. Moreover, they feel more comfortable and familiar with using codified colors.

FOCUS GROUP 2: "F.E.E.L."

Participants

Four people were involved two men and two women, aged from 25 to 32. In this activity were involved people with different background (there was a chemist, an engineer, and two-employee). All the participants are young adult who do not live with their parents.

Performance

The focus group lasted 40 mins (10 mins presentations and 30 mins of discussion). The activity was opened by a brief presentation aimed to present the importance of saving water and the concept F.E.E.L.. During the session, one module of the prototype was under the table available to all participants, with the aim to invite them to interact with it. Moreover, a video describing the concept's mode of use was shown. At the end of the presentation, participants were invited to discuss about the concept. The discussion was guided by open questions aimed to investigate the following aspects: the awareness about the issue of water saving, the engagement that they perceived with the concept, potentialities, limits of the concept and how the concept could fit with their daily life.

Focus group results

The results can be divided in three themes: the consciousness of the participants about the issue of saving resources, the experience create under the shower and the acceptance of the concept.

Water saving awareness

Testers demonstrated to be conscious about water saving. All of them agreed with the fact that they waste more water in the bathroom, especially under the shower. One participant said that he takes care about the water for saving money. However, it is hard for him to renounce the long shower for a long period. He confessed that when he wants to have long showers without any consequences on his money, he has a shower at his parents' house. Girls showed more awareness to save water, also for other activities in the bathroom like brushing the teeth.

Positive and negative experience perceived under the shower

During the discussion, participants were invited to reflect on the experiences perceived under the shower. Particularly, I asked to focus on tactile experiences. Participants claimed that they have no remembrance about the tactile experience under the shower. Testers claim that the tactile experience under their feet is quite imperceptible and it is not emphasized with traditional shower tray. As positive experience, the two women said that they feel as relax and pleasurable the sensation of the water on their skin and hairs. One of them said that she felt the same pleasurable sensation when she used the foot massager machine. As unpleasant experience, participants said that they feel uncomfortable when the temperature of the water is too hot or too cold.

Participants agreed on the fact that negative emotion elicited under the shower may be effective to push users to quit the shower immediately. However, users claim that they can sometimes bear negative experiences, but not always, they are willing to renounce to have long showers. Testers desire a flexible system that can give them the possibility to have long shower when they need without compromise their experience.

Moreover, they cannot be used as a support to learning because they are perceived as annoying, irritating and disappointing.

As a conclusion of the discussion, tester agreed on the fact that is more pleasant and (probably) effective, designing for positive emotions instead of negative and annoying ones.

Acceptance of the concept

In general, the concept of F.E.E.L. was accepted by users. Participants said that they are fascinated by the project and they seemed to be enthusiastic to make a trial with it in the real context and for a long period. Since the experience of F.E.E.L. was judged as innovating, surprising and unusual, participants claimed that without a use test in a real situation, they cannot evaluate its effectiveness. Only one participant seemed to be convinced of the fact that F.E.E.L. (enriching the tactile experience under the shower) can be able to influence his behavior into the shower. However, all participants asserted that positive experience may lead them to have shorter shower and to help them to change their routine over time.

Starting from effective positive experience, testers suggest to implement the system with music. Music was judged as positive and relaxing. Some of them asserted that also using colors like chromo-therapy can make the shower more pleasure.

FOCUS GROUP 3: GLASS OF WATER VS F.E.E.L.

Participants

Four people were involved two men and two women, aged from 28 to 36. In this activity were involved one man and one woman employed in the health sector and one man and one woman employed in the business sector. All the participants are young adult who do not live with their parents.

Performance

The activity least 40 mins (10 mins of presentation and 30 mins of discussion).

The activity was opened by a brief presentation aimed to present the two projects. During the session, two videos were shown in order to describe the concepts in the real context. At the end of the presentation, participants were invited to discuss about the concepts. The discussion was guided by open questions aimed to investigate the following aspects: the engagement that they perceived with the concept, potentialities, limits of the concept and how the concept could fit with their daily life.

Focus group results

As a result, the discussion had two main themes: the novelty factor and the clarity

of the communicative intent.

Novelty factor

As first, participants evaluated the originality and the novelty factor of concepts. Both the projects were evaluated as novel, original and unusual (compared to the objects that they have in their home). However, participants evaluate the project F.E.E.L. as more innovative:

"It proposes an unusual experience"

"This project is cooler!"

"I have never seen something like that!"

Glass of water was perceived as less surprising. As observed, the novelty factor influence the enthusiasm of the users to have a trial with the prototype. Three participants claimed to be more interested to have a trial with F.E.E.L.. Meanwhile, only one participant expressed his enthusiasm to test the project "Glass of Water".

Clarity of the communicative intent

Comparing the two projects, participants highlight some issues also observed in previous focus groups. Particularly, it emerged that the communicative intent of "Glass of Water" is more evident and immediate to users. Meanwhile, the communicative intent of F.E.E.L. is not so immediate and it requires extra explanations. However, as mentioned above, the concept F.E.E.L. was perceived as more able to influence users' behaviors. Since the learning process was judged as subtle and more linked to the personal sphere. On the contrary, the learning process provided by "Glass of water" was judged as cognitive and intentional:

"Glass of water is telling me how I am sustainable. In a way, it is pushing me to quit the use of water to save it! Meanwhile, F.E.E.L. helps me to relax and enjoy my shower. Water consumptions are up to me!"

FINAL REMARKS

From the users' point of view, it was observed that establishing a material dialogue through a codified code gives prominence to the message and to the communicative intent of the products (as underlined by the focus group discussion). A codified language can be applied when we want the user to be conscious of the informative content, such as when the aim of the product is to make users aware of the amount of water consumed in a given situation. On the other side, applying an empirical language means to underline the experience of interaction with the product. Such

experience is likely to be perceived as more engaging and attractive by the user, resulting in a subtle but fruitful strategy to motivate him/her to reduce his/her consumptions.

9. CONCLUSION

At the beginning of this dissertation, we argued about the shift of industrial design from form to the interaction. This evolution enrich the role of the designer who is not just someone able to shape things, but who is able to shape the interaction between the product and the user. This research is based on the idea that the interaction between users and products can be seen as a dialogue between them. A dialogue that is able to grow over time and to influence the user and the product's behavior. Each dialogue, and consequently each interaction, is based on language. For instance, if you think about the dialogue between two persons, it is based on words. In the field of Interaction design, four languages were categorized according to their "dimensions": 1-D (words), 2-D (icons, pictures, diagrams etc.), 3-D (physical form) and 4-D (animation, films etc.) (Moggridge, 2007). This research is motivated by the need to "*develop an independent language of interaction with "smart systems" and devices"* (Moggridge, 2007). There is a real need (express also by Ross and Wensveen 2010) to investigate new ways of expression in order to give more instruments to the interaction design field to build up its own identity. However, it would be too ambitious to think that the result of this research is a novel language. In this perspective, this thesis explored the sensory language in order to create novel perspectives for designing meaningful and engaging interactions, intended as a dialogue between the user and the product. The results of these thesis concern to new insights for industrial designers who are facing the design of interactive products. This study brakes the boundaries among the dimensions of languages identified in the interaction design field exploring the similarity among languages, particularly, between the 1D language and the 3D language.

Dialogues based on words are largely explored in philosophy (from Plato to Marx). From philosophy, I borrow the distinction between codified and empirical language and I transfer these concepts- explored in the 1D language-to the 3D language, which refers to material and sensorial properties of products (above defined sensory language). Since in this research, I refer to the field of interaction design as an Industrial designer perspective.

Thanks to new materiality of things (i.e. functional materials or computational composites; see Vallgårda, 2014; Vallgårda, and Redström, 2007), artifacts gain more capabilities in terms of: responsiveness, intelligence and ability

to adapt to the surrounding (environment, users and context in general). These abilities can support new dialogues between the product and the user giving prominence to the materiality of artifacts.

In this dissertation, I define *codified language* as a form of expression based on conventions, symbols and codes that can be share by a group of people. This language can be applied to establish dialogues in which the content of the information have to be clear and not misunderstood. For example, a traffic light that chance color (green, yellow, and red) to communicate if it is possible to cross the street. On the other hand, *empirical language* is defined as a form of expression in which the meanings are created by the user during the interaction with the product. Thus, the role of the designer is to design the experience and the meaningful interaction between the product and the user. *Empirical language* can be used to create individual and meaningful product experiences like in the artistic and poetic field. This research contributes to achieve a "cross-fertilization" between features that are traditionally apply to the alphanumeric language and the human sensory involvement typical of the sensory language. In order to test the real possibilities of such cross-fertilization, the two concepts of *codified* and *empirical language* were identified. Then, two different design activities were performed in order to explore the implication during the design process. Both the resulting concepts refer to the field of water conservation in which previous studies have demonstrated the importance to establish dialogues between the product and the user (mainly through a smart meter) with the aim of informing and motivating users to change their behavior in order to make sustainable choices in their daily life. At the end of the design activities, focus groups were organized to gain feedback from users.

This research have considered different aspects on the explored topic: (i) theoretical investigations; (ii) the design process (iii) the users' perspective. This research aims of having an overall view about the design practice and therefore some its aspects can be need more investigations.

Drawing the conclusion, I wish to summarize the findings of this research according three main aspects investigated: (i) codified and empirical language as opportunities for enriching the sensory communication, (ii) the implications into the design process and (iii) the user perspective.

CODIFIED AND EMPIRICAL LANGUAGE AS OPPORTUNITIES FOR ENRICHING THE SENSORY COMMUNICATION

This research contributes to achieve more knowledge about the sensory language. At the beginning of this dissertation, sensory language was considered a

strategy to convey simple messages (especially if it is refer to the static features) such as:

- Functional and ergonomic: how product should be handle and use.
- Product personality: e.g. the product gender or character
- Semantic interpretation: describe the proportion of the product's value that is attributed to its utility. It refer to how the product appearance makes sense to the viewer in respect to the consumer's personal, cultural and sensory experience.

Nowadays, thanks to the development of new materials and technologies, sensory features can be dynamic. Previous studies demonstrate that sensory language based on dynamic sensory features can convey more simple information that change over time (Colombo et al., 2013; Colombo 2016). This research, contributes to add another layer for the design of sensory language; like words, senses can be designed in order to emphasize emotions (empirical language) or to convey a specific message (codified language). (Fig.1 e Fig.2)

Figure 1. The focus of my thesis: 1D language (in which exist the distinction about codified and empirical language) and 3D language (based on sensory language as defined at the beginning of this thesis).

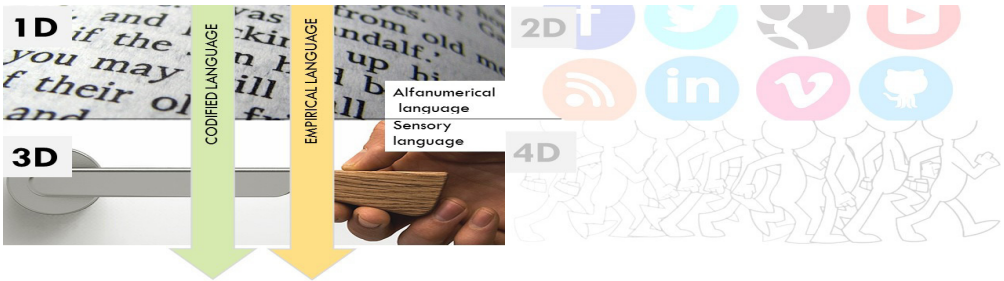


Figure 2. The tentative of this thesis is to transfer knowledge from the 1D language (alphanumerical language) to the 3D language (based on the sensory language)

Designing for the codified language instead of empirical one have different implications. Establishing materials dialogues through codified code give prominence to the message and to the communicative intent of the products. Designing for the empirical language means to underline the product experience and to focus on meaningful interaction.

During this dissertation, I have presented some projects resulted from previous researches that can be analyze according to the two languages pointed out in this thesis. Particularly, during previous study (Colombo et al., 2013) about sensory dynamic features 12 case studies (about sensory language applied to saving resource field) were collected (see the scheme p. XX). These case studies are representative of the sensory language and therefore they do not mention the distinction of codified and empirical language. As soon as I have verified- through the two design activities- that it possible to talk about codified (sensory) language and empirical (sensory) language, the twelve case studies have been classified according the codified and empirical language. Figure 3 represents visually the classification of these case studies and their affinity with codified language or the empirical one.

Figure 3.Classification of 12 case studies according the codified and the empirical language.

Looking to the figure 3, it is possible to observe that the sensory language is mostly used as a codified language. Several products convey information applying cultural codes, such as changing their color from green to red recalling the traffic light. Other projects (like Eco Drop Shower presented in the Chapter VII) decode information about the water consumed translating numerical data to specific stimuli

(Eco Drop Shower change shape according to the water consumed). As discussed in the chapter VI, messages can be codified though dynamic sensory features using different strategies (using cultural and conventional code or unconventional codes), thanks to these case studies, this difference is more evident.

During this thesis the codified and empirical language were considered in contrast to each other. However, it is possible to observe that there is a rich design space between the codified and the empirical language. Few products face the empirical language but they cannot be properly considered examples of it. This group of products, that is in between the empirical and the codified language, provided not just information but provide a kind of experience according to the consumption. For instance, Flower lamp (Fig.4) changing its shape creates different light effects in the surrounding environment. The ambient from brighter (when the lampshade is open) becomes even darker (when the energy consumption is unsustainable and the lampshade is closed). As a limit, the experience provided by Flower lamp is day by day the same: its material changes codify a specific amount of energy consumption.

Figure. 4 Flower lamp by interactive institute of Sweden.

According to the definition given at the beginning of this dissertation, the dialogue based on empirical language is a form of expression that create individual meanings and it is able to evolve over time influenced by the behaviors of the actors. Only F.E.E.L. can be considered a clear example of empirical language, which creates a loop between the user action and the product reaction, and vice versa. As a main feature of this product is that, the provided experience is able to transform interaction between product and user from time to time. F.E.E.L. reduces progressively the time of stimulation to lead users to have shortest showers.

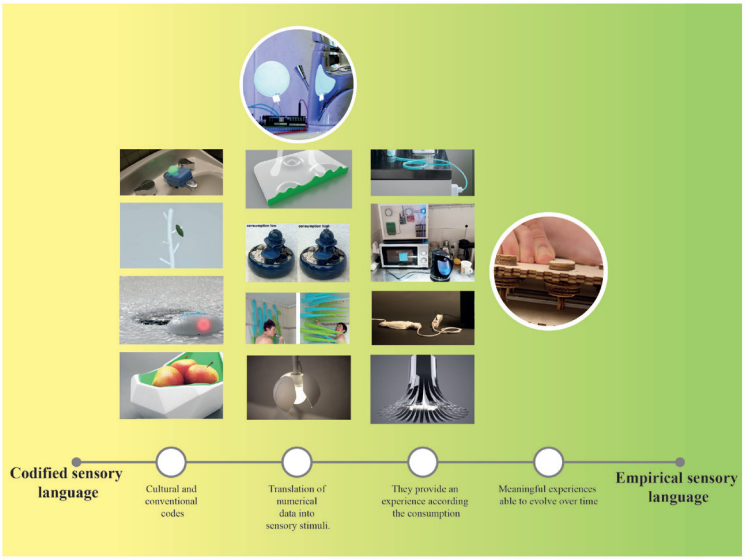


Figure. 5 Shade between the codified and the empirical language

DESIGN IMPLICATIONS

Two different design activities were organized, in order to understand the implication of introducing the codified and the empirical language into the design process. The results can be discuss in three themes: codified language implications (i), empirical language implications (ii), and designer's skills required (iii).

Codified language implications

As mentioned above, the first design activity is focused on the exploration of the codified language that makes a correspondence between a signifier and significant. The designer have two options for designing changeable sensory features in order to codify the message. The first one is to use conventional and cultural code (the traffic light is still an example), like Water pebble described in the Chapter VI (Fig. 5).

Figure 5. Water pebble

Another option is to define a set of parameters useful to convert the message from one form to another. During the development of the concept Glass of water, a set of specific parameters were defined in order to find new ways to inspire designer in the concept phase. They were defined as Metrics, Frequency and Representation. These rules focused on the translation from numerical data on water consumption to qualitative data convey through the product's materiality. These guidelines are specific for the context and they are based on previous works in the field of resources conservation. Talking about the design process, the designer has to perform some investigations in order to find out the appropriate set of rules according to the design context. Even if sensory language is able to convey several information, the interpretation of product sensory features cannot be univocal, but it make sense within groups of people belonging to the same culture or to the same historical period (Crilly et al., 2004). To overcome this issue, it is important that the resulting parameters take into consideration the users' perception and understanding. Within this aim, the designer has to involve users into the definition of such parameters (i.e. making some test with users or users' observations). In this dissertation, the parameters are the result of a literature research that has considered and analyzed twelve studies in which tests with users are provided. However, it is important to involve users also at the end of the design process, since, sometimes users can misunderstand the resulting concept or such project has sense for a cultural group but not for other.

Empirical language implications

The second design activity explored the empirical language. Empirical language refers to create meaningful experiences and interactions between product and user. Thus is important to set some users' exploration before create the design concept. Firstly, it is important to understand the current experiences and the usual interactions that are provided by the examined product (in my case the shower tray), and then reflect on the design for improving and enrich the usual interaction in order to create meaningful experiences for the user. Only with a deep users' explorations the designer can gain the knowledge needed to understand where, when and how the interactions – as dialogues between the users and the products- and the provided experiences can be re-designed in order to generate new meanings and sense into the users' minds. Designing for the empirical language means to be familiar with the circle of correspondences that involve physical properties of products, the user's actions on, or with, the product and his/her mind. All these actors contribute to

creation of meanings (Figure 2).

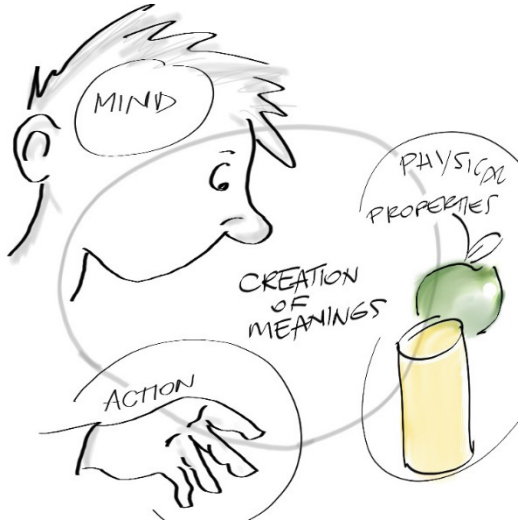


Figure 2. Influence of the physical properties of the objects on the user's actions on, or with, the product, and the creation of meanings in the user's mind. (Image based van Dijk, van der Lugt and Hummels, 2014).

In this research, two tools were used in order to investigate the current experiences and interactions between the users and the shower tray in their usual routine: Diaries and Videos.

However, it is important to involve users also at the end of the design process, in order to evaluate the overall experience and the users' understanding.

Designer skills

Industrial designers usually think and design physical feature in terms of product usability putting more effort into the 'hard' features of the project. Doing so, they overlook the 'soft' issues related to what a product says about itself, its functionality and feedbacks that can be conveyed through its materiality. In order to lead designers to design for both - 'hard' and 'soft'- features of the products new knowledge has to be learnt and new design tools have to be designed.

The two activities performed during this research light up the importance (for the designer) to develop skills both in the technical field and in the user experience field.

As a technical skills required, I can list:

- Knowledge about new materiality of things (computational and functional materials)
- Ability to develop interactive prototype (using microprocessor like Arduino or Raspberry)
- Know the limits and the implications of using sensors, actuator etc… to

control the interaction process

About the user experience, designers have to learn:

- How to perform a user research. Designer need tools and knowledge about the user exploration (diaries, video etc...)
- Tools and methods to explore product experiences
- Knowledge about how to design with senses. Different senses have different meanings. For instance, the sense of smell is strictly connected to people's memories or vibration instinctively alarms the user.

In previous researches, my research group and I have created new tools aimed to transfer some of these knowledge in a more intuitive and easy way. Two maps were designed: the sensory map and the Smart Material for Sensory Experiences Map. The sensory map collects all the sensory modalities and media that product materiality can use in order to convey a certain message to users (Fig. 3). For instance, in the sight category, sensory media consist of changes in the emitted light, in the shape, in the color of the object, and so on. The aim of the map was not only to visualize the possible product sensory transformations, but also to be used by designers as a supporting tool during the concept phase. In this thesis, the sensory map was useful during the development and the analysis of the concept phase resulting from the first design activity.

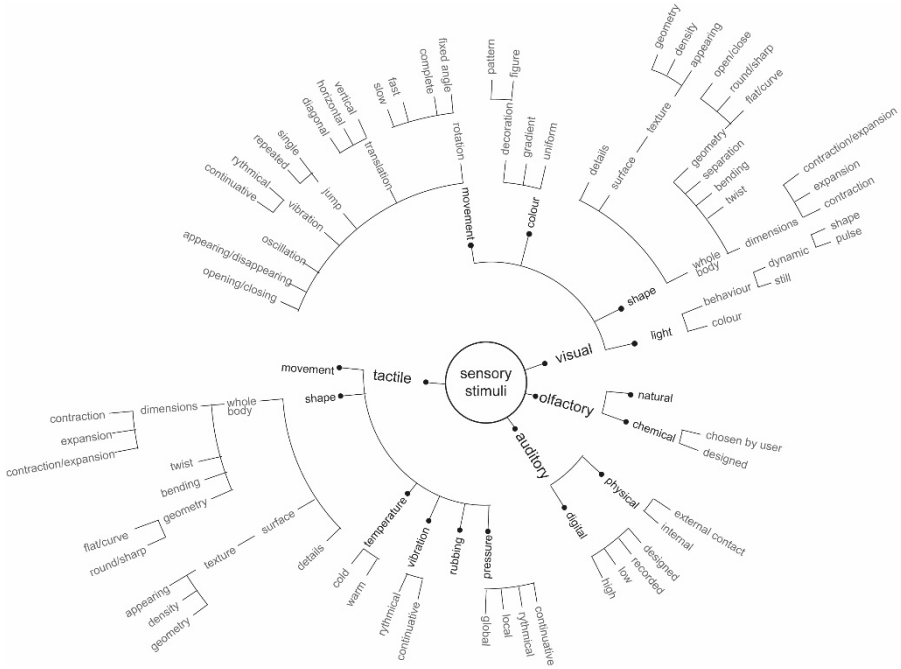


Figure 3: Sensory map Source: Colombo and Rampino, 2013

In order to support designers to achieve knowledge about senses and smart materials, the author created the Smart Material for Sensory Experiences Map - SM4SE map - (Fig. 4) which is a tool aimed to create a relationship between the sensory changes- that the designer intends to obtain- and their feasibility with smart materials. This tool should be intended as a practical aid for the designer's activity. However, in order for the tool to be effective, designers would benefit also from more detailed knowledge on smart materials' features and applications. For this reason, authors developed specific lectures about smart materials and dynamic sensory features to couple with the SM4SE map, in order to give designers a background knowledge useful for the design of these new materiality. If you want to gain more information refer to the journal article: *Bergamaschi, S., et al. Material and immaterial: new product experience; The International Journal of Designed Objects, Volume 10, Issue 1, March, 2016, pp.11-22.*

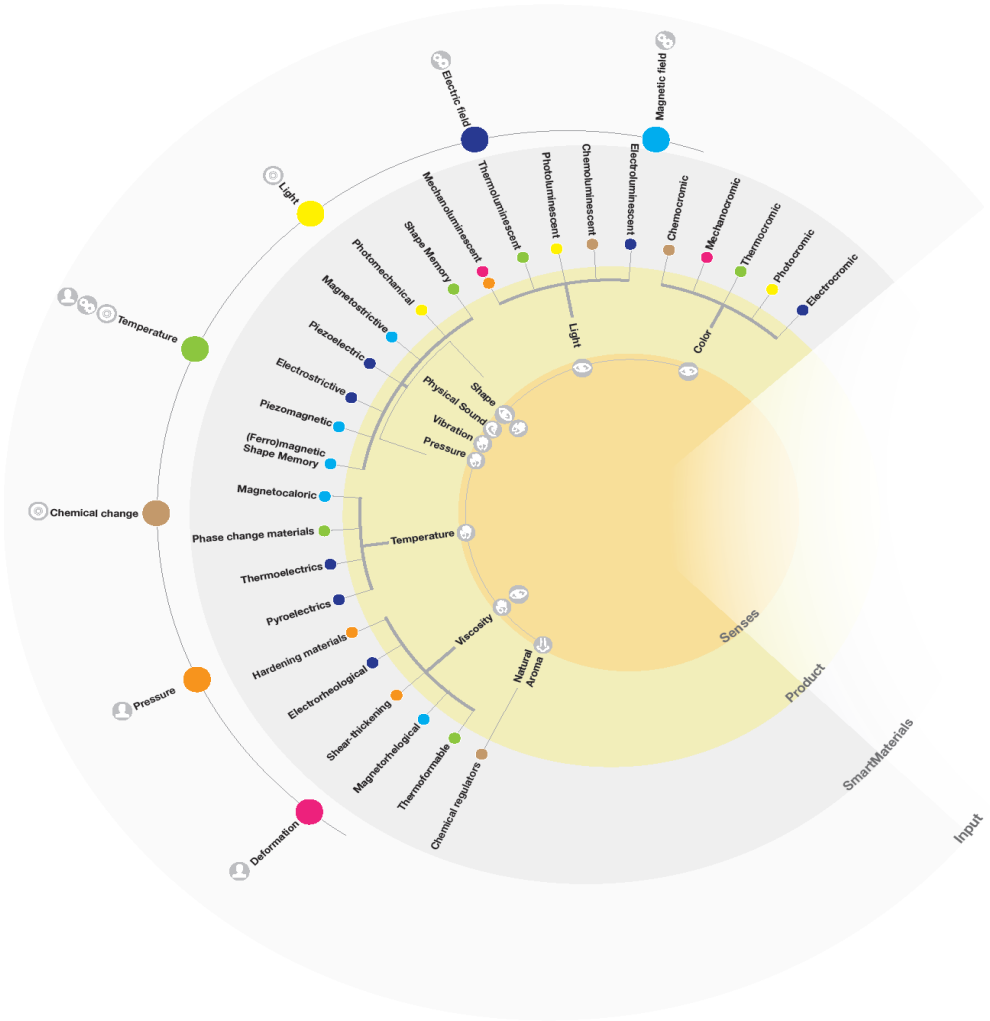


Figure 6: Smart Material 4 Sensory Experiences Map Source: Bergamaschi, S., et al., 2016.

USERS' PERSPECTIVE

Thanks to focus groups, feedbacks from users were collected in order to assess the two concepts and the application of the codified and empirical language.

In general, users evaluated positively the two concepts. Both the projects were evaluated as novel, original and unusual (compared to the objects that they have in their home). However, participants evaluate the project F.E.E.L. as more innovative. During the focus groups, it was observed that most users perceived the novelty of the products most they looked forward to interact with it.

Talking about the clarity of the communicative intent, it emerged that the communicative intent of Glass of Water is more evident and immediate to users. However, it emerged that the users feel more comfortable and familiar with using conventional codified colors that not require any explanation to be understood. Meanwhile, the communicative intent of F.E.E.L. requires extra explanations and the interaction in the real context can help the understanding of the overall project. These findings discussed on a general level- including also the analysis of the twelve case studies- open new reflections on their application:

- Codified language aimed to establish clear, immediate and evident dialogues between product and user. These kind of language is applied in two situation: when the functionality of the object is strictly connected to the information (i) (such as Water pebble, Fig.5); or to enrich the functionality of the products (ii) (e.i. Power cord, presented in the chapter III).
- Looking at the cases studies, it is possible to observe that cultural codified code are largely used when the functionality of the object is based on the communicative intent, meanwhile if the information can be a layer of the products, there are some tentative to translate numerical data with unusual sensory stimuli.
- Empirical language refers to the whole product. It is not just an informative layer that can be applied on artifacts but it refers on the overall experience of that product.

The concept F.E.E.L. was perceived by the participants as more able to motivate them to change their behaviors. The learning process was judged as: subtle, intimate, and linked to the personal sphere. On the contrary, the learning process provided by Glass of water was judged as cognitive and intentional, so it was perceived as something that is looking them and evaluating their behavior.

During the three focus groups, participants had interesting discussions about the usage of numbers (provided by screens), codified code and empirical

language. Codified language is perceived by the users close (or comparable) to digital interfaces, meanwhile empirical language is perceived as something new that brakes with usual experiences. When I invited them to discuss about the Glass of Water concept, they compared the message provided by the light with messages that they received from the metering system.

LIMITS AND FUTURE RESEARCH

This research focused on languages, based on product's materiality, applied to the saving resources field. Chose an application field was useful to focus the research on a specific situation but at the same time it encloses the investigation on specific issues. Thus, I believe that future works could considering others specific contexts in which it is important inform users in a clear and immediate way (codified language) or in subtle and personal manner (empirical language). For instance, in the healthcare sector or as a learning tool for children.

Activities performed in this investigation aimed to achieve more knowledge about such languages overlooking the exploration of their effectiveness on user's behaviors. In the theoretical investigations, it was assumed that engaging users during the interaction is a fruitful strategy to support and motivate householders to change their behaviors. Studies on emotions give evidence of the power of positive emotions to influence user's behavior (Fredrickson and Cohn, 2010), that means that the positive engagement can lead, day by day, the user to be more sustainable (saving resources in the domestic context).

During the focus group, it was observed the enthusiasm and fascination of users (especially about the concept F.E.E.L.) but is not sufficient to claim that one language instead of another can be more persuading over the long period. So far, a long period test is impossible, since prototypes are simulations and they cannot be tested in the everyday environment. Prototypes need to be implemented with sensors and actuators in order to make them functioning and testable in the houses of users. Indeed, further studies are required to test the effectiveness of codified and empirical languages as a strategy to influence users' behaviors over long period.

At the beginning of this thesis, the need of exploring new languages and new form expression in the interaction design field was presented (Moggridge, 2007; Ross and Wensveen 2010). These real needs have motivated this research. However, the results of this thesis cannot be interpreted as a novel language but they can be considered as a little step into the investigation of a sensory language as a rich, versatile and engaging form of expression. This research wants to encourage

product designers to go further and to explore different fields of knowledge that can generate novel forms of 'cross-fertilization' among disciplines in order to contribute to the creation of new languages.

References

Bergamaschi, S., Lefebvre E., Colombo S., Del Curto B., Rampino L.; Material and immaterial: new product experience; The International Journal of Designed Objects, Volume 10, Issue 1, March, 2016, pp.11-22. Article: Print (Spiral Bound). Published Online: January 8, 2016.

Colombo, S. (2016). Dynamic Products: Shaping Information to Engage and Persuade. Springer.

Colombo, S., Rampino, L. (2013) Beyond Screens. Exploring product dynamic features as communication means. DeSForM 2013

Colombo, S., Rampino, L., & Bergamaschi, S. (2013). What Are You Telling Me? How Objects Communicate Through Dynamic Features. xCoAx2013, 129.

Crilly, N., Moultrie, J., & Clarkson, P. J. (2004). Seeing things: Consumer response to the visual domain in product design. Design Studies, 25(6), 547-577. doi:http://dx.doi.org/10.1016/j.destud.2004.03.001

Moggridge, B., & Atkinson, B. (2007). Designing interactions (Vol. 14). Cambridge, MA: MIT press.

Ross, P. R., & Wensveen, S. A. (2010). Designing behavior in interaction: Using aesthetic experience as a mechanism for design. International Journal of Design, 4(2).

Vallgårda, A. (2014). Giving form to computational things: developing a practice of interaction design. Personal and Ubiquitous Computing, 18(3), 577-592.

Vallgårda, A., & Redström, J. (2007, April). Computational composites. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 513-522). ACM.