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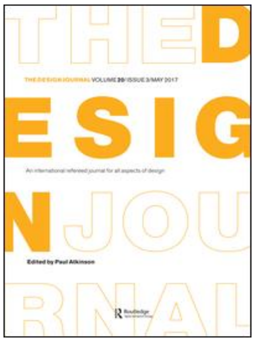
Abstract



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Designing Material Interaction To Promote Water Saving. An Exploration Of Sensory Language.

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Abstract: The present research aims at exploring the potentialities of applying a sensory language for the creation of meaningful interactions leading householders to decrease their water consumption. To this end, a Research-through-Design approach was applied and two functioning prototypes were developed and tested. The first one, "Glass of Water", explores the use of a sensory language as a codified one: a light decreases its brightness according to the amount of water consumed, so recalling the idea of a glass of water getting empty. The second prototype, "F.E.E.L.", investigates a sensory language that does not convey information through the recall of conventional symbols. It creates instead a dialogue based on the interaction between the product and the user. The two prototypes were tested during three focus groups. In this paper, the implication to design for a sensory language and the results coming from the users' investigation are presented and discussed.

Keywords: sensory language, material interaction, water saving

1. Introduction

In industrialized countries, easy access to water causes overconsumption for household purposes. Gleick (1996) estimated at around 50 liters per person per day the amount of water needed for basic household activities (i.e. cooking and cleaning, excluding gardening). However, the World Water Council declares that in some developed residential areas, such as in North America and Japan, the daily per capita use of water is around 350 liters: this is 7 times as much as Gleick esteem. In Europe, the average of water consumed is estimated at 200 liters per person every day (WBCSD, 2009). Studies have shown the importance of informing users about their water consumption in order to increase their awareness of - and motivation for - saving resources (Darby, 2006; Darby, 2010; Fischer, 2008). With this aim, various smart meters are now on the market. The majority of them interact with users through 2D screens that provide mostly visual and cognitive stimuli. It has been argued that the diffused presence of screens showing digital information has the effect to make us lose some of the richness offered by the material world that the human species has evolved in.

On the other side, in recent years 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” or, as Vallgårda and Redström define them (2007), “computational”. Thanks to smart 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 liquid 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 dialogues with users through their sensory features, defining a novel “sensory language”. Previous studies demonstrated that the use of a sensory language instead of an alphanumerical one could be a fruitful strategy to engage users during the interaction with products (Colombo, 2014).This research aims to explore the sensory language for the creation of meaningful interactions leading householders to decrease their water consumption.

2. Interaction as a dialogue

The technological evolution makes products smart, dynamic and interactive. Dynamic 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). For this reasons, recent studies introduced the idea of a fourth dimension of products: the dimension of time (Vallgårda, 2009).

“An interaction is a transaction between two entities, typically an exchange of information” (Saffer, 2009). Indeed, in the Cambridge dictionary, an 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). Thus, the main aspect of an interaction is that both the involved subjects have to be reactive and responsive to each other. For this reason, we assume that users and products should be related to each other in a circle of influences: the object with its (changing) material features (shape, weight, color, etcetera) affects the user’s behaviors and thoughts, and vice versa.

The idea of a transaction between two entities in an interactive relationship and the idea of an exchange of information over time is also at the core of the definition of “dialogue”: “A conversation between two or more people” (http://www.oxforddictionaries.com/definition/english/dialogue). To converse means to “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” (http://dictionary.cambridge.org/dictionary/english/conversation). In these definitions, it is possible to find several correspondence between an “interaction” and a “dialogue”. Both 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). This sharing creates a cycle of correspondences between actions and responses that is inherent to the human use of artifacts.

2.1 The importance of the language

Each dialogue – and, consequently, each interaction - is based on specific language. In the interaction design field, Moggridge (2007) categorized four languages 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: music, cinema, and animation.

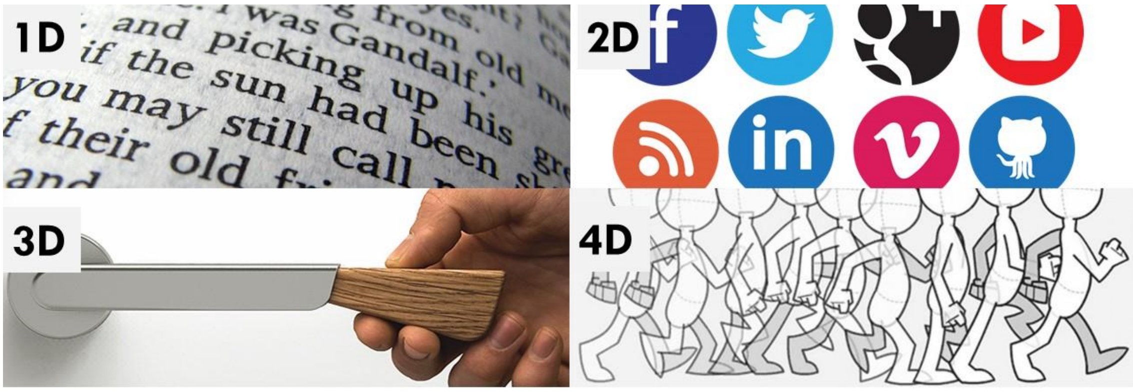

Figure 1. Representation of the four languages

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 a system (products or digital interface) and a user. We believe indeed 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 (Merleau-Ponty, 1964; Philip, 1966; Krippendorff, 2005, p. 20-21)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 studies by Merleau-Ponty (1964), we defined *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. On the other side, we defined *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 we are industrial designers, 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. As an example, the concept Scent of Time (Fig.2) is a clock that releases a different smell in the environment at each hour.

Figure 2 Scent of time by Hyun Choi

3. Objective

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.

The chosen field of application is that of the responsible consumption of water in the domestic environment.

4. Methodology

Given its experimental nature, this research applies a Research-through-Design approach. During the research, two design activities were organized in order to develop and tests design proposals based on the insights coming from the theoretical investigation.

The first design activity explored the sensory language as a *codified language;* the second activity explored the sensory language as an *empirical language*. As a result, two functioning prototypes were developed: “Glass of Water” and “F.E.E.L.”(Feelings and Experiences for an Embodied Learning).

The two prototypes were tested with users during three focus groups, organized with the aim of exploring the interests, feelings and engagement of the users as well as their understanding of the information conveyed through the material changes of objects instead of through the alphanumerical language.

5. Design activities

5.1 Glass of Water

The first design activity focused on the exploration of a codified language that creates a correspondence between a signifier and significant. In the field of semiotics, this correspondence is called “code” (Socco, 1996). Specifically, Lachman et al.'s defined a 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." (1979, p. 68)

In brief, codes specify how information is to be converted from one form to another (Durgee, 1986).

Literature review and the resulting set of parameters

Firstly, a literature review was performed in order to define a set of specific communication parameters. The objective of this initial investigation was to find new ways to inspire designers in the concept generation phase. The result is not a simple set of requirements to follow but a list of opportunities/limits for the application of the sensory language to convey certain kinds of information.

Even if the general focus was on the exploration of materiality and of tangible aspects of products, in this initial phase also studies performed in the field of digital interfaces, persuasive technologies and interaction design were considered. Indeed, in the above mentioned fields, several studies have already investigated the importance of giving feedbacks on energy consumption, and some of this studies tried to give suggestions to designers facing this matter. Only studies reporting results on users investigation were considered, since our intent was to explore the user understanding of the contents of the dialogue. As a result, 12 studies[1]were selected and analyzed in deep, and three main communication parameters were defined (Bergamaschi, 2015):

- Metrics (related to the unit of measure). It was observed that is batter to transmit qualitative information instead of quantitative ones (such as: “Today your consumptions are good”; instead of “today, you have consumed 120Kwat”).
- Frequency (related to the timing of the data: when and how many times it is necessary to give information to users). It was observed that users need continuous information instead of having information only when something happen (in a good or in a bad way)
- Representation (related to the “shape” of the data). Some studies underlined the importance of visualizing information through metaphors or analogy (e.g. recalling the nature). Moreover from these studies emerged the importance of giving positive information in order to support the motivation of users to change their behaviours.

Of course, the main design request was that any of this parameter had to be communicated through the products dynamics features, to make the product itself a media for conveying information about the user’s consumption.

Concept Description

Glass of Water takes inspiration from the study carried out by Gleick (1996), in which he estimated the basic requirement of water as 50 liters per person per day.

The concept consists of a set of little spheres that can be connected to all the faucets of the house. Any sphere is conceived as a meter of the water consumption for a given faucet in the house (from the kitchen to the bathroom/s). The aim of the set of spheres is to tell users the correct amount of water they should use (50 liters), by means of a blue light (Fig. 3). Any sphere change its brightness

[1] 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.

according to the total amount of water used. Any time the user turns the water on, the spheres gradually lose their brightness to show that the amount of water suitable for the domestic activities is decreasing until ending (the light turns off). Spheres remind users that they have not an unlimited quantity of water at their disposal.

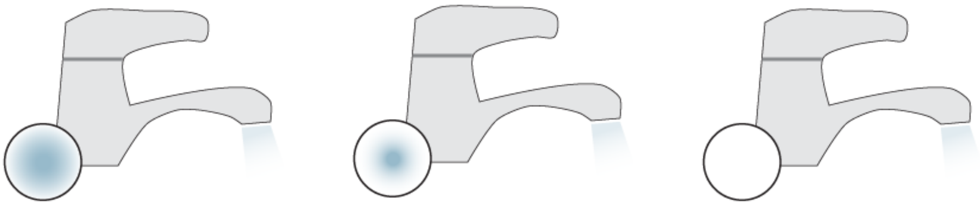

Figure.3 concept of Glass of Water

A prototype was developed, based on an Arduino board that control the brightness of the sphere's light (Fig. 4).

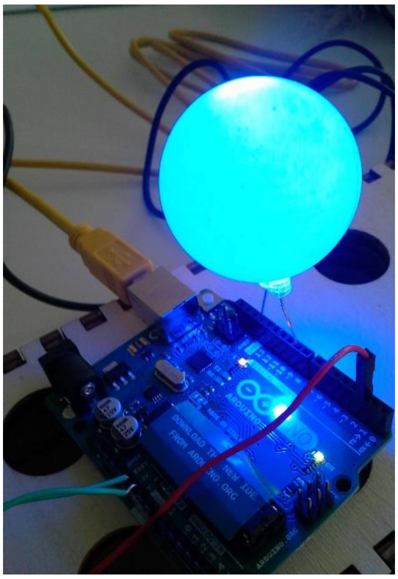

Figure. 4 Glass of water prototype

When the faucet is not used, the light is tuned off (Fig.5); as soon as the water is opened, the light gives information about the amount of water that can be still consumed. When the consumption of water exceed the 50 liters, the light does not react anymore until the day after.

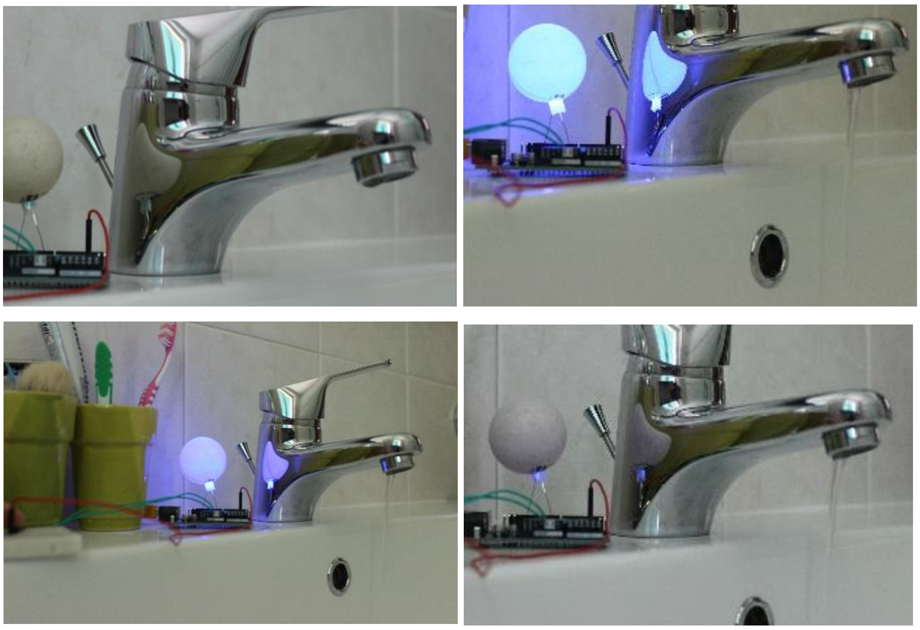

Figure.5 Glass of water storyboard

This raw prototype aims to be representative of the language. Thus, its functionality is simplified.

5.2 F.E.E.L.

The second design activity was focused on the empirical language based on the idea that meanings are created by the user during the interaction with the product.

During the development of the concept, we retained useful to apply the principles of Embodied Interaction. Indeed, according to the theories of Embodied Interaction, there is a circle of influences among the physical properties of the products, the user's actions on/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 are 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 of influences opens up a new space for designers: creating dialogues using the material properties of artifacts is not just to codify information through 3D shapes; it could be a strategy for creating personal dialogues between users and products, which encourage reflection-on-action and the creation of new meanings. Due to the complexity of the process, 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. The focus of this second project was to create engaging and meaningful tactile experience provided by the design of an interactive shower tray, which is able to effect the users' behaviours, influencing them 'in the situation'.

Preliminary research

An users' observation 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 userswere organized in order to gain some insights on: (i) users' behaviours, (ii) tactile feelings and (iii) users' emotional experiences. Video recording was used as a tool for exploring the users' feet behaviour 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 (Bergamaschi and van Dijk, 2016). At the end of this phase we collected 4 videos and 4 diaries.

Concept Description

Thanks to the users' observations described above, useful insights were gained referring to: (i) the shape of the shower tray, (ii) the materials' selection, (iii) the design of new behaviours and scenarios. These suggestions were conveyed into F.E.E.L. (Feelings and Experiences for an Embodied Learning). F.E.E.L. (fig.6) is a squared shower tray that change its shape in order to create a new routine into the shower. F.E.E.L. is composed by an external structure and some soft "pins". These pins pop up randomly according to different rhythms, creating each time a novel tactile experience as a sort of feet massage.

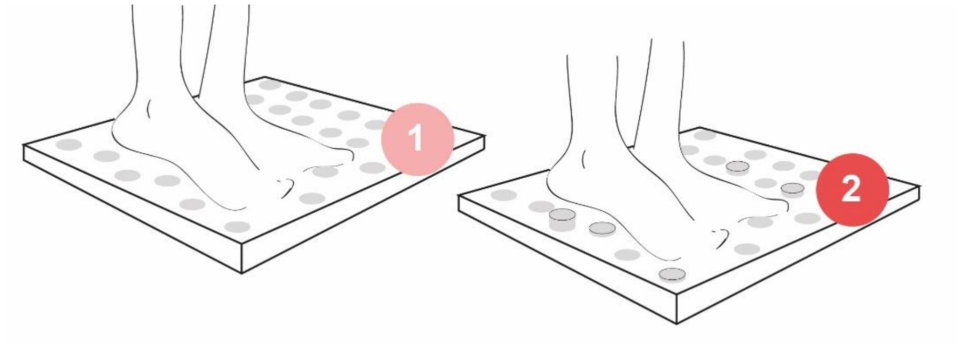

Figure 6. F.E.E.L. layout

Moreover 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. This way, from one side F.E.E.L. emphasizes the fast user movements during a short shower; from the other, it gives a relaxing feedback for the longer showers.

In order to lead users to decrease the time spent under the shower and the consequent usage of water, the system will over time decrease the durations of the stimuli in an imperceptible way (we can measure them in seconds). Indeed, it is important that the user feels as he/she has always the same routine and he/she perceives the same experiences during the shower. Over time, F.E.E.L. creates a dynamic coupling between the user's action and the responsive shower floor. A relationship may be created between the actual time spent under the shower and the temporal pattern of the tactile stimuli provided by the floor. Day by day, this relationship will be perceived as the usual routine.

We created a raw prototype in wood, steel and soft material. The general measure of the prototype is 40*40*5 cm (W*H*D). Wood pins are moved by a cam system made by a cylinder of steel and laser cut wood (Fig. 7).

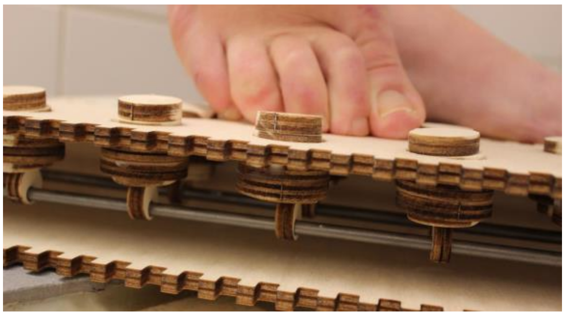

Figure. 7 F.E.E.L. prototype

This raw prototype aims to be representative of the language; its functionality is simplified.

6. Tests with users

Three focus groups with users were organized in order to collect feedbacks about the two concepts. The first focus group aimed at presenting to users the concept "Glass of water" that is an example of codified language. The second one aimed at collecting feedbacks about the concept FEEL that applies an empirical language. In a third focus group, both the concepts were presented in order to let users compare the two languages.

6.1 Organizations

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 who is not familiar with the topic of sensory language. Moreover, we decided to involve people who lives alone and who already manage his/her consumptions.

Each focus group lasted 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 fiveopen questions aimed to investigate the following aspects: (i) the engagement that they perceived with the concept, (ii) potentialities and limits of the concept and (iii) how the concept could fit in their daily life.

6.2 Results

As a result, testers focused on two main aspects of the proposed concept: (i) the novelty factor and (ii) the clarity of the communicative intent.

Novelty factor

Both the projects were evaluated as novel, original and unusual (compared to the objects that testers have in their home). However, participants evaluate the project F.E.E.L. as more innovative:

"It proposes an unusual experience"; "This project is more cool!"; "I have never seen something like that!"

Glass of water was perceived as less surprising and similar to digital interfaces with some limits in the communicative intent. It was observed that the novelty factor influences the enthusiasm of the users to have a trial with the prototype in the real contest.

Clarity of the communicative intent

Comparing the two projects, it emerged that the communicative intent of Glass of Water is more evident and immediate to users; as mentioned above, this project was perceived as similar to digital interfaces but with the limit to give only qualitative data. Meanwhile, the communicative intent of F.E.E.L. is not immediate and it requires extra explanations. However, 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 water to save it! Meanwhile, F.E.E.L. helps me to relax and enjoy my shower. Water consumptions are up to me!"

7. Conclusion

In the saving resources field, researches on smart meters and digital displays have shown some influence on users' behavior (Froehlich et al., 2010; Kim et al. 2009; Darby, 2006). But, more detailed investigations show that the situation is complex: numerical feedbacks may fail in taking into account 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). Moreover, they do not helps users' in having a wider understanding of theirs' behaviors (Niedderer et al., 2014). Another limit of visual displays is that they require the householder to look at them (often a small LCD, or a web page) regularly, to check the consumption trends. To overcome such limits, studies carried out in different domains (interaction design, aesthetics of interaction, ambient display, and visualization of data) have explored more sensorial ways (change in color, in light, in form) to give information about the amount of consumed resources.

With our research, we aimed to contribute to achieve a "cross-fertilization" between features that traditionally apply to the alphanumeric language and the sensory 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 two concept of codified and empirical language were first identified. Then, two design concepts were developed to 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 results shown that designing for a codified language or for an empirical one have different implications into the design process and also in 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 (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 possible fruitful strategy to motivate him/her to reduce his/her consumptions.

As a limit, prototypes developed in this research have to be considered as a research prototypes. Future studies have to be made in order to explore the implications of using such material features in the industrial process.

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