NordDesign 2018
August 14 – 17, 2018
Linköping, Sweden

A Design Model Roadmap for a Multisensory Experience

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Abstract

Designers have traditionally had two main foci: enhancing aesthetics, which is designing products pleasurable to the senses, and the functionality of products. A good design achieves several objectives: attracts consumers, communicates, and adds value to the product in terms of quality of usage experiences associated with it. The designers' ideal is to generate more positive psychological and behavioral responses regarding their creations. However, many of the design processes are visually oriented. Therefore, the purpose of this paper is to provide a tool to integrate different sensory modalities during the design process. To achieve this, it is necessary to understand the way in which visually impaired perceive the environment and translate the inputs that they could provide during the design process, called Multisensory Design Model Roadmap.

***Keywords:* HMI/ Cognitive Ergonomics; Multisensory design, Design process, Visually impaired, Inclusive design**

1 Introduction

How people perceive most of what surrounds them is mainly designed to be attractive through their sense of vision. Nevertheless, in this visual world, designers have been challenged to capture human perception through other senses such as audition, gustation, olfaction, and touch (Schifferstein, 2011). According to the World Health Organization, there are 285 million visually impaired around the world. So, if design has been mainly visual and the tendency is to focus on the experiences offered to the other senses, how could designers learn from people who lack of sight? Nowadays, designers are thinking of Universal Design, which is to design for all. If things are well designed, the accessibility provided to people that couldn't use it without a proper design also turns out to be beneficial to other users.

All the sensory information that humans receive while interacting with a product may affect the user experience, the consumer, and his consuming behavior (Schifferstein & Desmet, 2008). To enhance pleasant experiences with products, recent research has been pointing out toward multisensory design. Multisensory design is an approach taken by designers who become aware of the messages conveyed through the different sensory channels and their contribution to the overall experience (Schifferstein, 2011). Engaging several of a customer's senses in a congruent manner (e.g. the feeling of the package is congruent with the product's taste) develops product appreciation and loyalty (Spence & Gallace, 2011). Companies have realized that adopting a multisensory design approach is a prerequisite to connect with customers. As a result, affective or emotional engineers deal with individual user needs when designing a product drawing upon multisensory skills (Aziz, Husni, & Jamaludin, 2010).

Neuroscientists have already demonstrated that the brain's plasticity allows other senses to be intensified when one is lacking (Rangel et al., 2010). For instance, for the visually impaired, hearing plays a prominent role in navigation, allowing to locate objects and obstacles. In addition, after the eye, the hand is the first sensor to pass on acceptance (Spence & Gallace, 2011). Considering the brain's ability to adapt, the question that arises is: how do visually impaired perceive the world? The assumption is that if there could be a better understanding of their world, there could be a design process that would offer a more emotional experience for the senses.

To gain more insight into this matter, a literature review was performed to understand how visually impaired perceive the environment. It is well documented how sight allows to get detailed information and identify objects at a long distance (Rangel et al., 2010). However, there is a gap because design researchers have not focused on a multisensory design approach taking into consideration the insights that visually impaired could give.

The purpose of this paper is to explore multisensory design from a new angle. To achieve this, a conceptual approach was taken. With this paper, some light could be shed on how the world perception of a sighted person and one who is visually impaired complement each other. In other words, the contribution is a framework to use multisensory design to achieve a more integrated design process, in terms of being more appealing as well as more inclusive. This framework is denominated: the Multisensory Design Model Roadmap. The intention is that the designer will have a tool to design for all the sensory modalities. This first attempt is expected to lay the groundwork that will lead to future studies regarding design for impairments in general that will derive in beneficial designs for everybody.

The paper is organized as follows: after the introductory section, the theoretical foundations will be presented. The third section will describe the research method that will lead to answer the question that was raised. In section 4, the proposed framework will be presented. Section 5 contains the conclusions.

2 Universal Design

Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design (Persson, 2015). When something is being designed to be used by all, it is necessary to consider individuals with sensory (i.e. visual or hearing) or cognitive impairments and physical limitations. It is also important to think of users of different ages (i.e. children and older adults) and socioeconomic status. Accessibility is a moral imperative. Making a design accessible leads to universal design. Universal design is frequently a win-win because a proper design for a specific group will become into a side benefit for the rest of the users. The designer must think of the potential challenges that these different groups face and how his design choices impact the way information will be presented.

Is it possible for the visually impaired to develop an equivalent spatial representation as the sighted? Morash et al. (2012) claim that people come to understand space and how objects and persons are located within only through the perception and interaction with that space. It has been demonstrated that equivalent spatial representations can be reached through touch (for visually impaired) and vision (for sighted).

It is necessary to introduce the sequential perception, which is considered to be the nature of touch (also known as serial or successive). This means forming a mental image of a place by the addition of parts which the visually impaired gets to know piece to piece. On the contrary, the simultaneous perception is associated with minimal hand movements. This is also related to objects that fit within the hand. As Morash et al. (2012) state, "The movement from part-to-part observed when touching an object is similar to the behavior of moving from place-to-place to see areas beyond view. Touch is sequential only for objects that are large relative to the field of touch, like vision is sequential for objects that are large relative to the field of view." Then, it can be concluded that the result of sequential movements either of vision or touch will not necessarily be a fragmented representation of what is being seen or touched. It was also stated that equivalent spatial representations can arise from touch and vision, due to the functional equivalence that these two senses have. It might only take longer to extract spatial representations through touch than vision, which is more efficient in this context, but the produced representations are not inferior.

2.1 Human-centered design

Human-centered design is an approach to develop systems that focus on the users' needs and requirements (ISO 9241–210: 2010). There are four main activities that designers perform in HCD: 1. Understand and specify the context of use; 2. Specify the user requirements; 3. Produce design solutions; and 4. Evaluate the design.

According to (WATSON, 2017), common system design models, such as the system modeling language (SysML), typically represent human users and operators as external actors, rather than as internal to the system. HCD is a design process that focuses on creating designs based on information about the people who will be using them. It is an extension of User-centered design by considering not just the end user but all the humans that will be involved in the system, either in the interaction with it or affected by it. In addition, it allows to understand the role of the user during early system design. Given the above, a designer who wants to provide a multisensory experience should consider the needs and requirements of a great range of people, which includes considering people that might be impaired.

3 Cognitive Engineering as Research Method

In order to identify the state of the art of research in the area of multisensory design, the principles of Cognitive Engineering were considered. This is a multidisciplinary field that focuses on improving the fit between humans and the systems they operate. It is concerned with the analysis, design, and evaluation of people and technology. It combines knowledge and experience from cognitive science, human factors, human-computer interaction design, and systems engineering (Gersh, McKneely, and Remington, 2005). It comprises methods to describe, model, and simulate processes that can be used in the solution of systems engineering problems.

The problem that arises in this context is that the inputs from visually impaired might be subjective (e.g. feelings, thoughts). These inputs should then be translated into objective outputs that will allow to have a multisensory experience when using a product or service. Cognitive engineering then allows to sketch the Multisensory Design Model Roadmap taking into consideration the needs and requirements of the visually impaired because it provides structured methods for data collection and analysis. In addition, the use of cognitive engineering enables to display the steps to gather the information in a visual tool. This will allow designers to make decisions regarding the creation of the systems, such as the sensory information that wants to be transmitted and the materials to be used. This will derive in positive future system performance that will include all the people, as the universal design claims.

3.1 Tracing the requirements with Systems Modeling Language

The Systems Modeling Language (SysML) is a general-purpose graphical modeling language for specifying, analyzing, designing, and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities (Hampson, 2015). It is used to convey four main aspects of a system, which are requirements, behavior, structure and parametrics. Regarding this research method, SysML is the way in which the requirements from the visually impaired people are organized.

4 From perception to emotion: paving the way to multisensory design

One of the main purposes of our senses is to inform us about the properties of the environment that are important for our survival (Hekkert, 2006). According to Sternberg (2010), perception is a set of processes by which it is possible to recognize, organize, and understand the sensations coming from environmental stimuli. Percepts are mental representations of a received stimulus.

There are perceptual illusions which indicate that what is felt through the senses is not necessarily what is perceived in the mind. James Gibson, an American psychologist that contributed to the field of visual perception, provided a structure for understanding perception. He introduced the following concepts: distal object, information medium, proximal stimulation, and perceptual object. The processes of sensation and perception are part of a perceptual continuum where the distal objects (objects in the environment) offer the structure for the information medium (sound waves, chemical molecules, tactile information, or reflected light). Then this reaches the sensory receptors to finally get to the internal identification of the object (perceptual object).

Complementary to this view is the constructivism, which claims that perception is based on three main factors: sensory data (what is perceived through the senses), previous knowledge (what the person already keeps in his mind), and high level cognitive processes (what can be inferred). The first step in the multisensory integration process occurs when information is gathered through diverse sensory modalities and synthesized by the brain. The connections from the different sensory systems must converge onto individual neurons (Lim et. al, 2011).

Our sensations tend to be dominated by the modality that provides the most detailed and reliable information about the environment. The loss of one sensory modality (i.e. vision on a visually impaired) results in an increased use of the remaining intact sensory systems (i.e. tactile and hearing). Tactiles have always needed associated audio data (Landua and Wells, 2018). To get further information from photos or graphics or to understand the context of a tactile diagram with Braille legends, it is very likely that both sighted and visually impaired might need an audible explanation. Neurons that would normally respond to visual stimulation can be reallocated to serve other sensory modalities when visual input is entirely absent (Eimer, 2004).

Figure 4.1.A represents the sequence of the multisensory processing which derives into the integration of the information received. As it is exemplified in Figure 4.1.B, an environmental event causes stimuli (e.g. an image and a sound). Then this information is received through the senses, which are the receptors (e.g. vision and hearing). Then it converges into a multisensory neuron, which allows the integration of the different pieces of information to occur. Convergence is understood as the moment when information from different modalities meets. After the multisensory processing, perception occurs unleashing a specific behavior or recording a specific memory.

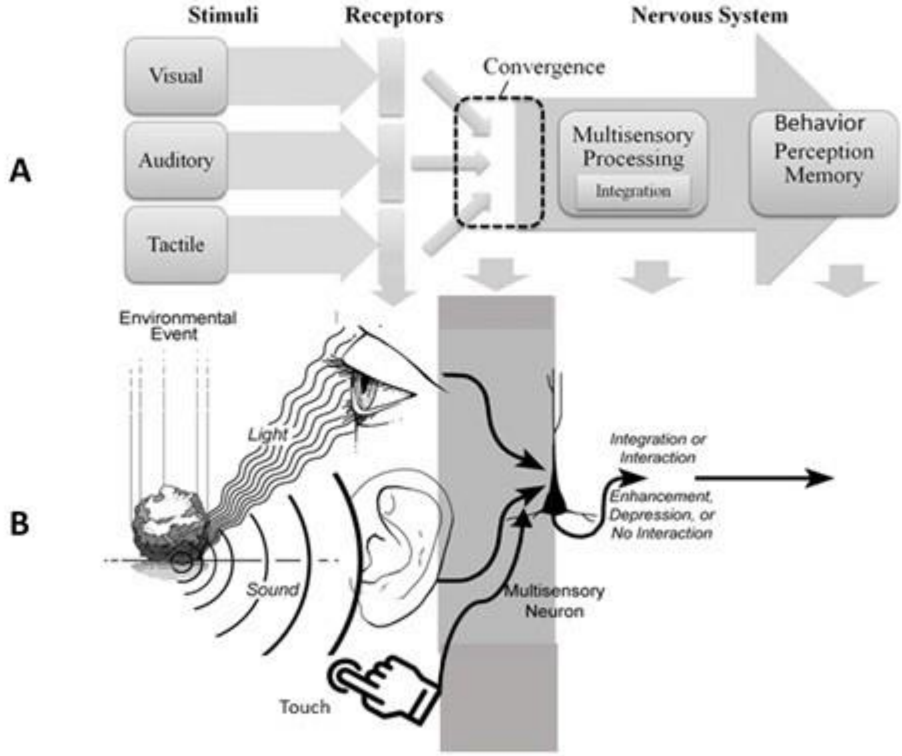

Figure 1. Model of the multisensory processing. Source: Adapted from Lim, Keniston, and Krzysztof (2011) and CiosLab.

The above given example could be applicable to a sighted individual. Yet, the question that arises is how the perception varies within the brain of a visually impaired due to the absence of the visual stimuli.

4.1 Multisensory design process integration

Given that blind people can develop a perception of the world equivalent to the perception of the sighted, some useful tools to design using a multisensory approach are presented. Schifferstein and Desmet (2008) claim that the final success or failure of a product depends on the ways in which all the senses are stimulated. The sensory information that people receive may affect the product perception, cognition, experience, and behavior. A product can have an aesthetic response (evoke pleasure) because of its beautiful appearance, pleasant sound, good feeling when being touched, or nice smell. Yet, many design activities have focused predominantly on the sense of vision. Intuitive designers are those who are able to develop more engaging products, understanding this as a source of multisensory stimulation.

There are certain levels of experience that a person might be exposed to: perceptual, aesthetic, meaning, and emotional. At a perceptual level, the person describes the properties of the stimuli (e.g. a sound is loud or soft). It answers the question: what do I sense? At an aesthetic level, the stimuli are given a judgment based on beauty (e.g. a sound is nice or nasty). The appropriate question is: do I like what I sense? At the meaning level, cognition has an important role (Desmet and Hekkert, 2007) because expressive characteristics or symbolic significance can be given (e.g. a sound is elegant). It should answer: what does the sensory information mean? Finally, at an emotional level, affective phenomena are considered (e.g. a sound is surprising, satisfying, inspiring). The person should ask: how does it make me feel?

During the design process, the design team should be aware at early stages of the sensory impressions the product should evoke. There are four categories of capabilities that designers can develop (Schifferstein and Desmet, 2008):

1. Sensory sensitizing: Designers should train themselves to explore objects with their non-visual senses in order to enhance sensitivity.
2. Sensory sampling: Designers can have an object collection that may serve as a source of inspiration. This collection might also be digital (auditory information and haptic feedback devices).
3. Sensory building blocks: Designers use systems that describe the structural properties of sensory information.
4. Sensory communication: All the people involved in the design process (i.e. technical experts, consumer researchers, marketers, etc.) need to understand the design intentions to be able to propose technological solutions. To facilitate this type of discussions, tools such as sketches, maquettes, mood boards, storyboards, animations, or videos can be used. Intuitive designers can also make sound, smell, and touch collages in addition to the visual ones.

At the end of the designing process, products will always provide sensory feedback given through its material properties. Sometimes, designers have to provide the feedback that will make the user understand what is happening, as in the case of electronics (e.g. beeps when a button is touched). Designers may also share some of their design freedom by providing the user the opportunity of interacting with the product and making decisions (e.g. choosing the volume). Whichever the feedback, products should communicate a coherent message. Consumers tend to prefer products for which different pieces of sensory information duplicate or complement one another (Schifferstein and Desmet, 2008). It has to be easy for the user to understand what the product is, what it does, and how it works.

It is important to acknowledge that designers have to avoid unexpected elements that might cause an aversion reaction. These unexpected elements might be potential sources of distress when experimenting the product. Sensory discrepancies should be small in order to improve product evaluations. This will happen only if the product is well known. Through a multisensory approach, the designer opens up the possibility of avoiding communicating conflicting messages and allowing the user to enjoy the product more intensely.

4.2 The Multisensory Design Model Roadmap

Based on Schifferstein and Desmet's (2008) tools for multisensory product design and on Chen and Chuang's (2014) study about the expressing vocabulary of tactile feeling, the main contribution of this paper is the Multisensory Design Model Roadmap, as is presented in Figure 2. This paper extends Schifferstein and Desmet's thoughts of how a designer could be better prepared for a multisensory design process through this roadmap. Designers will have to go through several steps in order to offer a multisensory experience with the system (i.e. product or service) that they come up with.

The Multisensory Design Model Roadmap comprises four main aspects which are divided in nine steps. These aspects are: to provide stimuli (steps 1-2), understand emotions (step 3), have a common sensory communication (steps 4-6), and make an integrated design (steps 7-9).

1. Environmental impressions: The objective is to sensitize designers. They must answer: "What impressions do I get from all the senses?" Designers must make an environmental exploration. They have to pay direct attention to the feel, sound, smell, and taste of the objects they are exploring and consequently give detailed descriptions. They can use multiple tactile exploratory actions: lateral motion, pressure, static contact, unsupported holding, enclosure, contour following, function test, and part motion test. Keen visual inspection may also be used.
2. Sensory collections: The objective is to have a sample of different objects. Designers should answer: What samples (i.e. objects, smells, tastes, sounds) could serve as sources of sensory inspiration? A multitude of objects can be used as a source of inspiration. Designers must search for interesting multisensory stimuli. The storage of sensory information is recommended for future references.
3. Understand emotions: What were the evoked feelings? Designers should try to identify which emotions were provoked (pleasure or displeasure).
4. Facilitate discussions: Does everyone understand the same? Establish common ground on what was answered. Use different tools to facilitate discussions (e.g. sketches, sound, smell, and touch collages)
5. Align terms of sensory characteristics: Are there any sensory standards? It is important to research if there are standardized systems in which the previous collections could be categorized. For instance, there are standardized systems that describe colors in terms of hue, saturation, and brightness (e.g. Pantone Matching System); or sounds in terms of time, frequency, and amplitude (e.g. sound spectrums). It is also suggested to reach experts, such as trained flavorists or perfumers, to teach further on the analyzed objects.
6. Vocabulary choice: What is the expected vocabulary to be used when describing our product? Designers have to align with the company's marketing strategy. In this step, they should choose the specific wording that they want their customers to use when referring to their product. They might even choose the main categories for the expected product description (See Chen and Chuang, 2014).
7. Design for all senses: How is all the information integrated in the design? Designers must be able to translate all the sensory information and emotions that were obtained in the previous steps. They should think specifically of not designing exclusively for the sense of vision.
8. Send a coherent message: What sensory information duplicates or complements to send a coherent message? Designers must test if the information is congruent or if

there are conflicting messages. Unexpected sensory elements are allowed only if they are not that drastic in order to avoid an aversive reaction. The unexpected elements should surprise but not create an overwhelming impression.

9. Select materials: What materials will transmit the desired tactile feelings and image? For the production stage, designers must also specify the materials that will reinforce the coherent message. They should consider not only the tactile feeling but also the different sensory modalities when possible.

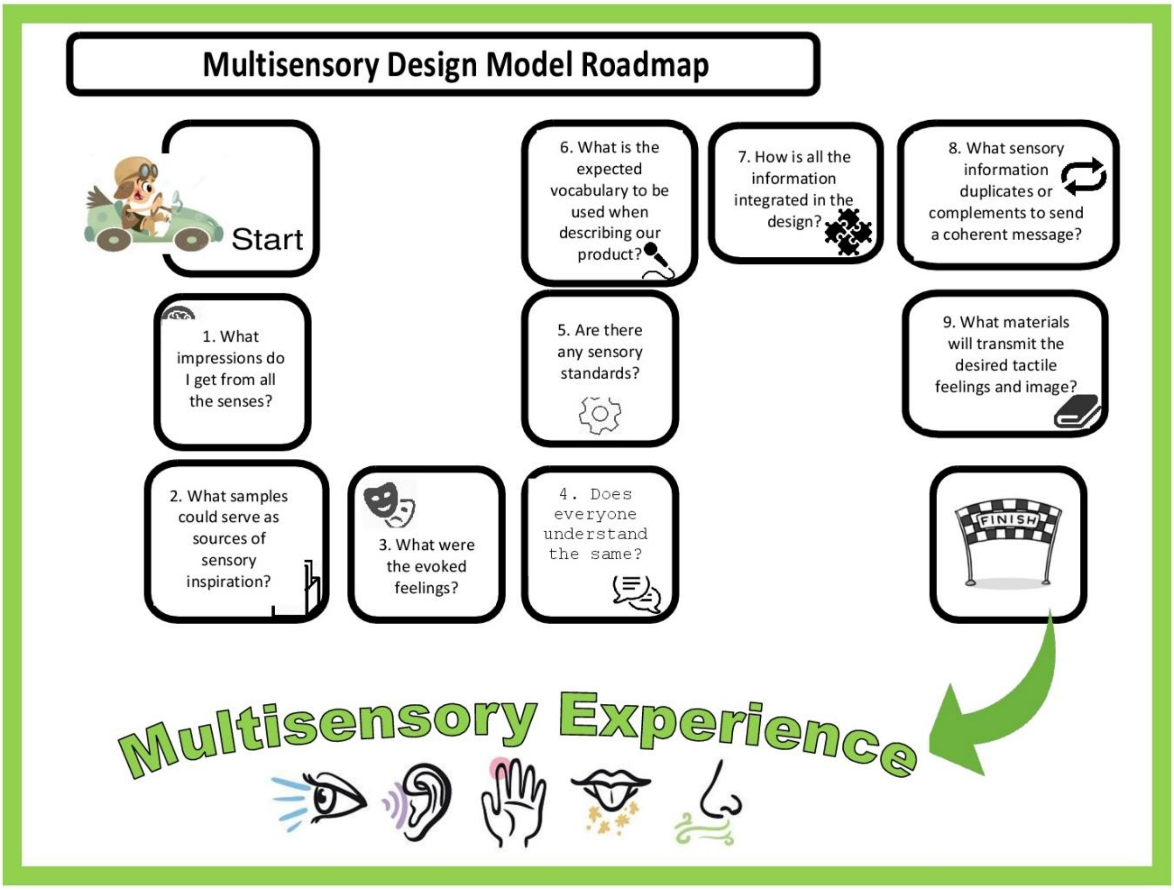

Figure 2. Proposed Multisensory Design Model Roadmap. Source: Elaborated by authors.

5 Conclusion

A literature review to explore how the world is differently perceived by visually impaired and sighted people was made. It was understood that a multisensory integration process occurs when one receives different stimuli from the environment. Then, the information meets, which is known as convergence. It is afterwards processed in a multisensory neuron, where the information integrates. That allows to have a perception of the environment, create memories, and demonstrate a behavior in reaction to those stimuli.

It was also researched that the blind can and do perceive and represent space in a functionally equivalent manner from the sighted people. Research has also demonstrated that the brain's plasticity allows neurons to be reallocated to serve other sensory modalities when one is lacking. This derives in keen senses of hearing and touching as is the case with visually impaired people.

The main contribution of this paper is the proposal of a Multisensory Design Model Roadmap that can be applied in product design processes to come up with more integrated designs that will be more inclusive at the same time. The Multisensory Design Model Roadmap is based on the requirements of visually impaired people to have designs that are oriented to all the sensory modalities and not only to be vision oriented, as it has traditionally been.

A questionnaire will be applied in future research in order to make a comparison between the sensory wording used by a visually impaired and a sighted person. The objective will be to provide a pool of words or phrases to choose from for the step of Sensory communication of the Multisensory Design Model Roadmap. The hypothesis is that visually impaired will present a larger amount of sensory words for the solicited descriptions.

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