Sensory Reflection towards Product Design Ideation

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Abstract

As humans' information processing abilities, have become more and more disconnected from their senses due to an increasing quantity of abstract information, so have design processes. There is a demand for designers to include human sensation as part of engaging product forms and experiences. This qualitative case study explores the role of senses and their potential use in design ideation. A literature review of related theoretical and pragmatic perspectives and a survey of 15- 20 product examples that provide unique sensory experiences are analyzed and sorted through four sensory design strategies: *Sensory Augmentation, Conversion, Transition and Isolation*. Using the four strategies as core concepts, *a Sensory Reflective Framework* with a mindful focus on sensory appreciation and translation is proposed to support designers' ideation in creating unique product forms and experiences. The paper reports the process and findings of a sensory ideation workshop which was conducted based on the framework, and further discusses the development and implications of the framework in supporting designers' sensory ideation.

Keywords: Sensory reflection, Sensory design, design framework, ideation, reflective practice, industrial design

Human senses are natural ways to gather information from our surroundings. The way we see, smell, hear, taste and touch, molds our perception of an object or the outside world. However, growing technologies and urbanization have led people to become disconnected from their sensory capacities. Further, human senses are increasingly neglected in information-gathering and decision-making processes when people yield the role of their senses to cognitive, reasoning capabilities. Humans are often oblivious to sensory stimuli and related information in their surroundings unless deliberately made aware of it. This qualitative design case study proposes a framework for using the five human senses (sight, smell, sound, touch and taste) within an industrial design ideation process for building emotionally engaging product forms and experiences.

Sensory modalities can still serve as a primary touch point through which people receive information about their environment and products with which they interact. 70% of UK and US Millennials crave experiences that stimulate their senses (JWT Report, 2013); these sensorial experiences can be augmented by considering new concept creation of products and brands, as an integral part of innovation (Currano et al., 2011). Although it has been well-

acknowledged that senses play a role in effective product design, research has found that perceptual processes for all people are not identical (Haverkamp, 2011). Thus, there is value in research that can systematically employ the characteristics of sight, smell, sound, taste and touch as a part of a design process.

Grounded in related bodies of research on human sensory abilities from psychological and design perspectives, this study aims to understand the practical and emotional significance of sensory experience in human-product interaction. The assumption that undergirds this research is that designers' deliberate focus on sensory inputs could be developed through their reflections on related experiences and associated meanings toward the development of novel product concepts.

Research Methodology

The concept, *sensation*, as defined in this research, refers to the processes of sending and receiving information through human sense organs. The Greek philosopher, Protagoras, as early as in 450 B.C, described man as a bundle of sensations, underlining the assorted senses and their manifestations in human perception (Watson,1907). Without the diverse effects of the senses of seeing, hearing, smell, taste and touch, our lives would be uninspiring.

In his book, *Sensual Relations* (2010), David Howes observes that sensory history dates to the 16th century, a time when people were more attentive to smells and sounds (Febvre, 1982) and visual cues were more significantly considered. A glimpse of our imaginative past can help us to project future trends by understanding the preferences of the earlier era. Historical precedents for the value of sensory data in human survival as well as quality of life provide a context for this focal research topic, Sensory Reflective Frameworks.

The current case study is a qualitative method of inquiry reflecting two key features of qualitative research, such as understanding the various perspectives on sensory perceptions in real-world settings (understanding the context based on the environment around us) and constructing hypotheses or concepts from the available data.

Qualitative case study approach for Sensory Design

Senses play a crucial role in a human-product experience because of our "intimate familiarity" with them (Fenech & Borg, 2006). This qualitative case study is undertaken to learn the underpinnings of sensory studies by backcasting[1](Robinson, 1990), seeking an understanding of the relationship of senses and emotions and how they are manifested in design. This study investigates various literature data sources and conducts a survey of products that exhibit sensory properties readily (characteristics exhibited by each of the senses like color, texture, temperature etc.,). Together, these approaches led to an awareness of how the senses prevail in design and in other fields; the combined approaches also revealed the methods by which these senses are employed. This study of the literature concludes that sensory qualities could be considered intentionally and productively by employing the sensory strengths within industrial design ideation.

[1] Backcasting was a method used in Planning outlined by John. B. Robinson. This form of scenario planning was used to explore possible futures by construing the past 20 – 100 years. (Robinson, 1990).

Significance of Research

This research topic is unique in not only proposing a framework which is original to this study, but also in probing how the framework could support designers consider rich and unique sensorial experiences in a product ideation process. Providing a context for the framework described in this thesis, there are other design theories that reference the role of the human senses in the design process. Chang (2006) offers perspective on using gestalt theory to help create innovative ways to design and use multisensory displays; Haverkamp (2011) stresses the importance of connections between multiple sensory faculties for product design; Lee (2013) evaluates the multisensory product-user experience in different scenarios; Schifferstein (2006, 2008), bases his work on awareness and contribution of messages obtained from different sensory channels; and Zuo (2001), examines the psychological responses by humans to material texture and sensitivity, lending theoretical support for this research.

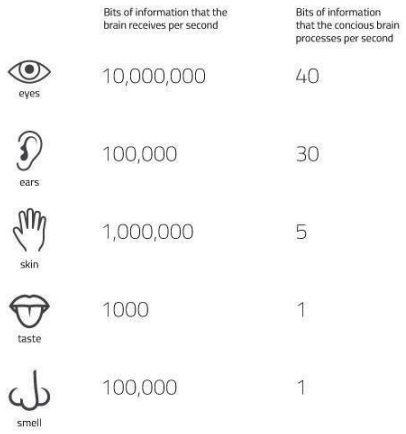
Literature Review

Sensory Integration in Psychology

As designers, we are gestalt[2] thinkers; we are constantly organizing the fragments of sensory inputs perceived from the external environment into patterns based on nine principles similarity, continuation, focal point, figure-ground, belongingness, balance, proximity, common fate, closure (Chang & Nesbitt, 2006). This helps our brain process the bits of information into a whole, to understand and navigate through our everyday processes.

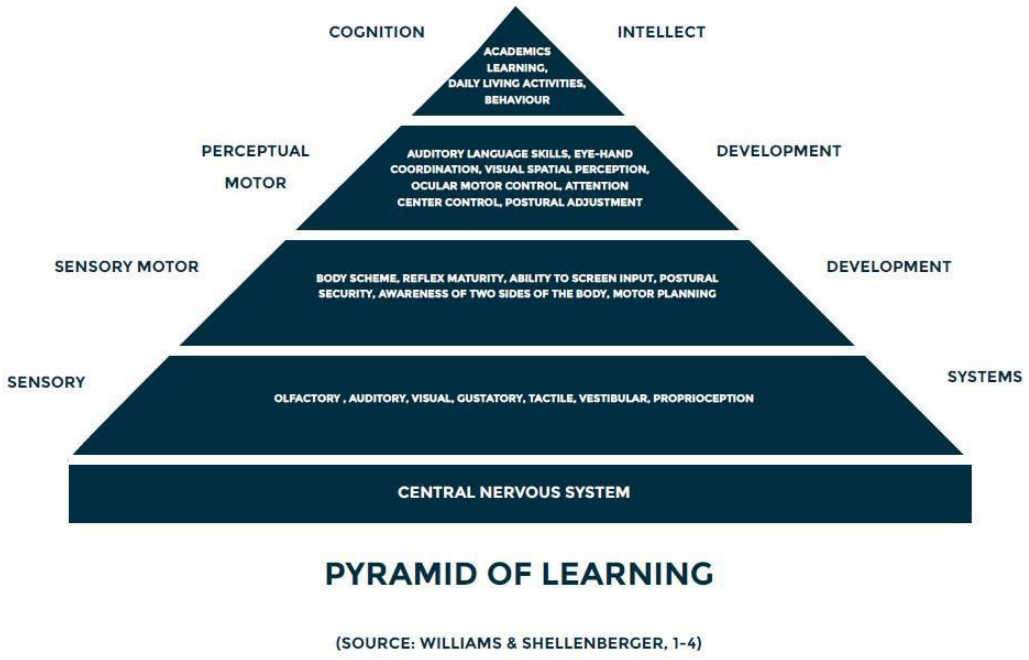
We are constantly processing information obtained from our senses through our nerve impulses to the brain. The brain filters out information into what is necessary and what is not. It is interesting to compare the relation between what is received and what is processed consciously in terms of their amount. The table below shows this relation with respect to the five senses (Figure 1).

[2] Gestalt Psychology suggests that we make strong and meaningful connections from the information we perceive in the chaotic world (Feinberg, 2013). The original idea was introduced in 1890 by Christian von Ehrenfels.



(Figure 1. shows the comparison of the amount of input to output data processed every second by the brain through the human sense organs (Shaffery, 2016))

We can see that vision is the most used sense, but only 1 out of every 250,000 bits of data received by a human eye is considered useful. The same ratio applies to the other senses. As a designer, it is very important to comprehend this information and maintain a balance of signals going into the senses to avoid sensory overload.



(Figure 2. illustrates sensory integration as a foundation for learning (Williams & Shellenberger,1996))

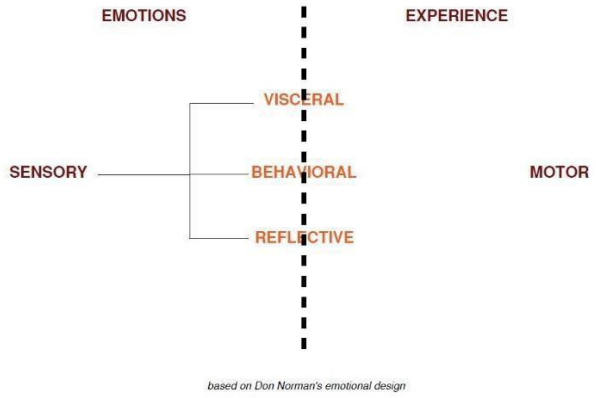
Sensory data is the most fundamental aspect of information processing in human perception and experience. Human beings evaluate their everyday experiences through one or multiple sense organs and we are familiar with how the perception of colors is different

from the depth of an object. The pyramid of learning by Williams and Shellenberger (1996) (Figure 2) explains how sensory systems work as the foundation for integrating information intake and processing in our body before being further translated into perception and cognition. This bottom-up process demonstrates how the information received from our senses develops into other forms of perceptual, behavioral, cognitive systems. This pyramid identifies the apex to be emotional or intellectual process, which requires the understanding of sensory behavior that can in turn be leveraged into creating emotionally driven artifacts.

Senses and Emotions

Emotions are complex bodily sensations felt as we encounter pleasant, unpleasant or neutral changes that occur after the information from our sense organs within our body are processed. We make meaning of the existing environment through an input (perception) and output (action) oriented system. Sensory data can either validate or disrupt thinking patterns. Research shows that design evokes emotions in the user through habitual use (Eyal & Hoover 2014). People love or hate a product based on how it evaluates over the categories of visceral (how things look, feel etc.), behavioral (effectiveness and usability), reflective (meaning of things) (Norman, 2004) (Figure 3).

Take for example, a stainless beverage cup which is aesthetically pleasing to the eyes, but the condensation on the surface while serving a cold drink or the surface heat on pouring a hot beverage makes it unpleasant to use. It is at these times that we need to consider the visceral aspects (Sight, smell, sound, taste and touch) of a design for the promise of its future usage, which are channelized into valuable experiences and meanings.



(Figure 3. explains how sensory inputs are used to feel, understand ease of use and make meaning in a design (Norman, 2004))

(Figure 4. shows children interacting with nature in hospitals using Wondersphere by Bresslergroup (Core 77, 2016))

The concept of emotion-driven design is relatively new in the industry. Wondersphere is one such experiential, multisensory initiative proposed by Bressler Group: the sealed mobile chamber (Figure 4) provides a playful and healing environment with added emotional benefits for hospitalized patients and immune-compromised children so that they can interact with nature by digging in the soil and playing with nature without any risk of infection. We can neutralize one or more of our senses temporarily to heighten the others for intended effects. Clearly, psychologists, anthropologists and other professionals have studied the importance of understanding the manifestation of sensory characteristics in their fields to make meaning of this *arational*[3] process of human sensations. How human senses gather and process information has been explored, but ideating for an unconscious behavior (Kamil & Abidin, 2014) like these sensations is an *arational* process that is rationalized in this design case study. One of the concepts explored through this inquiry is how the meaning-making process of research can be achieved through reflection on a portion of the familiar data or the whole body of data collected. This paper goes on to propose the concept of 'Sensory Reflection', in the next section, an original thought process that developed through this study.

Reflective Practice Using Our Senses

According to Schön (1983), reflective practice is a form of thinking and a process of continuous learning which involves paying attention to the important details of everyday activities and carefully reflecting on these patterns. Schön describes three types of reflective practice:

Reflection-in-action: This is a phenomenon which helps in developing a deeper understanding of the problem through thinking while acting.
Reflection-on-action: This is a reflection of our thoughts after the practice is done.
Reflection-on-practice: This is a combination of both first and second types of reflective practice.

[3] Arational by definition is philosophical idea that is not within the domain of what can be analyzed by reason. (WikiDiff, 2017)

This design case study finds that the knowledge gained through reflective practice based on sensory information is significant for helping a designer to critically examine their own design process. The result of the sensory reflective practice is a more personal and creative solution to design problems. The Pilot Design Workshop, described later in this paper, further elaborates how this method of self-reflection in ideation was tested. The current study proposes a novel form of creative self-reflection in design by adding a sensory component to the design problem to generate a wide range of solutions.

Sensory Reflection as a Form of Design Ideation

The developments in technology require designers to continuously better their design processes and methods in correspondence with a new design environment; thus, a designer's reflection on current practice is a crucial part of the improvement. Reflection as a designer means to step back and break down one's own process by defamiliarizing a familiar design subject and context, reframing related problems, and speculating about different perspectives on it (Reymen, 2001; Schön, 1983).

As suggested in this study, the integration of sensory data in designing novel products and experiences could be approached from the view of 'reflection in action' (Schön, 1983). This would be accomplished by a designer in bringing conscious sensory awareness' to a design process and reframing diverse sensory modalities and related human behaviors to product forms and interactions. In this vein, a '*Sensory Reflective Framework'* is proposed for supporting designers' reflection on human sensory faculties and their related meanings in product design ideation. In what follows, four strategies to deliberate the practice of '*Sensory Reflection*' to product design ideation are described as the core concepts of the proposed framework.

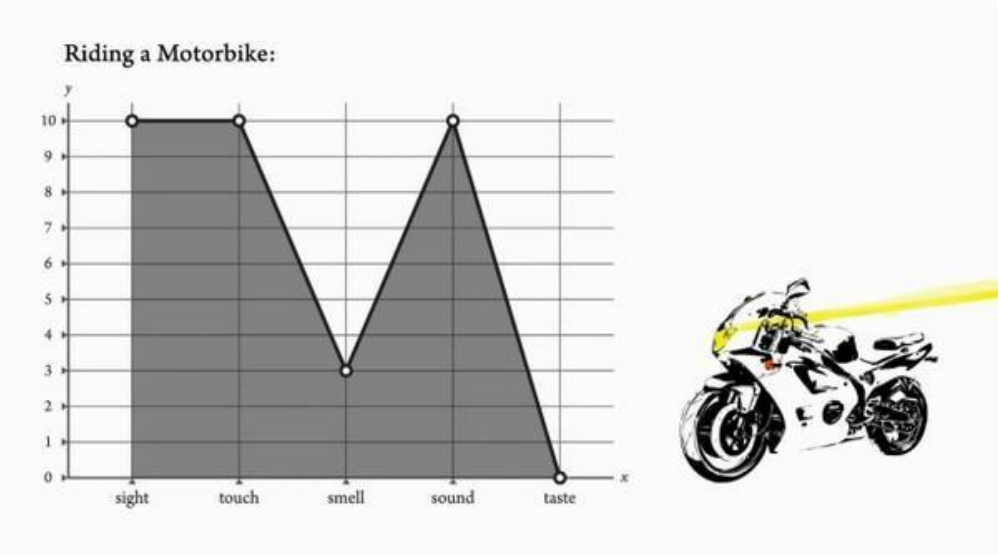
Grounded in the previous research, Sensory Reflection can be delineated as a reflective design approach with which a designer can intentionally create a new sensory experience based on how human sensory faculties receive and treat information. In this design case study, a designer's self-reflection is pursued in order to consider many non-physical aspects (Razzaghi, 2005) of designing that may be influential to the design process, and ultimately, significant to users' needs. To this end, a questionnaire was created to explore, reflect upon, and redesign the *Sensory Reflective Framework.* The next section explores different sensory design guides that offer insight on the value-opportunity gaps to further this research work.

Various Sensory Design Guides and Product Examples

There are very few design guides that elucidate the role of human senses in product design process. There have been studies that present theoretical perspectives related to human sense, but most of them center on evaluating sensory qualities of existing products, rarely informing a generative process to ideate novel product concepts in terms of how to consider and use human senses.

Five Senses Graph

Senses have been employed as a form of evaluation for human-product interaction: for example, the 'five senses graph' by the Industrial designer Jinsop Lee (2013) shows Lee's sensory experiences with his everyday product interactions. Evaluating sensory experiences on a scale of 1- 10 (1 being the lowest involvement of his senses), Lee collected data for 3 years using a journal. The wider area under the graph indicates higher sensorial qualities of a product (Figure 5). Lee's graph was meant to evaluate and compare sensorial experiences with current products rather than informing new product design in terms of how to consider and manipulate design elements relevant to human senses.



(Figure 5. shows five senses graph by Jinsop Lee shows a motor bike was evaluated on scale of 1-10; smell and taste was the least accounted for senses in transportation design (Lee, 2013))

Tools Facilitating Multisensory Design

Schifferstein and Desmet propose '*Tools facilitating Multisensory Design'* (2008) to support designers' new product ideation with novel ways of providing sensory stimulation and feedback through designs. They develop a matrix with four tools that a designer needs to consider — *Sensory Sensitizing, Sensory Sampling, Sensory Communication, Sensory Building blocks*. They raise designers' attention to the significance of multisensory design. However, they do not specify how to handle multiple sensory perceptions and sensory systems in design ideation to create intended product experiences.

Synesthetic Design

Michael Haverkamp in his book, *Synesthetic Design* (2011) details the theoretical aspects of sensory perception and distinguishes ten different sensory modalities- Visual (seeing), Auditory (hearing), Olfactory (smelling), Gustatory (tasting), Vestibular (sense of balance and body movement), Tactile (touching), Thermoreceptive (feeling temperature), Proprioceptive (positioning and movement of the extremities), Interoceptive (body condition and organ

activity) and Nociceptive (feeling pain). He explains how gestalt principles like similarity, consistency, proximity and seeking an order in chaos affect perception of objects and establishes connections between senses at their iconic (imagining sound based on the illustration of the words in comic writing) and symbolic (associating colors to smells) levels. However, these methodologies do not say how to use these sensory aspects as a primary factor that drive design ideation.

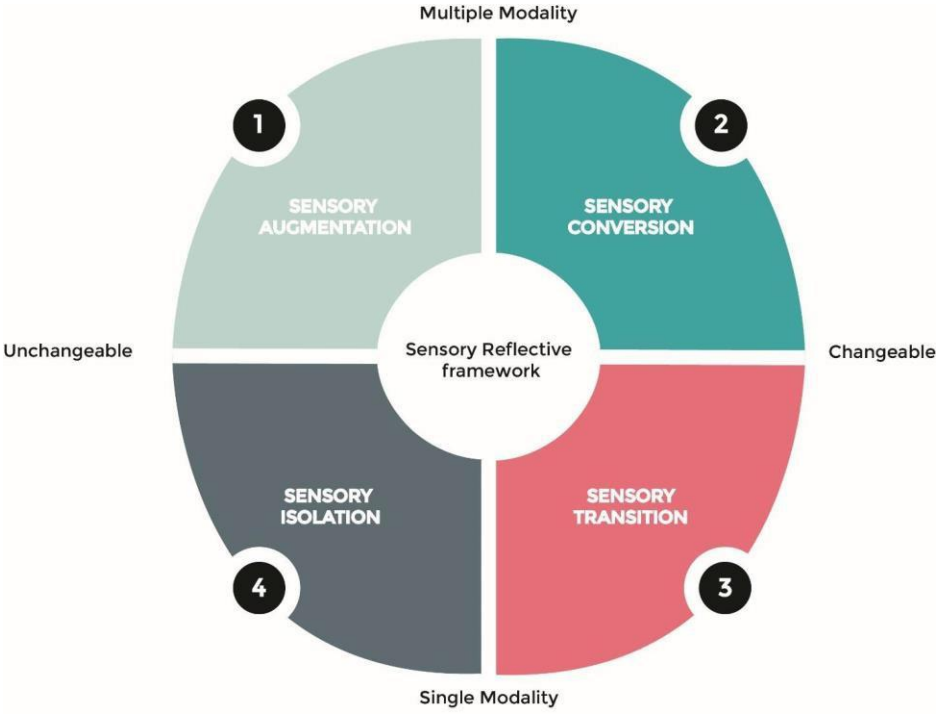
Sample Product Survey

In this study, a survey of 15 – 20 products, which are deliberately selected in consideration of their unique sensory stimulation in use (See Table 1.1 A, B, C), was conducted to analyze and reflect on various sensory characteristics exhibited by current products in practice. The survey revealed several keywords of sensory characteristics, including *emotional longevity, personal connection, sensory enhancement, sensory isolation, concentration, experience design, technology, noninvasive design, sensory cross wiring, synesthesia, sensory stimuli, experience design, simplicity, sensory stimulation, immersion, exploration.* These keywords were further categorized along with theoretical interpretations of prior research of the sensory design guides and a few other methodologies (See Table 1.2 A, B) to form the foundation of this *Sensory Reflective Framework.*

The preliminary prototype of this design framework was tested as a part of pilot design workshop to understand how designers would interpret and employ it for product design ideation. The *Sensory Reflective Framework* (Figure 6) consists of four Sensory Design Strategies and a S*ensory Library* (Figure 11), which lists different characteristics of the five senses to consider in generating creative product concepts beyond visual sensory features in consideration.

Framework Development

The framework consists of the four strategies— *Sensory Augmentation*, *Sensory Conversion*, *Sensory Transition* and *Sensory Isolation*—based on how multiple sensory modes are related to each other (y-axis) and change over time (x-axis), both of which are significant elements of sensory experience with a product (Figure 6). This form of reflective thinking for ideation intends to encompass simple yet comprehensive strategies that allow a designer to perform basic actions of addition, subtraction, multiplication to generate a range of creative solutions.



(Figure 6. illustrates the proposed *Sensory Reflective Framework* conceptualized for Design Ideation)

Sensory Reflective Framework

The qualitative analysis of the sensory characteristics of selected products identifies several categories of sensory design approaches that could constitute the framework. The initial framework has been revised through multiple iterations based on the feedback from pilot design (See Table 1.3 A and B). The proposed framework is the synthesis of the reflections from the preliminary literature review about related theoretical perspectives and the survey of product examples. In what follows, the four design strategies of the framework are described with supporting research and product examples.

Sensory Augmentation is a creative thought process which helps a designer to create a sensory experience that extends one sensory mode to multiple sensory characteristics beyond visual sensory cues (e.g., color, contrast, motion). It helps the designer to explore novel configurations or combinations of different sensory modalities, often to reassure a product function or user action with multiple sensory confirmations (Haverkamp, 2011).

Supporting Research: Augmentation means to increase or supplement the existing.We use vision as our primary sense to understand and confirm the perception from other senses, but more novel experiences are created by leveraging the use of other senses. David Eagleman (2015), a Neuroscientist, provokes sensory addition or augmentation by applying digital signal processing and audio codec technologies to expand our perceptual experience with biological sensory organs. His experiments were mostly conducted to enhance hearing with the aid of audio signal processing technologies, but further aims at restoring newer perceptions by using atypical sensory modalities like technology along with our sensory streams.

Each person can detect different characteristics of sensory modality working in congruence with the others. We live in a world full of information and innovative technology in realm of virtual reality and augmented reality. It is an emerging (imperative) design challenge to manage the multidimensional data generated in such hybrid realities beyond the two-dimensional screens (Papagiannis, 2015). The physical world involves natural interactions with objects using different senses, which could inform the conception for a virtual space. Skeuomorphism is a design trend conceived to design objects in a software or digital space to mimic its real-world counterparts (Campbell-Dollaghan, 2014). It was principally used in iconography. This concept can be useful in designing a virtual space as close to the physical realm as possible. Besides VR and AR, the addition of senses can have functional benefits in specific domains of practice, for example, by using tactile models of various anatomical parts to assist doctors during surgical reconstruction (Papagiannis, 2015).

(Figure 7. shows Synchrony is a music platform that helps parents and children with autism reduce tactile defensiveness (Tay,2015))

Example: Synchrony (Figure 7), a conceptual music platform to promote music therapy and intimacy between parents and children with autism. This augments a hand drum with a soft silicone surface, which responds to user's touch and provides feedback with changes in volume and resonance. This is an instance of how materials, vibration and level of sound are integrated to augment tactile sensation, thus to enhance the kid's sensory stimulation.

Sensory Conversion is a strategy for altering the behavior of one sensory characteristic with respect to another by combining them to create an interesting design dimension. In this framework, Sensory Conversion is not a mere replacement of one sensory modality with another because of a deficiency or inefficiency. Instead, it is grounded in a careful understanding of how one sensory aspect can be related to as well as influenced by the other sensory aspects in design ideation. Designers can draw a premise about how actions related to sound would affect one's visual perception; smell to taste; touch to taste; or as illustrated in the example, the sense of touch like peeling or scratching could change the visual aspect of a product (Figure 8).

Supporting Research: Each sense organ converts external stimuli into signals with efficiency and versatility (Henshaw, 2012) and our brain is trained for parallel processing of

sensory stimuli and responding to them. This happens both consciously and unconsciously. Often one sensory modality out-performs the other or lose their ability to perform well. In both the cases, substituting one sensory modality over another or altering the behavior of one sensory characteristic with respect to another adds an interesting design dimension to create a collective outcome.

The idea of sensory conversion is primarily based on 'Sensory Substitution' introduced in the 1960's by Paul Bach-y-Rita, a pioneer in cognitive neuroscience to study effects of tactile characteristic with respect to other sense. His book, '*Brain Mechanisms in Sensory Substitution*', introduces a way to use characteristics of single sensory modality to change the stimuli of another sensory modality. This led to the foundation of many upcoming studies, like V.E.S.T ("versatile extra-sensory transducer") which feeds brain information to alternative sensory channels for instance one could hear the world through vibrations felt through the vest on their chest (Eagleman, 2015).

(Figure 8 shows the creative packaging of the beer bottle from beck's brewery (Lin, 2015))

Example: Beck's brewery from North Germany is an example of creative and playful packaging: a user can scratch on the aluminum label of a bottle as a creative canvas open for personalization. This is an instance where a visual sensory character changes in relation to touch.

Sensory Transition is to transform sensory characteristics over time by exploring how a product would unfold new forms and sensory qualities in a temporal dimension. The longer a user spends time using a product, the more the user would develop emotional engagement with the product; and designers could consider this temporal change as an influential factor on user's attachment to a product.

Supporting Research: Everything we experience is analyzed, filtered, sorted and allocated a space in our brain. Brain combines and processes multiple sensory inputs received through sight, olfaction, auditory, gustation and tactile into functional units over a period. Information from different sensory is handled and processed at different speeds by different neural networks (Eagleman, 2009).

Sensory inputs are utilized consciously or unconsciously to influence perception, decisions and

behavior over habitual use. (Stein, Stanford & Rowland, 2009) (Eyal & Hoover, 2014). Based on the understanding of how each sensory characteristic change with the progression of time, designers could explore novel sensory experiences to deepen user's emotional engagement with and attachment to a product.

(Figure 9. shows the Fred Wake up cup which changes the sleepy eyes to bulging to indicate the user's reaction to a morning cup of coffee (Orchant, 2013))

Example: A hot water coffee mug changing the color of the material or graphics on the outside as time progresses to indicate the temperature of the water inside (Figure 9).

Sensory Isolation: Isolation is usually viewed as a negative connotation of things. In this study, it implies intentional cutting off other sensory stimuli or temporary detachment from them to reinforce one focused sensory modality. Why do we require this for design ideation, one might wonder? A designer can take a step back and reflect on this list of possible choices and determine which sensory aspect to enhance or diminish in ideating new product concepts. Considering the sensory cues in isolation might not improve the product in terms of technology but will enhance the sensory experience.

Supporting Research: We observe a series of events from our environment and tend to overload our senses. That is how our brain functions by building connections and associations between various words, colors, sounds, in general to develop perceptual patterns. It would be an endless process to sort and analyze these prevailing patterns to meaningful and meaningless information; and sometimes isolating and/or eliminating sensory inputs may help screen through and focus on critical information.

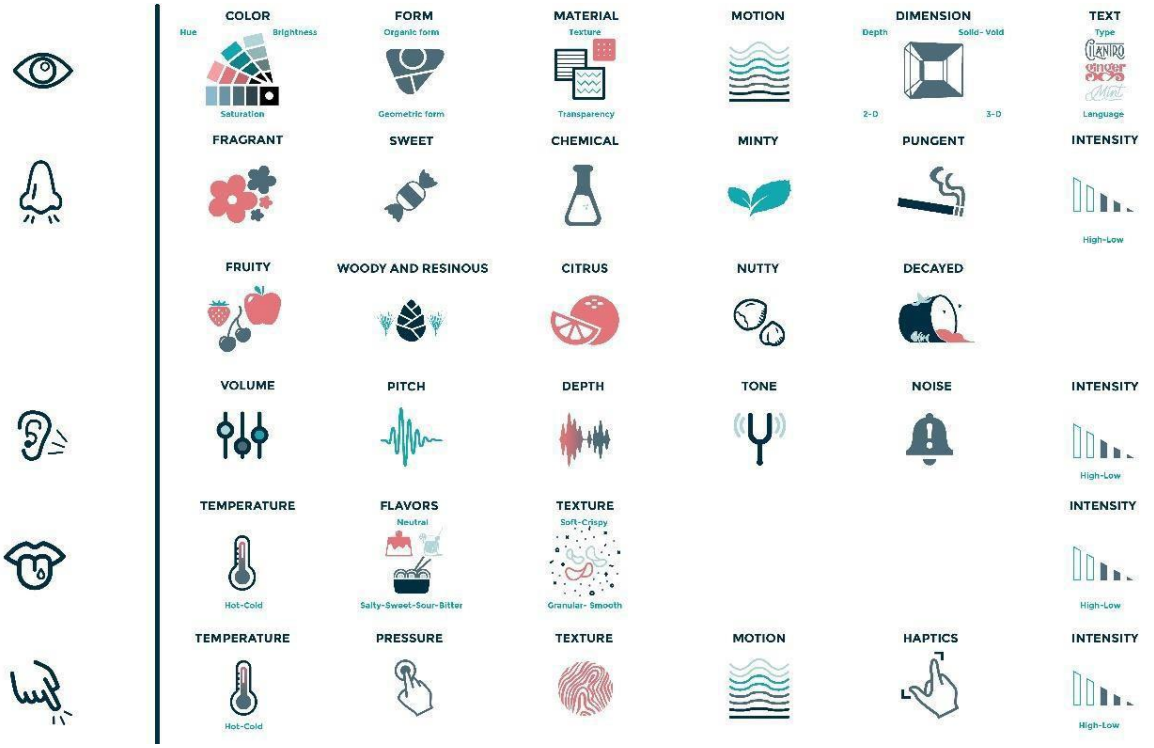
(Figure 10. shows the Eidos mask which isolates the sound in the user's environment (Etherington, 2015))

Example: Eidos Vision and Eidos Audio (Figure 10), a conceptual headset proposed by the Innovation Design Engineering students of Royal College of Art, is a good model of sensory isolation. The mask intentionally isolates facial movement and enhances the way how its user sees. The mask also fits the user's ears and mouth to neutralize the background noise and hear what the user speaks clearly.

Sensory Library

Sensory Library (Figure 11), as another component of the proposed framework, aims to provide designers with options of specific sensory properties from which to draw inspirations about how each sensory modality manifests itself in design. This library can be used in combination with the aforementioned *Sensory Reflective Framework* (Figure 6) as guidance for ideating new functionalities and sensory experiences of products.

Each category in this library is based on the inferences from different research journals. It contains the features of each sensory modality and how they are specified in other sub- categories. Understanding these sensory stimuli provides designers a new perspective to deconstruct familiar sensory experiences and explore new ones beyond color, form and material. In particular, there is an interesting research finding regarding the olfactory sense: odors can be classified into 10 profiles and various odors can be manufactured by combining one or more of the 10 basic odor profiles (Castro, Ramanathan & Chennubhotla, 2013).



(Figure 11. shows characteristic properties each sense manifests itself in a form of Sensory Library to inspire designers in ideation.)

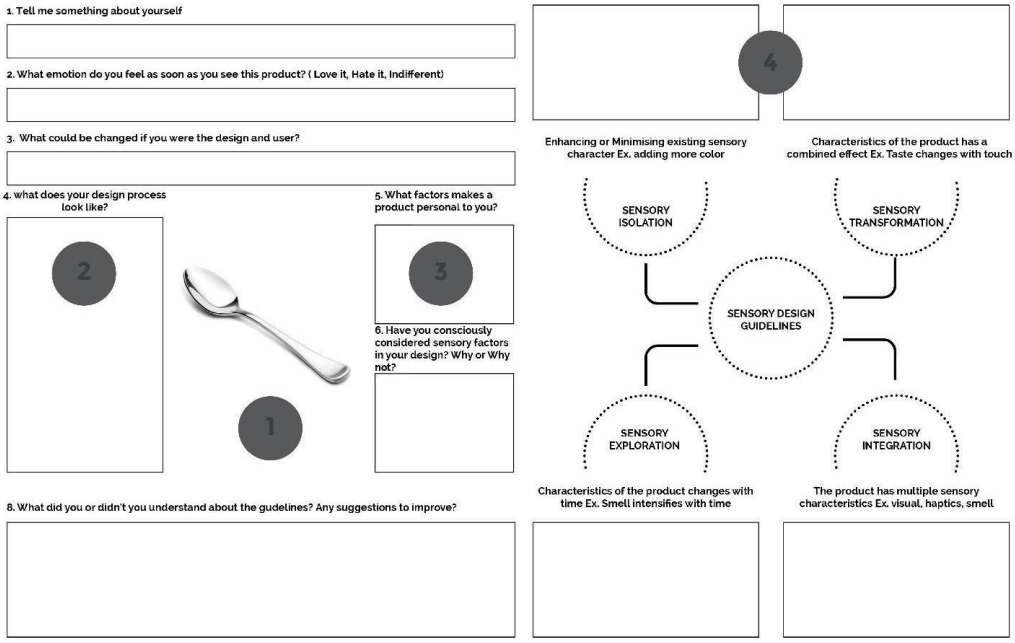
The sensory design properties that each human sense organ can perceive can be classified as listed below:

Sight: color, form, material, motion, dimension, text
Smell: fragrant, sweet, chemical, minty, pungent, fruity, woody resinous, citrus, nutty, decayed
Sound: volume, pitch, depth, tone, noise
Taste: temperature, flavors, texture
Touch: temperature, pressure, texture, motion, haptics

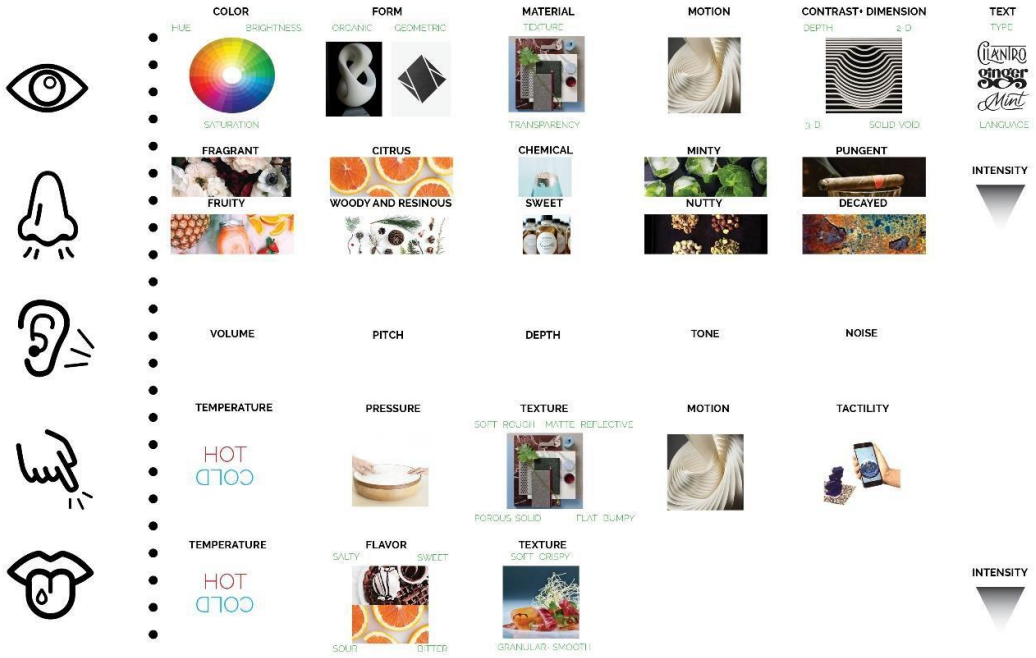
These sensory design properties could be combined to exhibit various sensory manifestations and corresponding user experiences*;* for example, Visual sense has 'dimension' listed as one of the sensory design properties and is further categorized into two-dimensional, three- dimensional, depth, solid- void relationship etc., The following section describes the ideation workshop conducted to collect preliminary feedback on the proposed framework, followed by discussions about findings and further implications.

Pilot Design Workshop

A pilot design workshop was conducted to evaluate and improve the *Sensory Reflective Framework* with four participants spanning for thirty minutes per person. The workshop revealed strengths and weaknesses of the proposed framework, although the testing was limited in terms of the number of subjects and the scope of design activity.



(Figure 12. is the workshop questionnaire with left hand side designed to understand participant's methodology and right side provided to ideate using senses.)



(Figure 13. is the sensory library with sensory design properties provided to aid ideation during the workshop.)

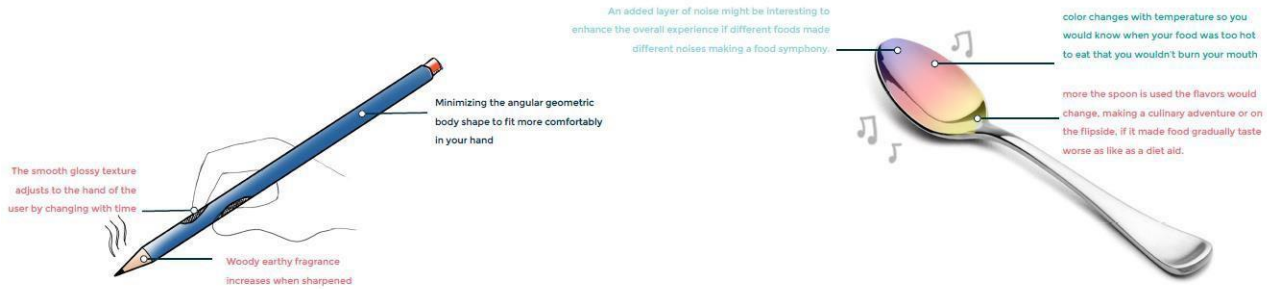
Task

Participants were asked to apply the proposed Sensory Reflective Framework as a part of a questionnaire (Figure 12) and the Sensory Library (Figure 13) presented in two separate sheets to ideate a new product concept. The questionnaire was introduced to obtain better insight on the framework. For the ease of understanding, the products selected for the workshop were the ones that were likely to be used by most people. The four products were – coffee mug, pencil, stainless steel spoon and a water bottle.

For each product, the respondents were asked four different questions: 1) What factors make this product personal to you? 2) As a designer and user, what would you like to change about the product? 3) How does your design process look? 4) Do you consciously consider senses in your design ideation process?

The second part of the questionnaire asked the respondents to navigate through the proposed framework and ideate freely. Each individual ideation session lasted about 20 minutes. It was followed by a short debrief about how the participants understood the questionnaire.

Analysis



(Figure 20 is the illustration of a few resultant concepts from the design workshop.)

Responses by each participant was transcribed in detail (See Table1.5 A, B, C). This gave an insight into an individual's design process, design preferences, emotional responses and innovative product ideas generated through the framework.

Compelling findings were collected/observed from the workshop (Figure 14). Participants visualized a re-designed spoon in multiple ways, including adding a heating element to the spoon, so that the color changes with temperature to tell whether food is likewise hot to eat. It would be an interesting experiment if the flavors would change with the usage of spoon overtime. This could help design an engaging culinary experience when complemented by a sound note. Food could be a musical symphony. On the contrary, the spoon can be designed to make food gradually taste worse, which could be a dietary aid. This framework has potential to generate new product ideas in consideration of repeated and habitual use. The detailed transcript of the workshop can be found in tables. (See Table 1.5 A, B, C)

Results

Phase one of the workshop was executed successfully with all the four participants' understanding and executing the given task of answering the questionnaire. Observing each respondent during the task, it was evident that each strategy within the framework without a detailed explanation slowed their ideation process. It was also noted that the participant used the sensory library for inspirations of sensory design characteristics over habitual use.
In phase two of the workshop, the participants reflected on the whole ideation process and cited that it was an interesting test of using senses to think and conceptualize creatively. Two of the participants agreed to having considered only tactile and visual aspects while designing and artifact. One of them wanted to know how this framework could be used in their own design process.

Sensory Isolation proved to be the easiest technique in the framework with all four

participants using it as intended. On the other hand, most participants had difficulty in understanding and applying the strategy of *Sensory Conversion* to their ideation. This may be because it requires the participants to predetermine what changes they want to envision in their product, although they are not yet familiar with possible sensory properties. Only two of the participants could accomplish this task.

The participants mostly seemed to clearly understand what they were asked to do, but the ideation only with images and guided questionnaire limited their design space. Interactions with actual artifacts could have further inspired them with richer sensory stimuli. Regardless of the limitation, the workshop provided deeper insights into the individual participant's design process as well as their interpretation and use of the provided framework in new product concept ideation. The findings are used to revise the visual representation of the proposed framework and library.

Revisions to the Framework

Conforming to the results from the workshop, the framework was redesigned by categorizing the four strategies based on the number of sensory modalities it involved and how they changed with time. The four strategies were renamed and provided with a description and a suitable example to supply the users with a clearer understanding of the navigation of the framework. (See Table 1.3 A, B)

Sensory library (figure 11) was visualized using icons instead of images so that the users could consider the categories the sensory design characteristics represent in general and not abstracted by the imagery that is presented in front of them.

Conclusion

This research examined the role of human senses in design through an investigation of relevant theoretical perspectives with an objective to support designers' conscious sensory reflection in their design processes toward novel and rich sensory experiences with products.
This study sought to ascertain how a qualitative research method of gathering and reflecting on sensory data could yield a method of product design ideation that uses inputs and outputs from the five human senses. When designers make a conscious attempt to understand the sensory attributes that influence product design and corresponding user interactions, they can generate novel ideas by leveraging sensory modalities and their manifestations through designed products. This sensory-attentive strategy could potentially help designers achieve emotionally-engaging designs with enhanced sensory characteristics.

While our senses are generally used for evaluation and verification of actions during product use, the proposed framework developed in this research is unique in that it seeks to deliberately push designers to consider sensory aspects of product experience in the design ideation phases. This study, as an initial attempt to actualize the goal of conceptualizing a sensory reflective practice, has defined four sensory design strategies and showed how they could be used to envision new and creative product ideas. Further studies are needed to contextualize the proposed framework for design ideation in practice.

Future Exploration

The ideation framework proposed in this thesis aims to complement current design processes by emphasizing sensory reflections in product experiences and eventually developing corresponding contextual user scenarios. Future work is needed to investigate and observe the use of each strategy in the proposed framework and probe its relevance to habitual uses of products over time.

Further, additional studies could be conducted to identify the sensory profiles exhibited by discrete user groups, including sensory tendencies that occur across various demographics or cultures. Finally, the continuation of the design ideation workshops described in this research could contribute to the identification of other sensory design strategies apart from the four proposed in this study.

Tables

Table 1.1 A Sample Survey of Products

PRODUCT	NAME	SENSORY DESCRIPTION	KEYWORDS
	***Mia & Ika* chairs and *Cufi* table** by Tink things Considering different sensory needs and using therapeutic principles to shape a comfortable environment for all kids are the driving principles behind this collection. We hope these pieces can maximize the potential of children's interplay with their surroundings.	The non-fixed fabric seat is helping concentration by gentle rocking and calming by providing deep pressure soothing. If feeling overwhelmed, the child can pull up the "cocoon" and partly isolate himself. The ika seat is essentially a swing that not only allows but encourages constant rocking and bouncing. Its adjustable tabletop offers a shorter viewing angle which is needed for healthier posture during writing, drawing and reading.	sensory intelligent environment, Sensory isolation, *active or passive behavioral response* *Tactile, visual*
	**With Sensory pad,** The user is exposed to simulated natural day light cycles, the fresh smell of grass, and is responsible in keeping the grass alive.	The lights of the lamp mimic natural day cycles, stimulating our sight. The smell of the grass within the lamp, along with the act of nurturing the plant allows the office to be less removed from activities and senses that have been proven to enhance creativity and productivity. By having a mouse pad attached, the sensory lamp stays close to you, allowing interaction. In a step towards the office of the future, the Sensory Lamp takes us back to nature.	Sensory stimulation, nurturing, intimate interaction, nature *Tactile, visual, smell*
	The project, ***Adaptive Manufacturing***, builds on van Herpt's work designing and building a bespoke clay extruder for 3D printing ceramics.	sensory machine that feels it's environment, and all of it's output becomes a real-time document of a specific time, location or raw material. Uses Hard clay	**Adaptive, layers, info-viz, materiality** *Tactile, visual, smell*
	Nescafé's new 3D-printed Alarm Cap design awakens caffeine enthusiasts with the sweet sounds of nature ,an alarm that can only be turned off once the cap is twisted and removed from the canister.	Now, instant coffee giant Nescafé has found a way to integrate that visceral coffee aroma into a morning wake-up call with a twist.	Experience design, interactive prototyping, 3-D printing *Tactile, visual, smell, sound, taste*
	Synchrony is a music therapy platform that helps parents and children with autism to develop intimacy and promote understanding of each other through improvised music play. Synchrony eliminates that technical barrier using an approachable and universally understood form language of a hand drum.	The soft, press-able silicone skin responses to the user's touch by producing volume and resonance according to the pressure applied and the duration pressed. This works to reduce tactile defensiveness The pleasurable multi-sensory experience guides and reorganizes the child's sensory information toward functionally adaptive interpretations.	Engagement, experience design, therapeutic, simplicity, interaction design *Tactile, visual, sound*

Table 1.1 B Sample Survey of Products

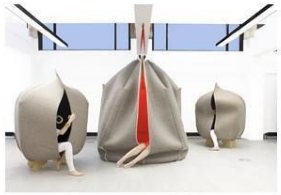
PRODUCT	NAME	SENSORY DESCRIPTION	KEYWORDS
	**Reify'S** team has devised a proprietary method for digitally recording and modeling sounds, ultimately creating what they refer to as totems—small, abstract sculptures 3D printed in various materials (pictured above). Each totem is encoded with music and visuals which can be activated using a mobile app.	Reify is a new music platform that wants to change how we experience music by transforming sound into a multi-sensory experience.	interactive, multi-sensory experience, creative expression for artists, physical to visual *Tactile, visual, sound*
	Driven by a belief that a heightened awareness of one's body, senses and materials can lead to a greater appreciation of the physical world, british designer freyja sewell has created the **'sensory concentration space' SCS.** The small enclosure allows users to completely immerse themselves in an environment where there is nothing to distract them from the sensation of their own bodies. providing stimulus for sound, sight, touch and smell, the interior has had all distracting elements such as support frames, control panels etc. placed on the exterior.	the tent-like structure is made from 100% wool felt, which offers high levels of insulation and a soft, tactile finish; has hidden color changing LED's integrated into the ceiling that help to transform the atmosphere; felt discs that can be scented and then scattered beneath the elevated floor to increase smell stimulus and speakers are also included for sound, enabling the SCS to be individually programmed into an infinite number of combinations.	Sensory stimulation, immersion, exploration *Tactile, visual, smell, sound*
	During milan design week, communication research centre fabrica and air conditioning systems company **daikin presented 'hot&cold'.** An exchange between opposites that represents the distinctive approach taken by fabrica, a place where young talents from across the globe can constantly engage with each other, in projects with universal appeal. a design that sets out from an object, and reaches towards sound, graphics and interactivity	the interactive exhibition was conceived as conceptual representation of temperature, guiding visitors through an experiential journey through a series of multi-sensory artistic and sculptural installations.	Temperature, universal design, sculptures, interactivity *Tactile, visual, sound*
	**Sensory Pods** are dedicated to satisfying non-visual sensory needs and enjoyment of visually impaired infants and toddlers.	These pods encourage interactive play through means of sound, light, scent and texture. Sensory pods can be hung anywhere in a living environment to initiate play and exploration, through these possible interactions care-givers and parents are provided a platform on which they can establish learning exercises	Learning and development design, secondary feedback *Tactile, visual, smell, sound*
	'beosound' at bang & olufsen is so much more than how it looks: it is also how it feels; how it works; how it sounds; it's the whole package when we talk about design.	very inspired by musical instruments and wanted to create a product that would bring people close to music plus get a sense of musicality.	experience design, simplicity, packaging *Tactile, visual, sound*

Table 1.1 C Sample Survey of Products

PRODUCT	NAME	SENSORY DESCRIPTION	KEYWORDS
	the **'forever yours'** project by product designer marc haldemann, focuses on the emotional longevity for furniture design and how this can be improved to lengthen its lifetime.	the **'wooden chair'** uses a strategy based upon the theory that playing is an elementary way of human sense-determination, to justify its ball carvings. these playful elements are conscious to the person and intends to create a personal connection which will grow as they get accustomed to it.	interactive, emotional longevity, playful, personal connection *Tactile, visual*
	**Eidos Vision and Eidos Audio** are headsets designed by a team of four Innovation Design Engineering students from the Royal College of Art in London that enhances the way the user sees motion and lets them hear speech more selectively..	The Eidos Vision is a mask that fits over the user's eyes to enhance the way in which they see motion, achieving a similar effect to long exposure photography. By detecting and overlaying movement, it allows them to see traces and patterns hidden to the naked eye. Eidos Audio is a mask that fits over the user's mouth and ears allowing them to hear speech more selectively. It neutralizes distracting background noise and then amplifies the speech they choose.	Sensory enhancement, sensory isolation, concentration, experience design, technology *Tactile, visual, sound*
	**The Nest** project, explains that the aim with the design was to make the product as visually soothing and reassuring as possible.	The solution to diffuse the scent of maternal milk to premature babies. The monitor that controls the scents is placed inside and can conveniently be changed through the use of plant-based biopolymer cartridges.	Non invasive design, health care, futuristic, therapeutic design *Tactile, visual, smell*
	**Tableware as Sensorial Stimuli** is about the relationship between food and the senses. Jeon created cutlery based on five sensory elements: colour, tactility, temperature, volume and weight, and form.	focus on each bite, feel the enriched textures or enhanced chewing sounds between bites; Other pieces are made from stainless steel, silver or plastic, and the various textures and shapes are intended to stimulate the sense of touch inside the mouth.	Sensory cross wiring, synesthesia, sensory stimuli *Tactile, visual, smell, sound, taste*
	BECK'S is a traditional beer brewery from North Germany. It's served in almost every bar and nightclub throughout the country and has a history in collaborating with artists and musicians.	An interactive and playful packaging that turned the whole bottle into an aluminum canvas; people like to scratch shapes into the characteristic aluminum neck of BECK'S bottles.	experience design, simplicity, packaging, interactive *Tactile, visual,sound*

Table 1.2 A Based on the sensorial properties, the materials in this study were divided into visual textures and tactile textures but initially they had to map the sensory perception based on four factors- Sensory properties, materials, subject group and environment (Zuo, Hope, Castle, & Jones, 2001)

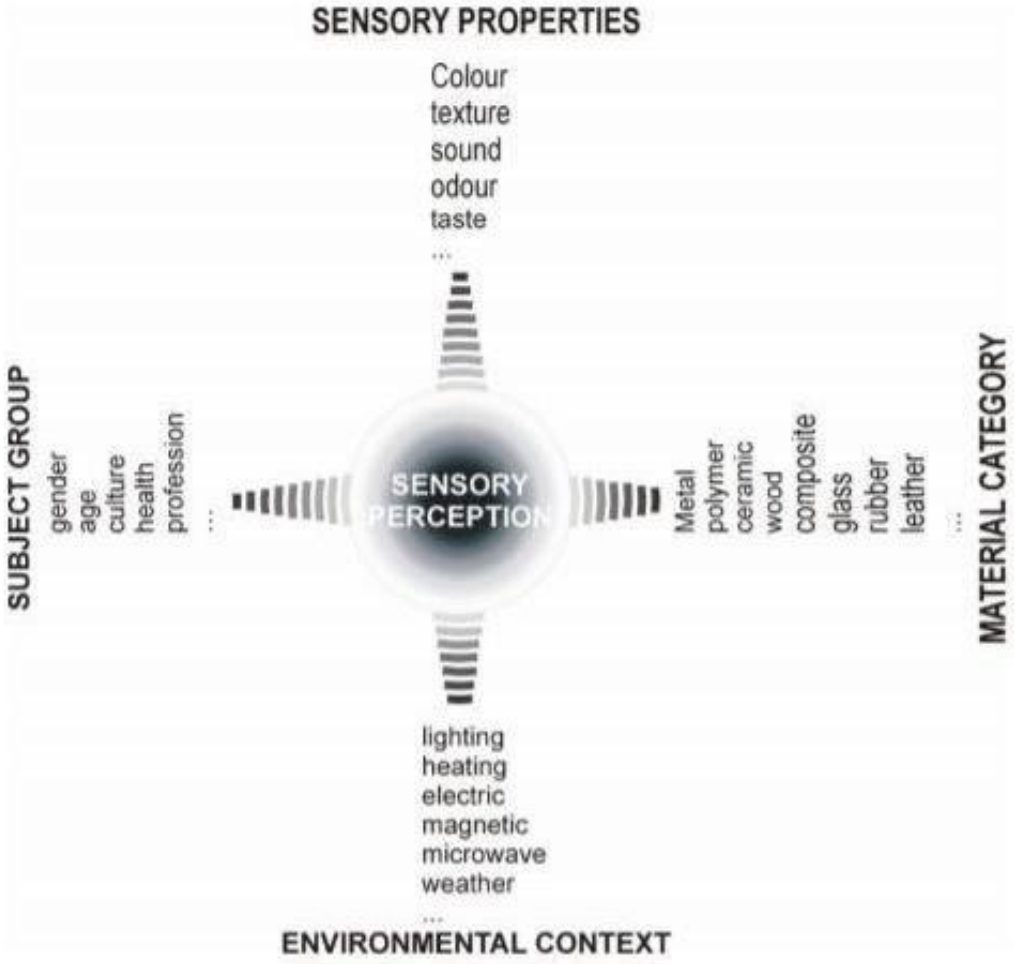


Table 1.2 B Sensorial Mapping to show the flow of information between interface and modalities. (Chang & Ishii, 2006) This helped the research in mapping different sensory characteristics.

Modalities	Relationships	Digital Medium
Vision	Status Change (state changes from off, to standby, different stages of activity)	• Lights, areas • Colors • Temporal effects (flickering) • Text • LCDs, LEDs, other displays
Audition	Directly Proportional (user action parallels digital medium)	• Sound, noise • Music selection • Volume • Number of lights
Touch (haptics and kinesthetic)	Inversely proportional (as user action decreases, digital medium increases… or vice versa)	• textures • manipulations • temperature • kinesthetic, motion • position • shape change • force feedback • vibration
Smell	Additive (persistence)	Smell flavor, intensity
Taste	Temporal (impulse fades with time)	Taste, texture, heat, flavor, intensity

Table 1.3 A Sensory Reflective Framework- Initial Proposal

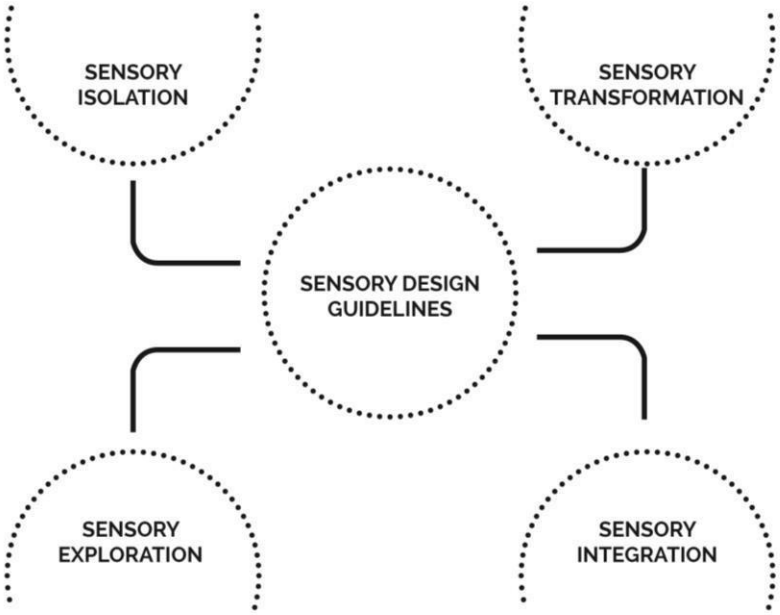


Table 1.3 B Sensory Reflective Framework- First Iteration

SENSORY DESIGN FRAMEWORK	MULTIPLE ATTRIBUTES	SINGLE ATTRIBUTE
FIXED	**SENSORY INTEGRATION** The product has multiple sensory characteristics Ex. visual, haptics, smell	**SENSORY ISOLATION** Enhancing or Minimising existing sensory character Ex. adding more color
TEMPORAL	**SENSORY TRANSFORMATION** Characteristics of the product has a combined effect Ex. Taste changes with touch	**SENSORY TRANSITION** Characteristics of the product changes with time Ex. Smell intensifies with time

Table 1.4 Selected ideas from the Pilot Design workshop

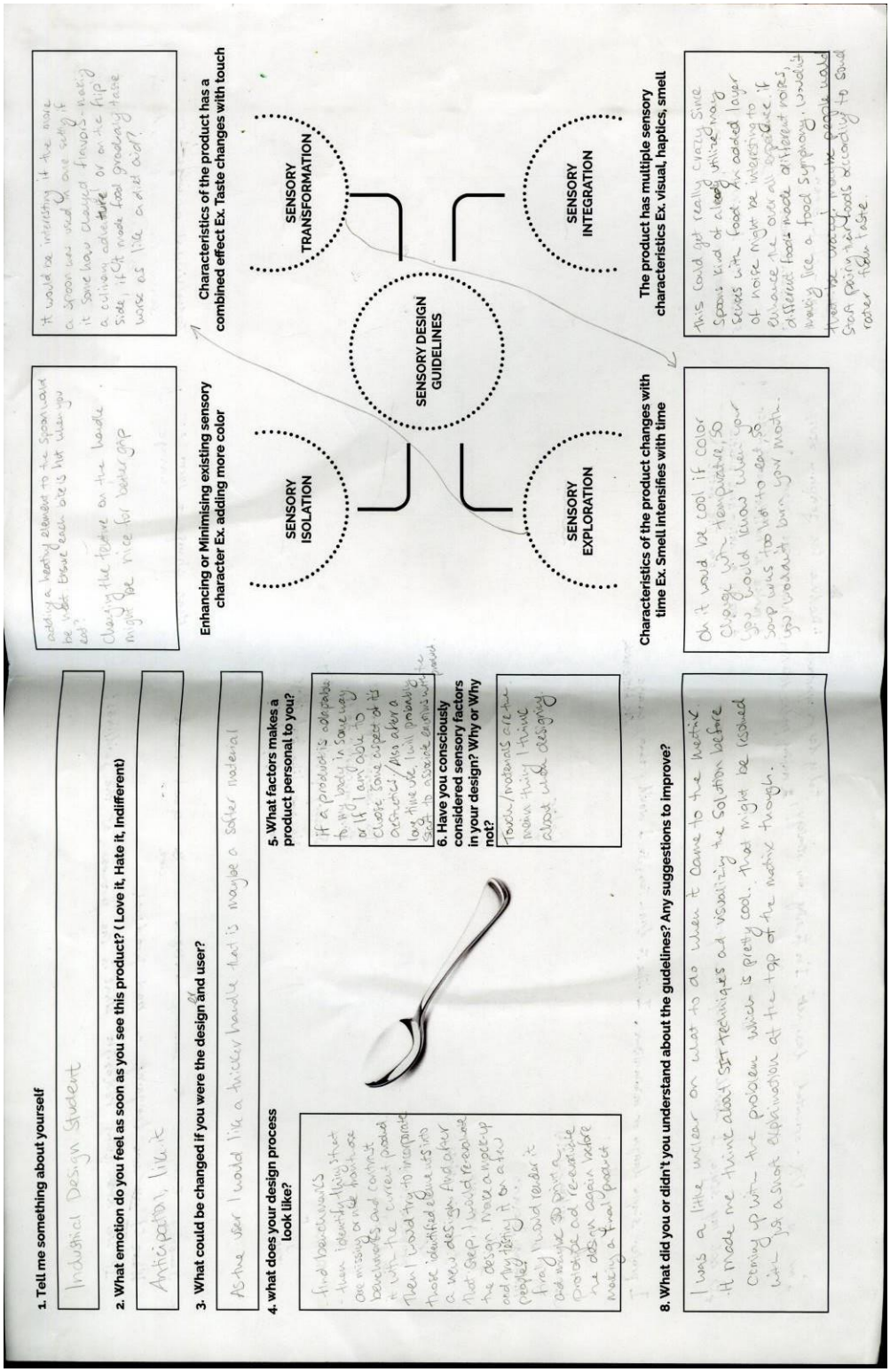


Table 1.5 A Data Collection from the Workshop

01

Product: Spoon

Preference: As the user, I would like a thicker handle that is maybe a softer material

Design Process: Finding benchmarks- what's missing or what's nice from those benchmarks- contrast it with current product- then I would try to incorporate those identified elements into a new design- reevaluate- make a mock-up – testing it on few people- render- 3D print a prototype – reevaluate before final

What makes it personal to you? If the product is **adaptable to my body** in some way or if I am able to choose some aspect of its **aesthetics.** Also, after a **long time** use, I will probably start to associate emotions with the product.

Sensory factors in your design: **Touch / materials** are the main thing I think about when designing

Sensory Isolation: **Adding** a heating element to the spoon would be neat. Ensure each bite is hot when you eat. **Changing** the texture on the handle might be nice for better grip.

Sensory Transformation: It would be cool if **color changes with temperature** so you would know when your soup was too hot to eat that you wouldn't burn your mouth

Sensory exploration: It would be interesting if **more the spoon is used the flavors would change**, making a culinary adventure or on the flipside, if it made food gradually taste worse as like as a diet aid.

Sensory Integration: This could get really crazy since spoons kind of already utilize many senses with food. An added layer of noise might be interesting to enhance the overall experience if different foods made different noises making a food symphony. Wouldn't that be crazy. **Food pairing according to sound than taste.**

Suggestions: I was little unclear on what to when it came to the matrix as it made me think about SIT techniques at **visualizing the solution before coming up with the problem which is pretty cool**. That might be resolved with a **short explanation at the top of the matrix though.**

Further probing: Before I **was thinking only about tactility**, I thought temperature was really something that I would not have thought about. It would be helpful for people to **list out that are currently there** and to see what is missing or to be considered. But no, in general I think you have covered everything. A **little bit of explanation of stuff would be good.**

02

Product: Pencil

Preference: change its shape from being hexagonal to cylindrical

Design Process: Familiarize with design brief/problem/ client- ideate/sketch/ word play- rough draft of design with media/ mock up- client feedback- refine or go in another direction

What makes it personal to you? **Soft colors**, solids, not usually attracted to patterns, **smooth form or texture**

Sensory factors in your design: No, they are generally **unconsciously considered.**

Sensory Isolation: **Minimizing the angular geometric body shape** to fit more comfortably in your hand

Table 1.5 B Data Collection from the Workshop

Sensory Transformation: Woody earthy fragrance increases when sharpened

Sensory exploration: The smooth glossy texture fades with time and good for use

Sensory Integration: The shiny material is smooth to touch, woody and earthy fragrance and added sound when pressed against fine grain paper

Suggestions: This exercise was very much conscious because of the sensorial factors being primed.

Further probing: mostly straightforward. I was just confused which product I was using. I would have eventually figured it out. Flow of the questions worked well. First thing I think of is color, all I think of are obviously visual. You can create volume by weight of a type. Doesn't have any physical weight but visually looks heavier.

03

Product: Mug

Preference: Based on different scenario and users, I will change the shape, size, color or the handle after research

Design Process: Research- define problem- User scenario- product definition- ideation- refinement-test

What makes it personal to you? Ease of usage will be essential consideration

Sensory factors in your design: This is not the top most thing that comes to my head. It is last one to be considered but needs to be reminded

Sensory Isolation: Add more texture, color

Sensory Transformation: Color and texture can let user feel flavor

Sensory exploration: the changing temperature will affect the texture and color. Changing more layers of texture can keep drink warm.

Sensory Integration: adding texture, temperature, smell, color

Suggestions: I think the guideline gives me an overview of how to design and create sensory product. It's really cool. But I don't know what's the relationship between them and what is the result in the end and what kind of product should use this guideline.

Further probing: I do not know the sequence. What next?

04

Product: Bottle

Preference: I prefer simple and minimalistic.

Design Process: choose an audience- making scenario- task analysis to find pain points- proposal to get feedback- refine- test- repeat

What makes it personal to you? Color, text, texture, graphics

Table 1.5 C Data Collection from the Workshop

Sensory factors in your design: Yes, sensory aspects provide first impression to people. It provides **credibility.** No one likes to buy bad things or bad products

Sensory Isolation: Reduce the graphics/ change the color/ change the material to anti-heat plastic

Sensory Transformation: one- click open/ separate section for water or tea bag

Sensory exploration: heat changes, form/ color changes

Sensory Integration: texture/ visual change to sense temperature of the bottle

Suggestions: Sensory exploration and integration are cool ideas. What if we are designing a new product? What to do if we are redesigning? Explain the process?

Further probing: Give clearer examples.

Analysis:

- Clarify the labelling
- A bit of explanation of what each category is
- Clearer test layout
- How to change a property visually without affecting the actual volume?
- How to consider ease of use, aesthetics and adaptability?
- Emotions gets enhanced over time
- Cohesive library
- Explain with clearer examples
- Relationship between each property

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