SEE THE SMELL

Participatory Design with the Lost Sense

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ABSTRACT

Smell is the only sensation that reaches the emotional and memory centres of the brain directly, which results in a close connection between memories, emotions, and odours (Shepherd, 2005). However, with the development of modern science and technology, the sense of smell has gradually come to be perceived as less important when compared to the other senses and the other ways we connect with our surroundings such as sight and hearing. Current research into smell primarily focuses on explaining biological phenomena, such as the individual differences in olfactory perception and the mechanism of odour receptor genes, whereas the aesthetic aspect and how olfactory experience could be applied in visual arts is rarely examined.

This thesis explores the opportunities and creative methodologies of an alternative way of creating an interactive experience: applying smell to design to enrich the sensory experiences. This project was led by several inquiries that questioned the effect that smell brings to people, unveiling deeper research potential in the process. It not only focused on people's relationship with smell, but also explored the possibilities of applying olfactory stimuli to alternate fields in the search for balance between all five senses in the general design field.

The goal of this research has been to investigate the affective and evocative impacts of scent, review how scent is treated as a medium in a design context, examine the current usage of smell, especially in interaction design, and lastly, discuss the opportunities of combining smell with design to provoke communication.

KEYWORDS

Olfactory System, Smell, Multisensory Design, Interaction Design, Participatory Design, Storytelling, Communication

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1. INTRODUCTION

1.1 Personal Experience

When I first came to Vancouver in 2017, the new environment excited me. As one that has lived in Asia for 22 years, I was curious about Western culture, people with diverse backgrounds, and graduate studies. However, at the same time, as an introverted person, this huge life change made me anxious. One unnoteworthy day, on a quotidian ride on local transit, the scent of the lady beside me suddenly brought my mind back to my grandma's old house. Since my family rarely mentions her place, I had almost forgotten about her home. However, the scent at that moment unearthed many precious, deep-seated, and warm memories of her home, providing significant relief from the anxiety I had been feeling. Since that moment, I have found myself noticing more and more times that my mind and memories wonder, influenced by the smells that pervaded the air. This was particularly fascinating as the influence smell had on my emotions were often stronger than other sensory stimulation. Thus, my inquiry into smell began.

When I first began this research, my goal was to use peoples' personal memories to help tap into an idea of a "collective memory". People appreciate smell in various ways and different smells can induce a vast array of diverse memories. I truly believe that smell is subjective in its entirety and felt that finding a common touch point where everyone may agree would open peoples' minds and give a foundation when smelling a new scent. What would happen if smell became the dominant sense? Could smell be described and archived by images? Could it work as a medium of artistic expression and creativity? Based on these assumptions, trying to find a non-visual form of expression to produce a telepathic link with the viewer became the starting point of my interest in smell. Working with the sense of smell to redefine the relationships between humans and odour, and to explore how to apply that to design context became my intention behind this research.

1.2 Project Background: Proust Effect & Multisensory Design

1.2.1 Proust Effect

> "This kind of memory, where an unexpected re-encounter with a scent from the distant past brings back a rush of memories, is called a 'Proustian Memory'." (Karl, 2001).

This phenomenon often happens unconsciously, with a specific scent recalling a long-forgotten scenario in our lives. Unlike any other sensory experience, smelling something related to past meaningful scenes usually produces an emotional response and may trigger memories (Saplakoglu, 2019). Olfactory memories tend to resonate with individuals more closely than other memories. Although other stimuli can also trigger our memories, "they are usually not as detailed, sudden, or vivid as those related to smells" (Levine, 2015).

As Proust discovered, olfactory memories are deep and hard to put into words, but are extremely powerful. This partly explains why smell is such a unique and significant sense to us and why this research is grounded in this area. The scientific explanation of this connection is further discussed in *4.1 Embodied Scientific Knowledge of Smell.*

1.2.2 Multisensory Design

Multisensory design is a method that encourages designers to realize the values conveyed through various sensory systems and their influence on the overall user experience (Schifferstein, 2011). It challenges designers to consider human perception not only through the sense of vision but also through other senses such as olfaction, gustation , and somatosensation.

The intention behind sensory design is that the combination of technology and multisensory method can create design experiences that may improve the user experience. Although designers pay conscious attention to the users' sensory perception in their work, multisensory design highlights the fact that people feel the world in different ways and this creates a dynamic context for designers to both explore and employ a more balanced sensory experience.

Instead of overwhelming the function and characteristics of a project, multisensory design enriches the object in an acutely systematic way. This thesis focuses on smell in design; it does not intend to apply smell to all aspects of design, but rather to recognize that smell is ubiquitous and an intrinsic dimension and extension of design.

1.3 Research Questions and Objectives

My research activities focus on asking the following questions:

· What is the common conception of olfaction in modern society? Has smell become a neglected sense for people?

· As the role smell is playing in modern society, how to integrate olfactory experience into design to make smell a more meaningful and helpful sense for users?

There are two main objectives for this work. First, to remind people to embrace the world of smell through the use of design by presenting a series of smell-based works. Second, to encourage designers and artists to conduct their works with the existence of smell in mind, not to solely rely on visual influence but to also explore the possibility of introducing smell into their works. Both of these objectives are unequivocal links to bring the status of smell to the forefront and to shed light on the strong mental influence that smell has on human beings; an influence that was previously mired by a lack of understanding in the art and design field.

2. METHODOLOGIES

2.1 Preliminary Research

> "A preliminary research design describes the specifics of a planned project and should address the purpose of the proposed study, as well as details on how the study will be conducted." (Griffin, 2020)

To find a context for this research and uncover design opportunities, the preliminary research in this thesis contains two exploratory projects in the olfactory space and an interview. Through engaging with and reflecting on them, I was trying to find the role smell plays in my life and others' expression of smell.

Smellscape Map of Xuzhou is an imitation of Kate Mclean's project, Smellmap (2011). It helped me to explore my interest in the topic of smell and guided me to continue to study the relationship between olfaction and memory. In the next design research *Smell My Day*, I examined the importance of smell in my daily life by consciously recording each moment I perceived any scent. After that, I conducted an interview with 80 people to collect their smell narratives and developed the results into more perspectives of potential research directions.

2.2 Theory-based Research

> "Theory enables us to connect a single study to the immense base of knowledge to which other researchers contribute. It helps a researcher see the forest instead of just a single tree." (Neuman,1997)

This study is an interdisciplinary research which requires considerable theoretical support, especially in the olfaction and anatomy fields. Through summarizing and collaborating these existing theories, I was able to improve the overall effectiveness of my research.

I firstly examined the importance of smell through my exploration of the nature of smell (Sarafoleanu et al. 2009) and the connection between olfaction, memory and emotion in anatomy (Herz, 2009). However, because of the difficulty in expressing

(Majid et al., 2018) and transmission (Genva et al, 2019), the importance of smell has been ignored in modern design context. Based on these findings, my study in olfaction and design field was able to move forward to answer my research questions.

2.3 Practice-led Research

> "Practice-led research presumes a process of the development and testing of knowledge which has an outcome in the production of works of art, design, performance and professional practices" (Jolly, 2019).

The research methodology developed for this thesis is primarily based on a practice-led research. Practice-led research is "a conceptual framework that allows a researcher to incorporate their creative practice, creative methods and creative output into the research design and as a part of the research output" (Smith & Dean, 2009). Throughout my two-years of studio work at ECU, all projects in this thesis followed a reflective design practice, and focusing on the design projects themselves was the dominant force driving this thesis forward.

This thesis exploration contains three experience design projects, including Seeing Your Drink (2018), Don't Just Pass by (2019), and Smell Story Kit (2018). Each of these was designed for a particular scenario, while sharing the same design principle: creating an interactive experience with smells through playful installations. With the support of interaction design and biological and chemical knowledge about olfaction, this research was undertaken in an interdisciplinary context and the three experimental projects were built upon one another, designed to advance the research depth of the previous. With each project, my technical skills improved, leading to enhanced participant experience and improved results of each project.

3. CONTEXT & FRAMING

3.1 PRELIMINARY RESEARCH

3.1.1 Smellscape Map (2018)

This preliminary inquiry is inspired by Kate Mclean who has created Smellmaps (2011) for several cities around the world. By communicating with local people, organizing and leading a volunteer team of “sniffers”, and immersing herself in the smell of a city, Kate has developed ways to recreate the fragrance of a place.

Rummaging through my old diaries and photos with memories attached, I tried to recall as many scents belonging to the city as I could by recalling their location and spatial range and placing them all in their corresponding locations on the map. This is the resulting smellscape map of my hometown.

Figure 1. The Smellmap of Xuzhou

Regardless of where I am at any moment, if I have a look at this map, all the smells and stories are immediately conveyed and sensed in my brain. I found that this is a good way to free smell from the limitation of space and time, to rebuild smell memories in a regional context, and to relax and comfort the otherwise tumultuous emotion and senses we are always bombarded with. This is an odour visualization at the beginning stage of my exploratory research.Through converting smells into visual symbols and locating them on a map, I explored the urban landscape from a new perspective. This Smellscape Map not only represents the odour distribution of the city, but also shows the diverse cultural characteristics and creates a unique sensory perception experience of the city.

3.1.2 Smell My Day (2018)

This project aims at observing smells to find if there are unnoticed perennial smells around me to explore the unrecognized influence these may have on my daily life. I recorded all the odours I feel from 9pm to 12pm for twenty days and evaluated the emotional value of these scents.

Figure 2, 3. Some of the Smell Sources I Recorded

Each scent is located along the x-axis to show the time when I noticed these smells. The y-axis represents my enjoyment or the positive emotion I felt when I smelt the

corresponding smells. The orange dots on the line represent odours I smelled most frequently during the project, what I've labeled as my daily smell-routine. I love the fragrance of orange because it reminds me of warm memories in my grandma's tiny garden. Cigarettes, on the other hand, I have a negative impression burned into my mind as when I was young, a smoldering ember from my father's cigarette fell onto my leg, permanently scarring me.

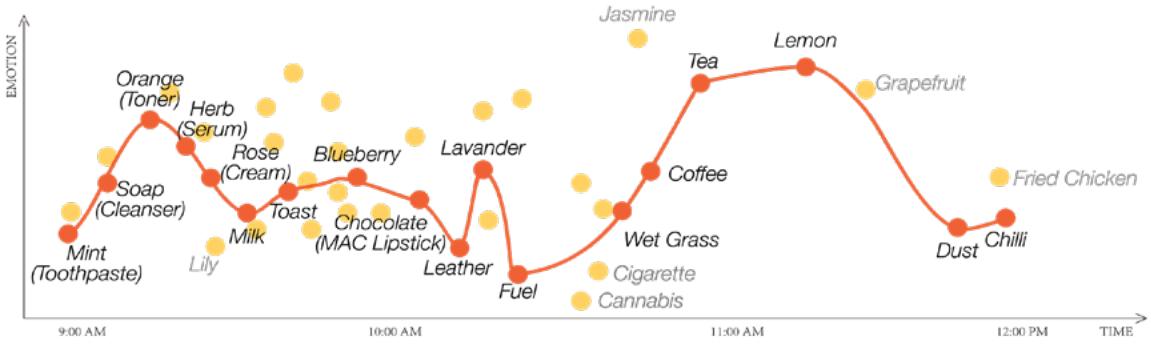

Figure 4. The Axis to show my preference on each smell

I found that my enjoyment in the y-axis is, to a great extent, decided by my memories that revolve around those scents, corroborating a tight relationship between olfaction, memory and emotion. This led to the inspiration that smells could be seen as a vehicle for memory.

Through my project, I came to the realization that I am exceptional at distinguishing odours. This discovery allowed me to appreciate, to a fuller extent, the richness provided by odours of places I thought I was familiar with. Happening at the beginning of my study, this epiphany was both a capricious and welcome exploratory opportunity of intuitive experience and, as Kate Mclean put it, "sensing selves". By forcing myself to focus on the odour changes around me, I found that smell not only arouses memories, but also provokes emotion, which pushed me to continue to delve deeper into the research of the olfactory system and it's related effects.

3.1.3 An Interview to Collect Smell Stories (2019)

During the summer of 2019, I hosted 80 interviews, both face-to-face and via social media, to collect smell-related stories and thoughts. 16 participants were my friends and were interviewed face-to-face when I traveled back to China. The others were volunteered to fill an online questionnaire I posted in English social media. All of them were asked the same questions with a focus I focused the interviews on scent stories—could we remember scent through a narrative? My reflections that follow present how people experience and think about smell.

Upon completion of the project, I noted and categorized the scents mentioned. There are a few notable findings from the data: 70% of the smell sources mentioned by participants are natural, like plants and food, while only 17% are artificial and 13% are abstract, like seasons and family. It is easy to conclude that the more impressive or remarkable scents come from nature, not chemical or artificial products.

Figure 5. The Most Mentioned Words from the Interview

Among all the words mentioned, the most frequent was “cigarette”. There were 10 participants who shared their cigarette-evoked memories. Some participants had a negative reaction to the word whereas others did not. Below are excerpts from two interviews with participants.

"I was raised by my grandma who is a heavy smoker. There is always the smoke smell in her breath. When she is getting too old to smoke that much, the cigarette smell in her breath turns lighter as well. Finally this smell gives me a sense of security and is kept deeply in my memory."

— Blue, China

"Usually, I hate the smell of cigarette, but my girlfriend's mom smokes and I love the smell of the smoke on her. The smell of smoke on her gives off an almost comforting vibe."

— Jesse McCammon, USA

Based on these findings, the sentiment around cigarettes can vary from person to person, decided by their personal past experiences. No two people attach quite the same meanings to the same scent. The same way a person may be comforted by a certain smell, another may find it revolting, and vice-versa. We can see a variety of emotional values across the spectrum, ranging from good and bad, enjoyment and revulsion, and happiness and sadness; all are feelings our brains attach to the signals we receive from our noses. We apply memory to scents to help us comprehend (discussed in *3.2.1 Embodied Scientific Knowledge of Olfaction*) and to relate scents with both happy and bad times. This makes smell a very subjective sense.

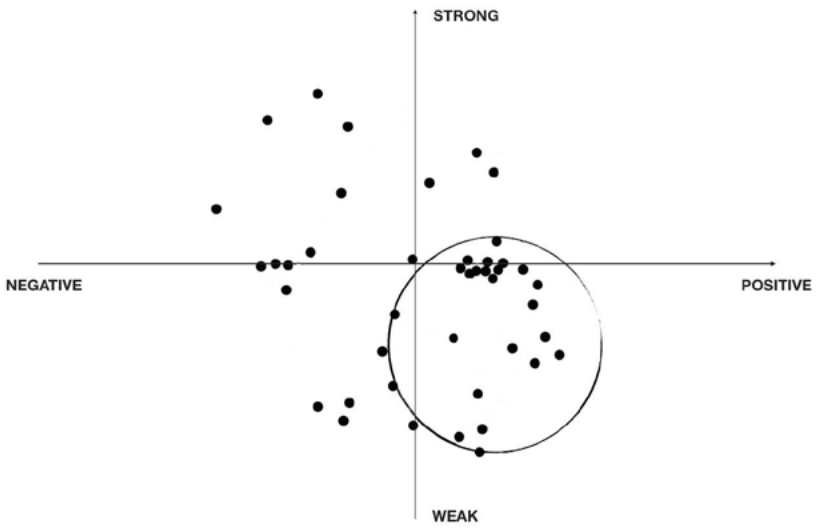

Figure 6. The Visualization of Emotion Value

Thirty-four interview participants were invited to locate an emotional quality to a memory that is triggered by smell. In the visualization above, the horizontal direction shows the emotion's property - negative to positive, and the vertical direction presents how strong and weak the emotion is. The outcome is that the majority of the dots are crowded in the lower-right quadrant between 'positive and weak'. It seems that people tend to tell stories which evoke happiness or relaxation and are, generally, more averse to recalling stories that may draw up negative emotions.

The meaning of an odour is based on how we firstly meet the odour. Perceiving the scent initially in a pleasant situation will bring a positive impression to the subject in the future. From this interview, we can see how strong the relationship between smell and memory is. Due to the fact that the response to odours are based on peoples' experience, olfactory perception and the related memories are considered subjective.

3.2 THEORY-BASED RESEARCH

3.2.1 Embodied Scientific Knowledge of Olfaction

The Connection Between Olfactory System, Memory and Emotion

Smells are not neatly defined objects. They can travel a considerable distance and appear seemingly unattached from their origin. Smellscapes can vary significantly in scale, ranging from entire continents to small rooms. Through the connection between smell, memory, emotion, and space, olfactory perception makes a substantial contribution to our understanding of the world around us. The perception of smell includes not only the sense of odour itself but also the experience, cultural association, memory, and feeling of arousal (Almagor, 1990). Smell cannot be isolated from the space where they were produced, rather, smell are concerned with an immediate localized and immersed experience that involves emotions.

The description of the connection among memory, emotion and olfaction lies in the anatomy of the olfactory system. Olfactory signals are transmitted from the exposed olfactory bulb along olfactory neurons to the limbic system (Mori et al, 1999), which is the control centre of emotion and memory. The strong stimulation activates the hypothalamus, which activates the endocrine system which releases hormones to stimulate the autonomic nervous system, which abandons logical reasoning (Herz, 2009). Thus, the process of olfactory perception is “similar to an unconscious, whole-body activity” (Gilbert, 2008).

Smells are complex, full-body experiences, making it difficult to communicate them to anyone but ourselves. It often is easier to describe a situation where one encountered a particular smell than to name the smell itself. To perceive a smell narrative means to engage and experience the story about a place and others’ experiences. Smell and story is further discussed in my design practices in Chapter 3.3 Practice-led Research.

The Unavoidable Sense

People can look away, and people can cover their ears, but people can’t not breathe; breathing people can’t not smell. Thus, scent is invisible, permeating, and profoundly effective in engaging audiences. To escape an unpleasant odour, one must leave the affected room. On the contrary, one may be directly attracted to a scent that arouses their curiosity, their hearts, and their thoughts. This makes smell a powerful tool in

the artist’s field.

While a modern life without a mobile phone or social media would be especially difficult, losing smell can impact a person's life far more than one might expect. The sense of smell has a strong effect on modulating human behaviours, and it plays a significant role in the evolution of human habitat, food preparation, and social behavior (Sarafoleanu et al., 2009).

First, olfactory-impaired people can't use their sense of smell to identify risks around them such as whether or spoiled food. When there is smoke or a gas leakage, they can't respond in time. Second, the loss of smell often means the quintessential loss of taste as people can't enjoy food without smell (Bromley, 2000). In addition, people with dysosmia (olfactory impairment) often suffer from social anxiety related to body odour. They have to rely on others to help identify odours, which removes their autonomy and often leads to frustration (Schienle et al., 2019).

The Lost Sense: the Difficulty of Expressing Smell

McCann, a global creative agency, used to conduct a study called Truth of Youth (2011). They surveyed 7,000 young people aged from 16 to 30 in several countries. More than half of the interviewers said they would rather lose their sense of smell than their technology such as laptops or smartphones. Compared to real world activities, the online world is scent-free and the mainstream digital product is odourless.

In addition, The difficulty of expression also results in the smell losing its discourse. When looking at the formal language of contemporary art and design, we can see a variety of media, from visual to auditory, from graphic arts to interactive installations. The development of science and technology enables designers to have more tools and also enables viewers to get closer to artistic works. We have so many words to describe, appreciate, or even criticize them, but due to our language, we can hardly describe, record, or even transmit smell the way we treat images and words.

The ability to accurately describe what the sense of smell is transmitting to our brain doesn’t come easily to most people. One study showed that English speakers have a particularly hard time describing smells compared to speakers of other languages. For example, in Southeast Asia, people who speak the Jahai language have a larger number of words describing smell (Diep, 2019). They were able to describe the smell of cinnamon more concisely and consistently than english speakers were. It's not that Jahai speakers have a better sense of smell, it's that they are more alive to odours

and their language has evolved to include vocabulary to accurately describe various smells. English speakers have the same ability to smell as Jahai speakers do, but the language does not support the communication of smell (Majid et al., 2018). However, Western societies are saturated with perfumes and deodorants. People tend to cover and eliminate most smells, which leads western people to be less able to describe the wide range of smells (Fox, 1999). The difficulty in articulating makes smell more of a 'speechless' sense.

Jahai Word	The English Explanation
plʔɛŋ	the bloody smell that attracts tigers
pʔih	the smell of raw meat, raw fish and blood
tpɨt	the smell of some ripe fruits and specific flowers
cŋɛs	the smell of wild mango, wild ginger roots, bat caves, droppings of bats, smoke and petrol

Table 1, Some Examples of Jahai Words for Expressing Scents (Majid, 2014)

To improve the sense of smell, people must somehow create their own olfactory language. The people who have an extensive olfactory vocabulary are those who use their nose to make a living, like sommeliers and perfumers. These experts tend to name odors by associating them with things that have similar odours. Their descriptions are not always understandable to the rest of us, especially when they come to professional and abstract terms. For example, when a wine critic identifies a wine as "austere", "brawny" or "decadent", and most people, even if they know the "dictionary" meaning of the word, do not know what those mean when used in relation to an olfactory sensation (Miller, 2014). A "fat" wine does not mean that it fills the mouth or that it has any more calories vs a "thin" wine, a "fat" wine has a higher fruit concentration and a lower acidity level.

During a perfumers' career, they usually smell thousands of unique fragrances. These olfactory experiences are not marked in their brains as widely used and vague terms, like "gorgeous" or "spicy", but instead perfumers use their own vocabulary to mark words for their own understanding (Alač, 2017). Each olfactory experience is independently memorized for future reference. Thus, they have created a personal dictionary of smell that they can refer to.

It is not a feat most people can achieve, but everyone could improve their relationship with their senses and better understand the world. When people learn painting, they must give up the preconceived prejudice that language imposes on vision. The human body is not simply white or black, it is a mixture of shadow and tone. Painters need to learn to understand what they really see, rather than what they thought they could see. In the same way, a person must relearn scents to truly identify and express their sense of smell.

The Application of Smell in Product Material

Materials with pleasant scents can be found in handcrafts, but it is relatively hard to find design that focuses on incorporating the sense of smell into consumer products and appliances. One example is the common garbage bin liner which can be found with a range of smells, mostly smells signifying cleanliness; however it is not common to find smell associated with way-finding or aesthetics.

Most materials have little scent or even, in manufacturing and processing, have unpleasant smells associated with them that are treated or reduced. Because of this, most scented products are generally not natural, but achieved through additives. This removes the shackles of production design to a great extent, allowing a more tailored approach to integrate fragrance directly into materials.

Human senses do not work autonomously. People's five sensations are interrelated as a whole and will continuously generate new feelings based on diverse stimuli (Rupini & Nandagopal, 2015). For example, there is a delicate relationship between smell and vision. Imagine the smell of watermelon suddenly did not come from a slice of red but of dark purple; the disconnect it would cause our senses would be poignant. Therefore, during the design of a product incorporating scent, it is necessary to consider not only the appearance of the material but the association of smell with other sensations.

The exploration of applying sensory perception, such as olfaction, in material depends on curiosity, continuous innovation, and practice between designers, scientists, and engineers. Taking smell into account by re-combining existing materials for their essential olfactory qualities would encourage the development of more sensorially attractive products.

3.2.2 The Application of Olfaction in Modern Technology

The Transmission of Smell

Current communication technology can convey a lot of information, such as sound, text, pictures, video, and so on. From a technical point of view, odours are more difficult to convey than sounds and visuals. The nature of odour perception is molecular stimulation which is hard to quantify (Su, 2009). To fully record this signal, it is necessary to record the concentration of all different types of molecules in the sample, which is extraordinarily tough to achieve by modern technology. Even if the signal can be reproduced, ensuring safety is also a problem (Rokni & Murthy, 2014).

There are two main technical barriers to the transmission of smell by digital means. Firstly, unlike colours which can be encoded with RGB or CMYK, with the known kinds of molecules we currently have, we struggle to encode odours (Genva et al., 2019). That means people cannot obtain the full range of odours from mixing only a few. Secondly, it has proved impossible to stimulate the olfactory system without an actual odour molecule in the air (Lapid & Hummel, 2012).

At present, people do not have a wide-used technology to transmit smell. Although smell cannot be communicated , it is a way for humans to perceive the world. If people found a method to transmit smell beyond the current spatial limits of its existence, the application of olfactory technology would expand immeasurably.

The Application of Smell in Marketing and Environment Design

Brand marketing is an area where the demand for smell transmission lies largely untapped. Through emanating smell from areas such as the preparation area (e.g. the aroma of coffee in Starbucks), or through manufactured ambient smells (e.g. the fragrance in Hollister retail stores), there are advantages of designing smell into the consumer service environment. One of the reasons is that there is a belief that such design improves the service environments in which olfaction takes place (Bradford & Desrochers, 2009). If the scent within a service environment induces a positive affective state in consumers, then it may leave a positive impact on the image of the service provider, its brand positioning in consumers mind, and as a result, the potential likelihood of future visits.

However, caution should be taken from the fact that the associations made by consumers in regards to smell can be both positive and negative. Such variations may be influenced by consumers' previous experiences with a smell and their individual characteristics, such as gender and age. Seniors may have different reflections to

scents versus their adolescent counterparts. Furthermore, some olfactory stimulation may cause an allergic or physiologically unwelcome reaction in certain people (Wolkoff & Nielsen, 2017). At this point, if the service provider is designing smell into their environment as the marketing method, there is an ethical responsibility for those managing consumer service environments to consider the potential hazards.

A Case Study: 'oPhone', the mobile that sends Smells

Products related to the diffusion of smell have been proposed and designed in the past. The design team of the product “oPhone” believes that smell has an effect on humans that vision and sound can't achieve. Sharing aroma with friends is like sharing memories and emotions, which is the hope that the oPhone team intends to deliver.

Figure 7 has been removed due to copyright restrictions. The information removed is oPhone by Blake Armstrong, 2014. Available at https://www.indiegogo.com/projects/ophone-duo#/

Figure 7. oPhone (2014)

The appliance of oPhone contains eight small odour chips, each containing four odours. Based on that, the ophone duo can emit more than 300,000 unique odors. After the user takes a photo through oPhone APP, he or she selects a series of odour tags for the photo. Such a message, consisting of photos, texts and odour, is called an "oNote". oNotes can be shared with friends on a variety of platforms. Images sent to friends through social networks will give a full-dimensional smell, making the images more vivid and believable.

People enjoy experiences best when all the senses work together harmoniously. In the age when touch, hearing and vision have been preferentially developed, smell will drive storytelling to a new stage. Although this product was not commercially successful, it was an innovative attempt of turning this idea into a meaningful entertainment experience,bringing the sense of smell into the limelight of design intention.

3.3 PRACTICE-LED RESEARCH

3.3.1 Exploration Interactive Design Prototype: Seeing Your Smell (2018)

The Creation Process and User Feedback

Scents are molecules that exist in the air to be captured by our olfactory system. In my project *Seeing Your Drink*, I visualized the concentration of the number of alcohol molecules in the air with a sensor. Then through code, converted the value into a visual representation that was then displayed on a screen. The higher the concentration of alcohol molecules, the more red dots will appear.

As a signal index of scent, concentration shows the volume of the scent and can be precisely measured by sensors. Based on the interviews I conducted (*3.1.3 An Interview to Collect Smell Stories*), the odour of alcohol was one of the most cited odours and alcohol sensors are one of the most accessible sensors in the market, I felt it was apropos to choose alcohol as the measurement object in this project. Firstly, using Arduino to code and connecting an alcohol sensor to the computer, an accurate concentration of alcohol in the air could be detected and recorded. The value was then transferred, processed and was shown on screen as a cloud of red dots representing the alcohol molecule density.

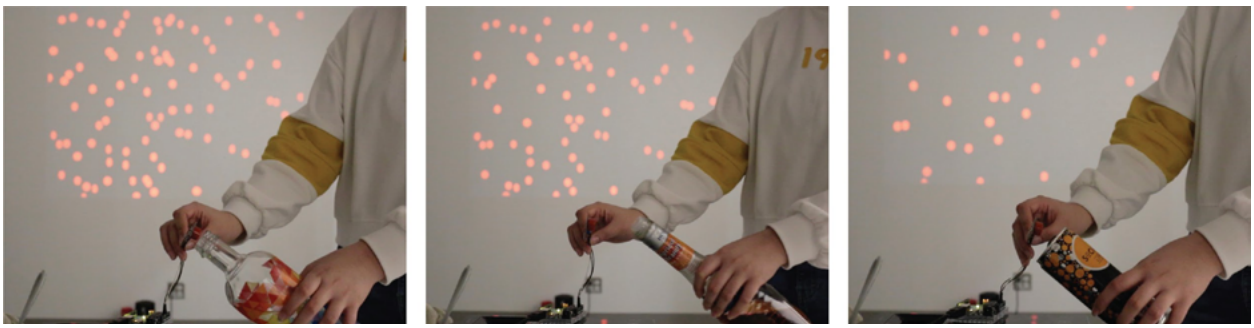

Figure 8. The Tests on High to Low Alcohol Beverage

During the presentation in the studio class, alcoholic drinks with different alcohol levels were provided. My classmates and professors as participants could put the sensor in an open space or beside an open drink to observe the changing dots. Some participants, before and after consuming some alcohol, tried the application with their breath to view the concentration on their breath. Although the changes of concentration could be very subtle in numbers, the visualization magnifies the changes with a more obvious visual effect.

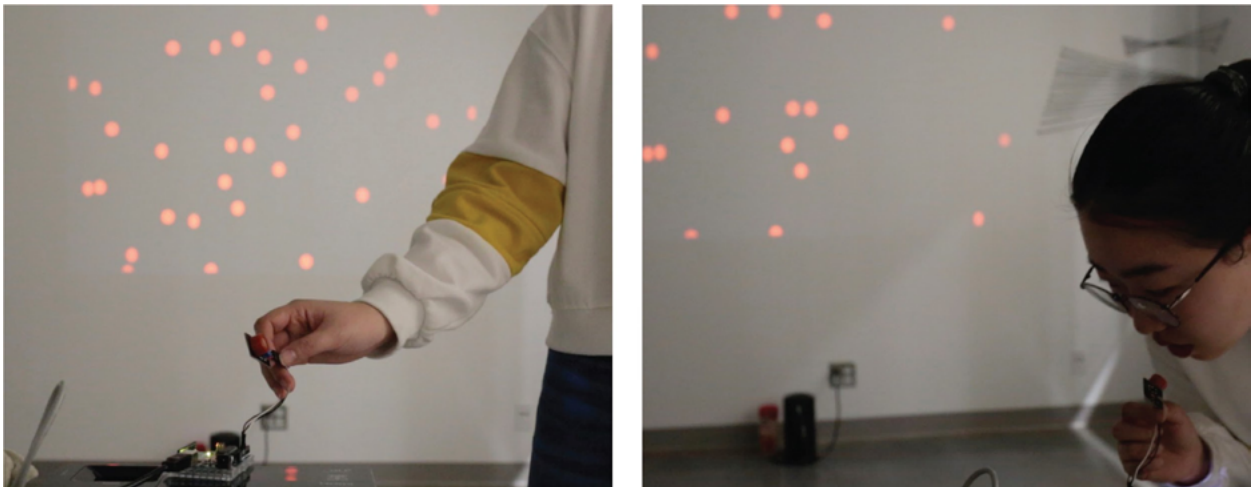

Figure 9. The Tests on the air and breath

Conclusion and Reflection

Numbers express values and information clearly. However, a visual representation of numbers is more intuitive. Digital alcohol detectors are already widely applied as a method in traffic control and health tests but compared with the display of plain numbers, using shapes to show the difference is more striking. Some participants indicated that this application brings in an alternative observation via changing graphics so they do not only smell the alcohol and glance at the numbers, but are able to see a visualization of what they smell. Although, in this prototype, the visual image was simple red dots, it is not hard to see that this multisensory application could be more interesting and attractive with a more robust visual expression. In the combination of visualization and olfaction, humanized appeal and diverse visual styles leave people with space for imagination and give smell a unique visual impact and emotional power, which is the charm of multisensory design.

3.3.2 Exploration Interactive Design Prototype: Don't Just Pass By (2019)

The Creation Process and User Feedback

Don't Just Pass By is an interactive spatial installation that allows people to engage and call attention to the smell which they could have easily ignored. It aims to induce people's interest in smell, sharing their feelings of smell and encouraging them to interact with smell in their daily lives. It communicates by distance—a key part and input is an infrared proximity sensor that detects the distance between the visitor and the smell source.

The development of the project started with coding and processing to build an interaction prototype. Flowers are commonly used to represent nature and, in my summer preliminary research, were frequently referred to by the interviewees when asked the question "what is your strongest memory related to a smell?". In the foreground of this installation, I chose to display a fragrant white hibiscus as the main visual focus in the installation. Hibiscus is a very common and visually attractive flower and its fragrance is subtle yet inoffensive. This makes the holistic sensorial effect more inclusive, inviting and acceptable.

Projected in the background of the installation is a series of images—the blooming of a hibiscus—controlled by the processing of the participants proximity to the hibiscus. The images will change according to the proximity to the origin of the dominant scent, to encourage participants to approach and to know the scent. To make sure that the projected images will not be influenced by visitors' shadow, the hardware is discreetly placed.

Figure 10. Hibiscus Leaves as the Smell Source

Figure 11. Distance Sensor Hidden under the Smell Source

The whole installation was located in an open and public space to maximize invitation for interaction with smells. As participants approach the hibiscus leaves one-by-one to smell them, and as the imitation of the blooming hibiscus on the screen occurs in real time in the same space, many shared their feelings as a group.

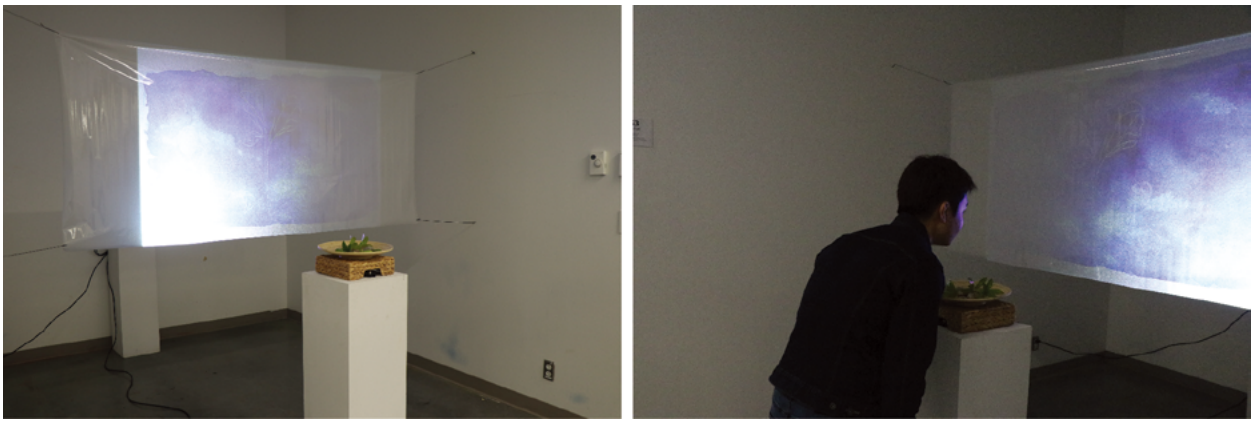

Figure 12. Test-site 1

Figure 13. Test-site 2

Reflecting together offers a moment for participants to share their memories and stories recalled by experiencing the smell around them. It allows visitors to share their feelings and precious memories with each other, creating a spatial environment for storytelling. Incorporating a strong interaction design for the participants' experience adds to and benefits people's enthusiasm for sustained cooperative use of their sense of sight and smell in this space. Supported by the properties of smell, the

longer participants stayed in this space, and the closer the proximity they were to the installation, the more emotional depth they experienced when sharing their stories. This space not only provides more opportunity for understanding the important role smell plays in our lives, but affords an experiential understanding of the vivid, yet vague, connection between smell and us.

Figure 14. The Animation of the Hibiscus Bloossom

Reflection and Future Thinking

The way the screen and the smell source was placed, isolated from each other to some extent, was commented on by some participants. Also, there was no obvious sign to guide people to approach from the appropriate direction to the sensor when smelling the hibiscus leaves. Despite these minor shortcomings , this prototype opened a number of possibilities for future research and design. It shows that interactive experiences and modelling for the senses—smell, in this case—can provide an inspired environment for participants to recall stories and communicate with each other.

Based on the outcome and feedback of this prototype, I would like to reset this project on a larger scale in the future. Projecting, not only on one wall or screen, but the whole space, could bring a stronger and more attractive visual impact. Also, sensors and different smell sources set in various spots would capture the viewer's movements, bringing a series of changes on all projections. Feeling the subtle smell changes in the whole space would encourage more interaction with the application.

Figure 15. Concept Sketch for 'Don't Just Pass By'

3.3.3 Experience Design: Smell Story Kit (2019)

Through previous projects, I've learned that smell could be used as memory cues to provoke shareable stories. For the next stage, I would like to develop the application of smell on a systematic basis, to explore people's deeper relationship with the sense of smell without the limitation of space.

This is a practice-led project to explore the use of smell to motivate the sharing of memories. It starts from material prototyping, which in this case is the selection of odour sources, leading to the design of the *Smell Story Kit*. It contains a series of 10 selected smells, providing a guide to help evoke stories that can be used to build relationships among participants. By going through the process of smelling, collecting keywords, and making up a story, participants share their memories with each other and get a better understanding about the smells.

Smell Session

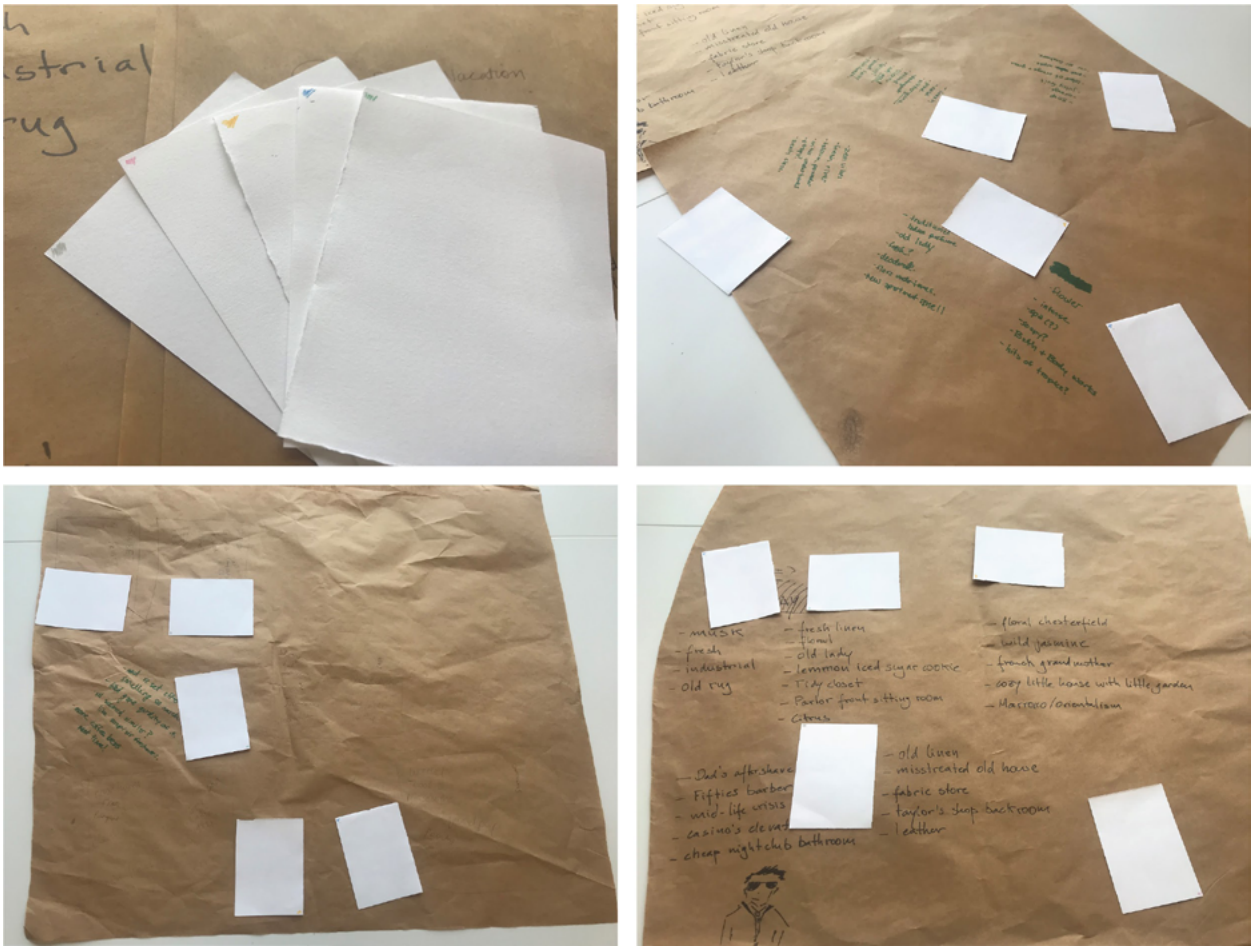

Figure 16. The Conversation Records of Each Group

For the first stage, I worked with 16 participants and divided them into four groups to conduct a ‘smell talk’. Each group got five different cards with varying colours and perfumes. They then smelled the cards and had 20 minutes to communicate amongst their group members on how they felt about each scent.

The outcome indicates that participants were willing to practice with the focus on olfaction and smells provoked dialogue for them. For example, some smells, such as the red one, result in mixed reactions: “It smells like an old lady scent. It smells floral. It smells like a vintage room.” It shows that the smell could elicit specific memories and related emotions that stimulate dialogue.

Figure 17. The Smell Bottles

Based on this outcome, Smell Phase #2 was designed to choose the specific smell objects in the kit. Building on the interview in my preliminary research asking “what is your strongest memory related to a smell?”, the ten most mentioned and accessible objects were chosen as the test objects. They are cigarettes, fresh cut grass, chocolate, laundry detergent, alcohol, spice, tea leaves, coffee beans, roses, and soil. I packed them into small glass bottles covered with odourless black thread to prevent people from seeing the contents before they smell it. During the pretest with three participants, none showed discomfort from these odours, establishing these odours as low-offense and smell-friendly for the project.

Prototyping the Smell Story Kit

During the test, I first provided participants with the procedure for the smelling activity and some smelling tips. Participants were asked to smell each of the ten samples without looking at the contents.They could choose five bottles and write down some keywords as their first reflection by each odour. Then, they could communicate in the group about these keywords to share their explanations behind the words, slowly leading to an exchange of memories. As a closing, they were to choose one keyword for each of the five smells they selected and try to make a story utilizing all the chosen keywords.

During the process, some participants explained that since objectively there are no right or wrong responses, what matters was the personal experience. This helped relieve nerves while talking about themselves. In addition, some said they got to know each other more intimately than they had prior to attending. Feedback from this event suggests that the interactions with smell facilitate the sharing of individuals' memories and help to reveal meaningful insights about themselves.

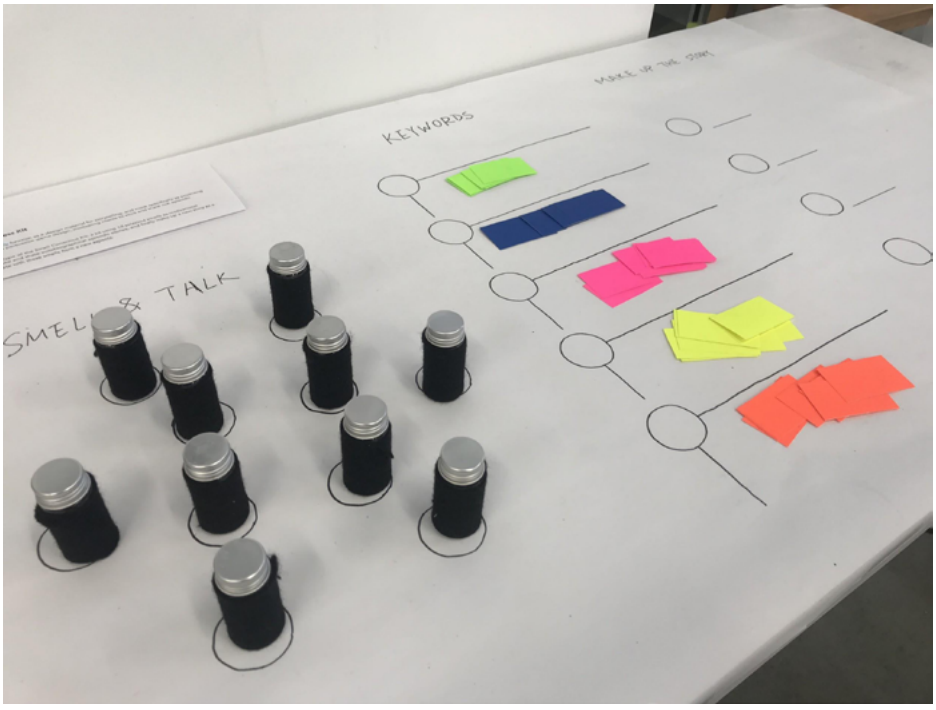

Figure 18. All Probes in the Smell Story Kit

Figure 19. Participants are Sharing Their Stories

Reflection and Future Thinking

The value of this practice shows in focusing on smelling and sharing stories. Moreover, because this specific practice of sensory imagination implies the ability to negotiate new meanings, it also constitutes a learning process. In addition to decoding past experiences, smell can also create new memories through this participatory practice.

When people engage with smells in the kit, their intuitive responses explore the connection between the perception trapped in the mind and body, similar to holding a paintbrush and transferring a mental image to a page. These memories and events might have happened years ago or yesterday, but they are all contained in smells and could be vivid again through people's narratives when the smell appears. Through sharing smell experiences, we can learn so much about our own lives as well as others' lives. Thus, smell also functions as a social connection; it is like an unseen connector between individuals.

In this project, I tried to use smell as memory threads to develop a friendly context for storytelling, which also highlight potentials of the application of smell to design fields. For example, for mental patients who are hesitate to share their personal information, smell could function as a trigger effective for reminding their memories. (See more details in section 3.3.5. Further Reflection and Application)

The visual frame of *Smell Story Kit* that makes up the whole experience process can be further developed with more explanatory text to improve the instruction system. Also the kind of smells in the kit can be adapted to social context depending on the requested characteristics for participants.

3.3.4 Practice-led Research Summary

This research contains early explorations related to people's expression on smell as a way to find a context for this research and uncover design opportunities. As a primary exploration, the project inquiry *Seeing Your Drink* showed that smell is a sensory field that people are not as familiar with compared to the other senses. The combination of olfaction in an interactive art form could attract people's interest to a great extent. The outcomes of, *Don't Just Pass By* pointed to opportunities for visual designers to bring out the beauty of scent in the modern age. This interactive installation created a space for participants to focus on their sense of smell, to talk about smell, and finally, to guide them to realize the role smell is playing in their lives. My primary interest in smell, that scent is closely related to our memories, was further applied to the design of *Smell Story Kit*. This kit encouraged participants to share their personal impressions of selected smells and create a friendly context for storytelling. It is also a resonance for EL Haj's research (2018) that that smell might be used as an element of autobiographical recall and is applied to situations where dialogue needs to be stimulated.

3.3.5 Further Application of Smell

The Application of Smell in Healthcare

If we consider the sensation's undeniable capacity for affecting emotions, we can see the undeniable opportunity for smell to be used in healthcare. For instance, I have observed many hospitals adopt warm colours and soft textures in their interior design in order to improve patients' and visitors' sense of security. Despite these interior environment changes, they sometimes can be overwhelmed by the smell of disinfectant, reducing their effectiveness.

Thus, can we as designers explore the potential benefit of designed smell for users in healthcare spaces in order to take advantage of the characteristic of smell to provide patients and visitors with a better sense of security and trust? Current research has shown that smell can also be useful in relieving patients' mental stress (Chamine & Oken, 2015). When patients come to a new environment, they are usually hesitant to share personal information about themselves because they tend to see the hospital as a strange place, lacking a sense of trust (El Haj et al., 2017). To reduce this anxiety and insecurity, it is necessary to build a positive relationship between patients through communication (Chichirez & Purcărea, 2018). Since the connection between the sense of smell and memories is relatively close, smell can be used to improve communication among patients and healthcare providers. Although the connection is subjective, it plays the role of a potential "icebreaker" that could be considered to apply in the initial communication stage.

The Application of Smell in Education

Through the integration of VR technology, olfactory technology could also be applied to education fields to achieve a better effect.

With the popularization and development of VR, more and more technologists have begun to move their attention from vision and hearing to touch in order to pursue more immersive experience (Perret & Vander Poorten, 2018). They are now looking further, into the field of smell, to seek portable olfactory experiences (Parry, 2018). Education with VR equipment has been shown to be far more realistic than browsing videos, and is the lowest cost solution, both for manpower and hardware, for training students (Gossett, 2019). It has been used in disciplines such archaeology and biology, among others (Doležal et al., 2019).

With the capacity of smell being able to deeply affect one's memories and emotions, the combination of digital odour technology and VR would enable students to smell the pungent odor of a fire scenario within a safe environment, to understand the sense of immediacy and crisis. For example, through digital smell technology, students could learn to identify the pungent smell of the fire scene and how to escape. By simulating a more authentic situation, students receive a deeper impression of the knowledge and skills they must employ. In emergency training, this would help to improve the quality and efficacy or education to aid students in how to identify dangerous situations and escape.

There are still a few obstacles need to be overcome in the digital olfactory experience. A study from Monell Chemical Senses Center (2019) shows that individual differences in genes, which are extremely common, can affect the way one perceives smells. The density, duration and pleasantness of an odour could be perceived differently by people (Trimmer et al., 2017). Although olfactory perception is such a complex and developing field, applying smell to education could still inspire designers and technologists to move forward to bring the new sensory experience into our future lives.

4 RESEARCH SCOPE & SUMMARY

4.1 Research Scope and Limitations

I limited the scope of my study in several ways: First, all the projects are conducted in ECU and most audiences are students and faculty members in the university. I summarized the results by focusing on the participants' reflections and behaviours of my design projects. Although I will consider olfactory impaired participants as a potential group in future application, this study was universal in the design process, including all people. Second, odour is constantly flowing through space. This means that the quality of scent perceived by each participant could vary significantly depending on the location and time; the ability of odour perception is also different from person to person. Instead of analyzing the difference caused by individual perception, this research focuses mainly on the effect of the existence of odour on the whole group of participants. Third, the range of design in this research included not only visual design, but also space and experience design. Smell is an invisible object that can not be treated like the other senses, opening a wider range of conception for designers.

4.2 Answering the Research Questions

· What is the common conception of olfaction in modern society? Has smell become a neglected sense for people?

Through the close connections between smell, memory, emotion and space, our olfactory sense has made great influence on us about understanding of the world. The perception of The perception of smell includes not only the behaviour of smelling itself, but also evokes experience, cultural association, memory and feeling. Through sharing smell experiences with each other, we can learn so much about ourselves, others and their lives. Thus, smell is a fundamental aspect of social connection, it is like an unseen connector between individuals. However, compared with the study of other senses, smell has been ignored in the modern age because of the difficulty of description, translation and the specific circumstances of place and regional limitation.

Smell has become a neglected sense in several ways. First, compared to devices

designed to please our vision, hearing, and other senses, the importance of smell is usually buried under the presence of modern technology. Second, smells are hard to put into words, which increases the difficulty in communication about smell.

· How to integrate olfactory experience into design to make smell a more meaningful and helpful sense?

First, olfaction affects people's judgement when we use it apply is in space design., always. For example, functionally, the strong smell of alcohol may be identified as a hospital; the characteristics of a floral fragrance can tell people whether it's a florist or a cosmetics shop. Moreover, smell can be used in "barrier-free design" rather than just using the tactile method. The information contained in smell is more useful to let blind people know their situation. Some researchers believe that the person with visual impairment usually has a more sensitive olfactory performance than others (Araneda et al., 2016). If visually impaired people have been taught that a scent is the symbol of warning, they would avoid the space with this scent naturally, which could help them avoid danger. On the other hand, if we consider its strong connection with memory, smell could also be used as a cue for stimulating potential communication in experience design. Through my observation in Don't Just Pass By and Smell Story Kit, people are willing to share their autobiography narratives in this context. These could be applied to special institutes where communication needs to be provoked.

Second, the feedback of *Seeing Your Drink* and *Don't Just Pass By* has shown that the combination of olfaction and interactive art form could attract people's interest to a great extent. Applying smell into comprehensive aesthetic design and visualization is a valuable opportunity for artists and designers to explore. As an attractive means to involve participants or to gather visitors, it gives the work an added sensorial experience of a different order. But it is necessary to note that, if the scent is applied to an art work, the primary aim should not be asking people to consciously focus on sniffing, but to take in the smells to find a balance amongst all senses and bring a new experience with smell.

CONCLUSION

Smell is a crucial sense, considering its connection with memories, emotions, and taste. The way it expands and spreads through the air we all breathe makes it an acutely unavoidable sense. However, the difficulty of expression and transmission with modern technology has weakened its importance among the other senses. This research therefore aims at exposing the potential opportunities of smell to rouse peoples' interest and verify its status in the design and modern technology field.

The three studio works in this thesis showcased the speciality of multisensory design with smell. The two exploratory projects, *Seeing Your Drink* and *Don't Just Pass By* , focused on the participant's experience in their interaction with smell. Although these two projects are prototype design rather than completed work, they are the basis of this design exploration. The last thesis project *Smell Story Kit* is developed from my past experiences and findings to explore a guiding experience design exceeding the space limitation. During the process of researching, preparing, and designing for my projects, I gained more understanding of multisensory and interdisciplinary design.

Integrating smell into design could create an environment that meets the functions and requirements of the actual, expected context. First, by using smell as the guiding factor in functional design, smell can highlight the effect of the object and improve the user experience. Second, smell can be used as an auxiliary tool to provoke communication, especially in special occasions where it is difficult to take the initiative to engage in dialogue. Adding olfactory design to artworks can improve the sensorial completeness and enrich the sensorial experience, potentially improving the attractiveness to the audience.

This practice-led research also inspires designers and artists to challenge the sensory limitation of universal design, as the sensory thinking mode should be more widely applied to the design field. The curriculum of design education in most institutions like ECU focuses on vision-based design in order to meet the preference of a vision-domain society. Yet, more and more designers and artists are showing interest in and exploring more multisensory and creative user experiences. Because of its vast untapped potential, sensory design should be more integrated into and encouraged in the design education and practice.

GLOSSARY

Interaction Design

The design of interactive applications or services in which the views are no longer onlookers, but the ones who complete the purpose of the project or to participants in its realization.

Experiential Knowledge

Learning obtained through the process of design practice. The learning outcomes could be individually different as each person may have their own concerned field during the experience.

Participatory Design

A method to bring viewers into the design process through a collaborative approach. In this study, participants work directly with the writer to create user-friendly designs to better improve the user experience.

Smellscape

A varying combination of smells, subjectively particular to a location in a city or place.

Smell Awareness

A participant’s ability to become aware of the existence of smell that surrounds them, everywhere, all the time and to realize how to enrich not only the environment, but life itself. It leads to how much attention people pay to odours in their daily lives.

Modern Technology

Most technology devices that rely on the user's vision, hearing, touching to experience in the past fifteen years.

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APPENDICES

Appendix 1. Interview

In my series of 2019 interviews to collect people's stories on smell, there were 86 interviewers in total. 13 of them took the interview face-to-face and the other filled a chinese questionnaire online. All of them were asked similar questions.
Here are the leading questions:

1. Are you sensitive to odour?
2. What is your strongest memory related to smell?
3. Do you have a favourite or least love smell? What is it? Why?
4. What do you think of scent? How important do you think the sense of smell is?

After translating the chinese answers into english, I extracted some of them and the interview to make a booklet to show these interesting smell memories and thoughts.

Figure 20. The Printed Booklet

Appendix 2. Documentation of *Don't Just Pass By*

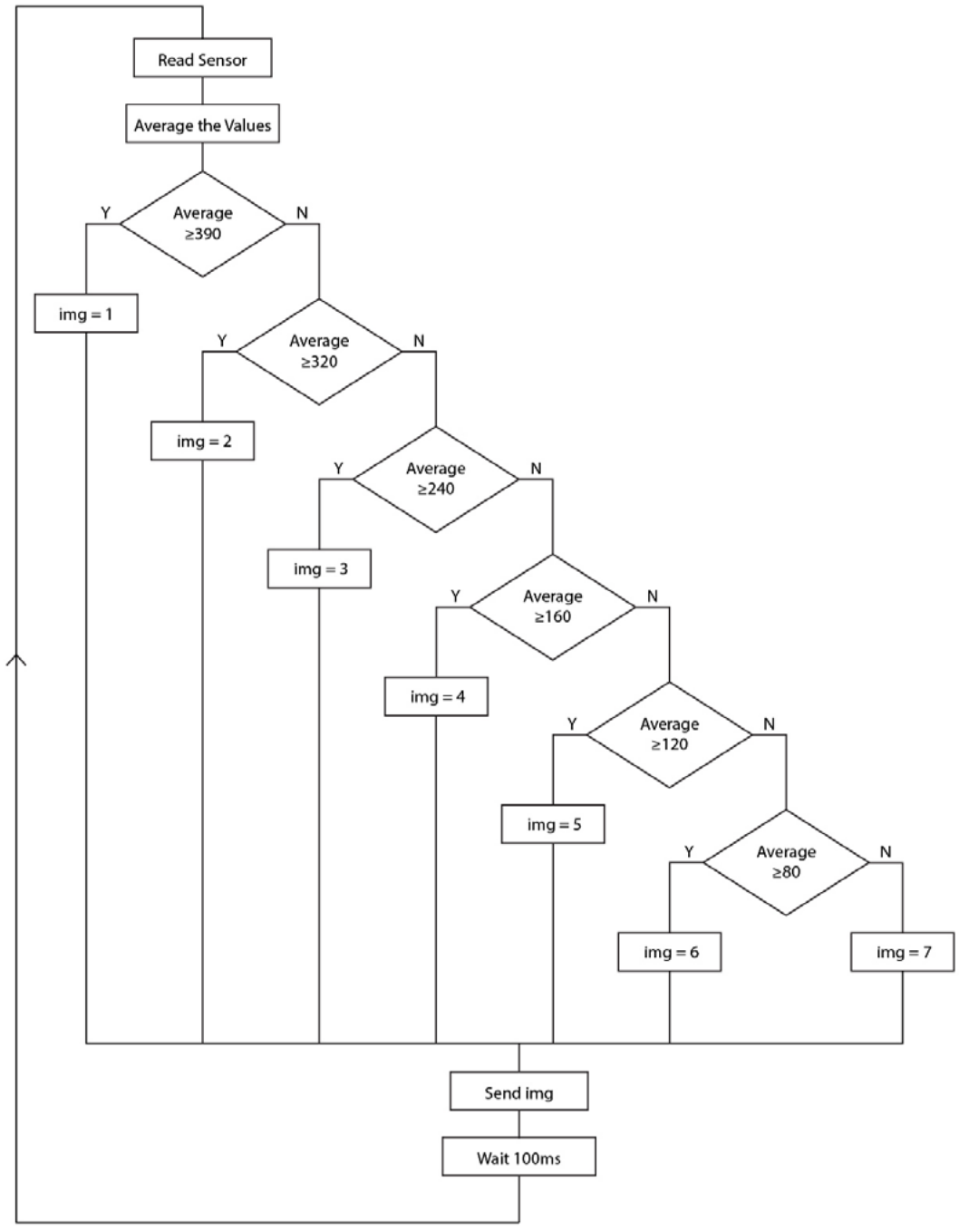

Figure 21. Flow Chart of Arduino Code

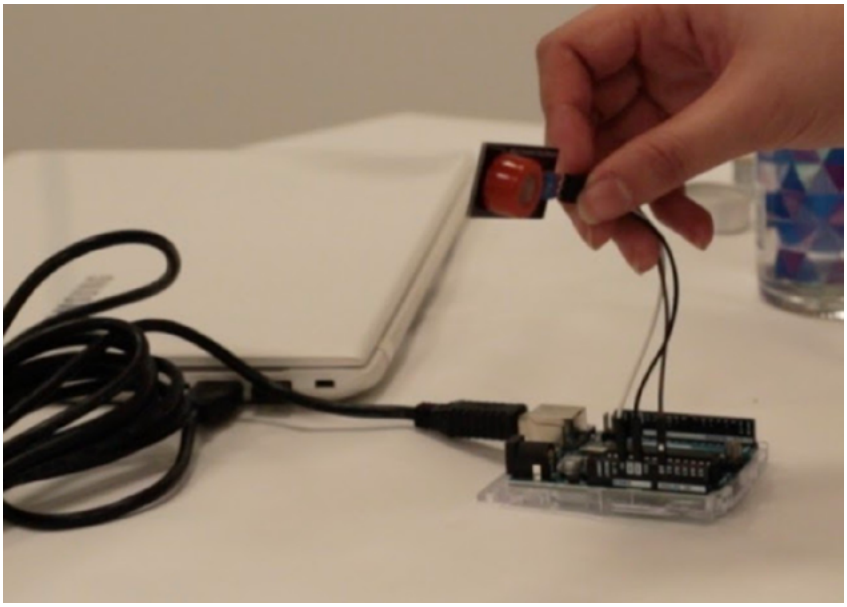

Figure 22. Connecting the Sensor with Arduino Board

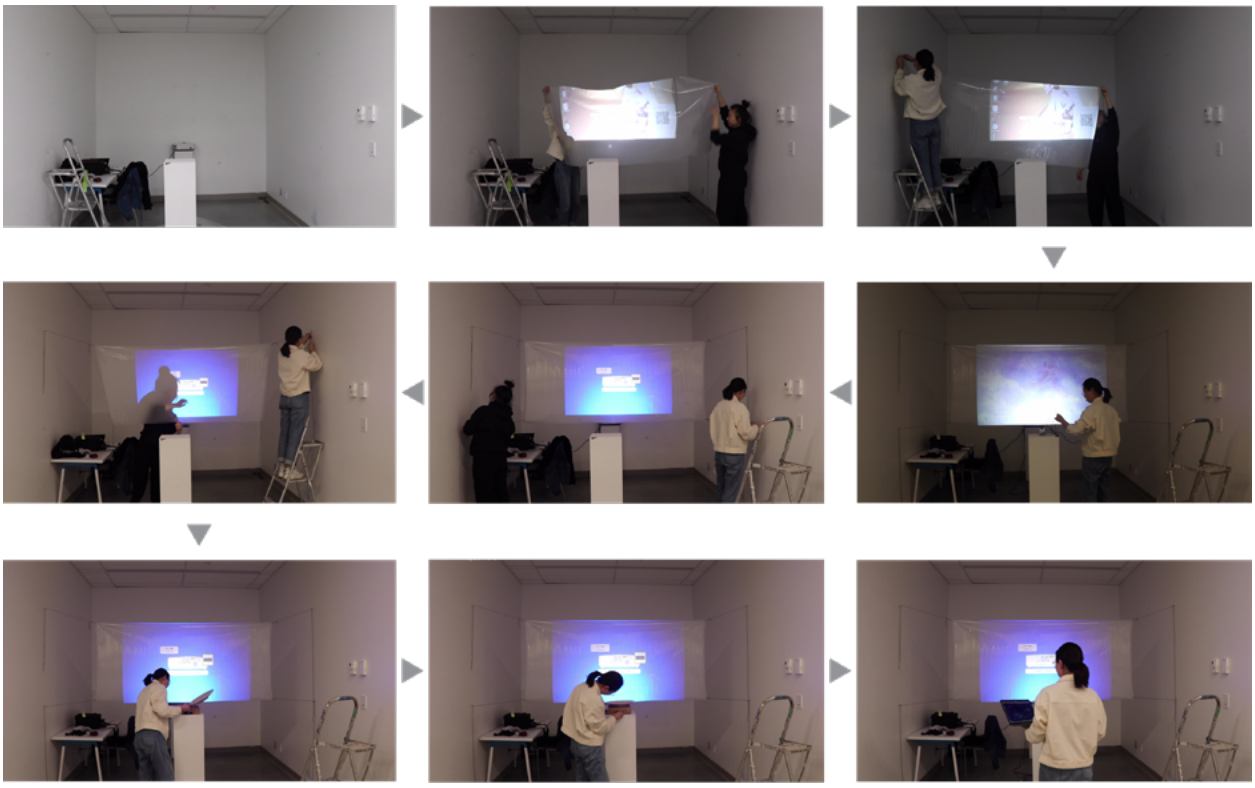

Figure 23. Installation Process of The First Test

Figure 24. Participants Interacting with the Installation

Appendix 3. Documentation of *Smell Story Kit*

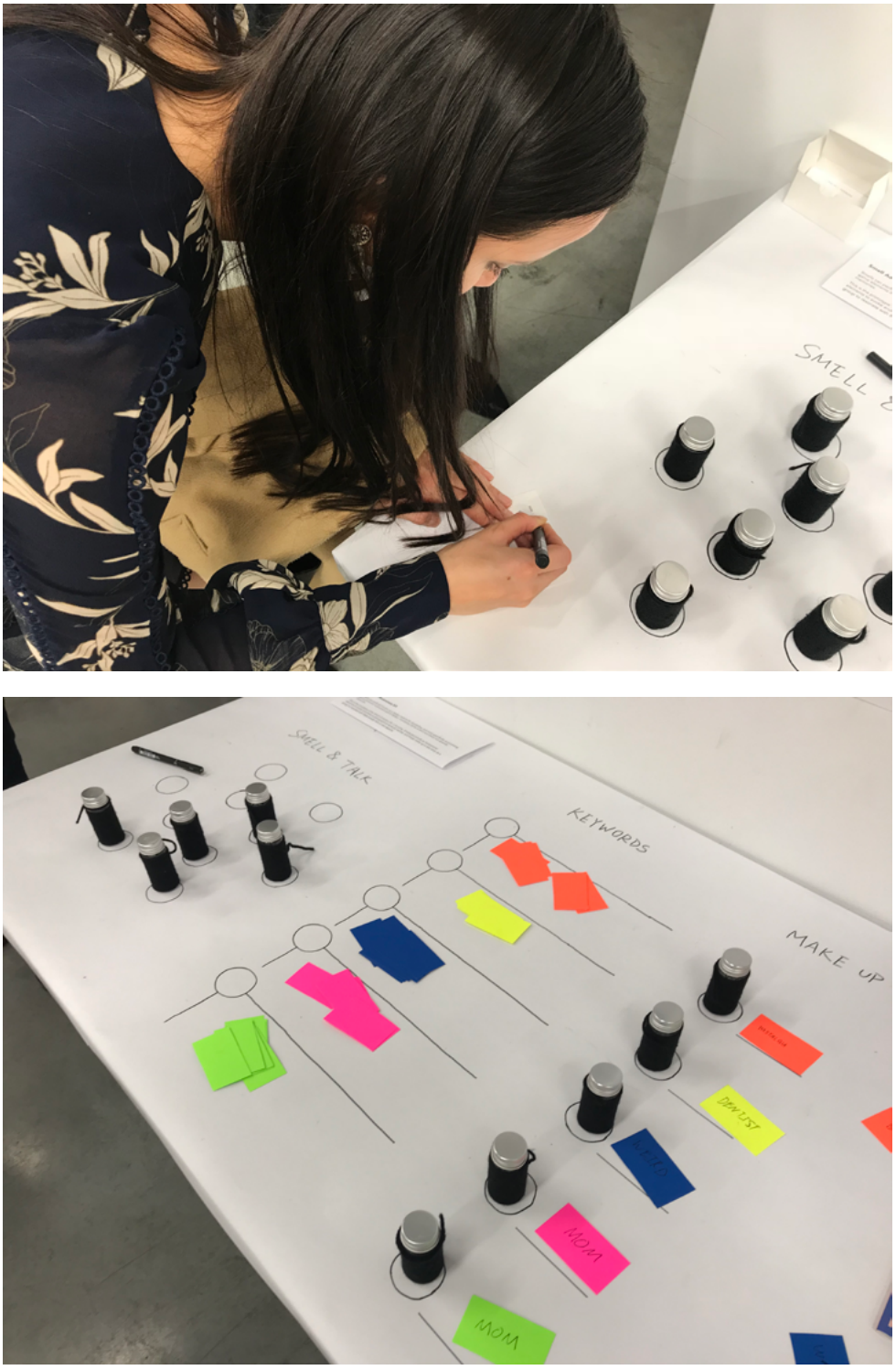

Figure 25. Prototype Test of the Kit

Appendix 4. Smelling Tips

In the *Smell Story Kit* project, participants were encouraged to smell 10 different odours, which might lead to over-stimulating or olfactory fatigue. So I provided some smelling tips for them to improve their experience.

1. Close your eyes and smell. When you feel the odour, slowly bring it to your nose. Some smells may be stronger than others. Move the bottle from left to right under the nostrils.

2. When you feel your olfaction are becoming duller, taking a moment to smell the skin on the inner side of your elbow could help you to recover.

3. Some aspects to start the sharing: How does the smell make you feel and why? Consider what memories, places and people the smells remind you of. Discuss which smells you prefer over others and expand on the answers.