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Scented Pebbles: Co-Creating
Value with Interactive Ambience of Smell and Lighting in Commercial Space

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Abstract

This thesis challenges to create interactive ambience of lighting and smell in order to augment experiential value of customers. With a co-creation perspective, it addresses how value is brought to customers relevant to their individual experience and background, known as value-in-context. On the other hand, the unconscious impact brought about by smell has the potential of creating values that encompass our emotions and mental imaginations. By creating embodiment through interactive technologies, the value of smell and lighting goes beyond ambient information and can be integrated as part of the service design of the commercial space.

*Scented Pebbles* is a collection of light-weight interior artifacts working in tandem with network of sensors embedded commercial space. The sensors takes the form of everyday objects or part of furniture i.e.: coffee coasters, sofa seats, carpets. By sensing customers’ behaviors, *Scented Pebbles* creates interactive ambience of smell and lighting in commercial space such as cafe, co-collaboration space and lounge. The research proposes interactive ambience of smell and lighting artefacts for commercial space, to create sensorial playful, social and lighthearted encountering moments.

In the co-creating culture where consumers are empowered by technologies to create value that are relevant to their individual context
Consumers are considered as actors to create value rather than passively consuming the experience designed by the business supplier. By providing an interactive ambience of lighting and smell, Scented Pebbles allows customers to co-create their experience. This creates opportunities where customers could personalize and create adaptive ambience as part of their experience in commercial space.

Scented Pebbles gives service providers an interactive ambience tool to connect to their customers on sensorial level and create experience that matters to individual consumers in their own personal context. Through co-development of prototype and scenarios by engaging business suppliers and customers, it expands value specific to customers’ contextual background, known as value-in-context. Through interactive ambience design, business suppliers could connect with consumers create and benefits for customers to make them feel social, playful or relaxing at the right moment and make it enjoyable.

By bringing Scented Pebbles to business partners in the real field, my research presents the research process of discovering and creating the value of interactive ambience in commercial space. The design illustrates how interactive sensorial experience can benefit customers, as part of the co-creating value in commercial space.
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Chapter 1

Introduction

This thesis challenges to create interactive ambience of lighting and smell in order to augment experiential value of customers. With a co-creation perspective, it addresses how value is brought to customers relevant to their individual experience and background, known as value-in-context. On the other hand, the unconscious impact brought about by smell has the potential of creating values that encompass our emotions and mental imaginations. By creating embodiment through interactive technologies, the value of smell and lighting goes beyond ambient information and can be integrated as part of the service design of the commercial space.

*Scented Pebbles* is a concept designed to create interactive experience of lighting and smell designed for spaces such as lounge, cafe, and co-working space. It is designed as collection of interior objects, capable of providing patterns of lighting and smell according to the contextual information of customers. For example, in co-working space, when people lean back onto the sofa, a programmed sequence of smell and lighting will be created to provide relaxation time; when they are having a drink together, it provides social game interactions through coffee coasters; people may also enjoy personalisation of the smell and lighting by interacting with *Scented Pebbles* directly and exploring combinations of lighting and smell. Through interactions, members of
1.1 Enhance Co-Creating Experience through Senses

Co-working space become actively involved in creating their sensory experience. The lighting and smell responds to their activities to support their goal. For example, *Scented Pebbles* supports members’ goals in co-working space such as getting refreshed during break time, creating social interactions with visitors and co-workers, and creating their own personalized space. *Scented Pebbles* are integrated in two real commercial space: cafe and co-working space to discover value-in-context for customers.

1.1 Enhance Co-Creating Experience through Senses

I have adopted the framework of co-creation approach in designing the interactive experience, and providing value-in-context for customers. Co-creation approach emerges from research on Service Domain Logic, first proposed by Lusch and Vargo\(^1\). In the book *Service-Domain Logic of Marketing*, Lusch and Vargo give a meta-theoretical framework of value creation. It mainly states that customers are no longer passive consumers but are active creators of value. And it is also important that value is determined by customers through experience related to their contextual background, known as value-in-context. This way of thinking is widely accepted and intensely discussed by scholars such as Christian Grönroos and Adrian Payne from the field of marketing and business management.

In the last ten years, the co-creation approach is shaping how industries are delivering value for customers. In the book *The Future of Competition: Co-Creating Unique Value with Customers* why companies could not sustain growth by producing experience,

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products or services from the producers’ point of view. No longer can firms autonomously create value. Business suppliers and managers should consider providing offerings that suit consumers’ needs. In today’s economy, consumers are increasingly empowered by social interactions, technologies, connectedness to create value that are suitable for them. C.K Prahalad wrote that "Co-Creating Experience is the Brand", he firmly believes that the success of the company can only be brought about by enabling services and platforms that allow customers to create value adapted to their individual experience and contextual background.

Many commercial applications have emerged, using social media and technologies to engage customers. For example, Nike+ was one of the first co-creation initiatives, where it implement platforms and smart devices to track users’ running experience and encourage them to take part in virtual competitions. This allows the brand to be engaged with large community of runners and create huge differentiation with the competitors with a strong community base. Following the success of Nike+, it calls upon the creativity of consumers to create their own Nike design. Other brands start to pay attention to engaging customers co-creation of products and experience. For example, Starbucks created MyStarbucksIdea.com to invite consumers to contribute their ideas, in order to grow communities around the Starbucks brand.

Besides collaboration and social engagements, co-construction of experience is another angle for co-creating experience. Ramaswamy has illustrated how top brands like Apple and Starbucks create assemblage of service where consumers can co-create their experience. Apple shop features an assemblage of products on display makes consumers feels easy to browse and select, meanwhile, Apple employee acts as source of knowledge not as sales, to provide help based on individual’s demands. Customers can make use of digital service Apple Pay to complete transactions. Customers are provided with the tools, space and service to co-create their own experience based on cohesive
1.1. Enhance Co-Creating Experience through Senses

Apple brand design and offerings. Instead of producing a monotonic experience for everyone, they pay attention to individual customers and allow them to assemble their own experience. As customers personalize their experience, value is emerged from the value-in-context. In this co-creating experience perspective, organizations provide services and offerings that allow customers to customize and co-create their own experience.

By co-creating experience, it means to allow customers to co-construct their experience, personalize their experience related to their context. During the consumption of the service and products, customers can further engage with the service to define their own personal experience suitable to their own goal. Design of experience has new priority and meaning in the whole value creation process. This brings new light to service industry and how interactivity and design of artefacts and experience could bring value to the brand, to create experience that interact with consumers so they can create input in the experience.

With many approaches of co-creation, researchers start to address value emerged in co-creating experience. Current deployment co-creation in the industry mainly focuses on social engagement and satisfaction in expressing creativity as part of product design (as seen in Nike and Starbucks example). Some has also addressed the power of personalization during the co-creating experience (as seen in Apple retail example). Heinonen\(^3\) and Helkkula\(^4\) have addressed that value emerged as phenomenological experience encompass mental experience, imaginary experience, experience before, during and after consumptions. Gentile includes the emotional and sensory dimension value created. This has painted a bigger picture of what the value of co-creation entails.

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1.1. Enhance Co-Creating Experience through Senses

Rodrigues and Hutlens et al.\(^5\) specializes in sensory marketing and turns to co-creating experience to propose future sensory marketing strategies. They have proposed that sensory strategies can further cater towards individual of customers with integration of digital technologies. This creates emotional and sensorial value as part of co-creating experience. This sensorial and emotional aspects is often missing in most co-creating practice and yet to be explored.

Therefore, *Scented Pebbles* leverage on embodiment of sensory experience for co-creating experience. With advancement in technologies, it is possible to create sensory experience that can be personalized according to users’ behaviors. This sensory layer of co-creating experience could further strengthen the value experienced by customers.

### 1.1.1 Definitions

The following concepts and terminologies appear throughout the thesis, some of them looks similar but not close in meaning. A list of the key definitions are highlighted here for reference.

*Co-Creating Experience*

Co-Creating Experience follows Prahad’s experiential view of brand, it is an experience where consumers are part of creating the experience. It creates new opportunities for interactive experience design, where consumers can create input to the service they receive, i.e. expressing their interests or preference, giving feedback about the system, co construct the experience, personalize their experience, engaging with the service. It focuses on co-creating experience at the moment of consumption in the space.

*Value Co-Creation (Process)*

Value Co-Creation (Process) refers to the process of value emerged or formed

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1.1. Enhance Co-Creating Experience through Senses

from interaction among suppliers and customers. In Payne’s view, he states that value co-creation process starts with business suppliers proposing the value as series of services, products and offering. I followed Payne’s view that the value is ultimately determined by customers as value-in-context, while they experience the service and product. From business suppliers’ point of view, the higher value created by customers, the more loyalty of customers will be. In the mean time, through interaction of customers, they may improve their service offerings to gain further loyalty from customers.

Value-in-Context

Value-in-Context is the value that emerges when customers experience the service, defined in Service Domain Logic. Customers will make use of organization’s offerings to create relevant value according to their social environments, personal demands and lifestyle. Apple’s approach: Apple shop features an assemblage of products on display makes consumers feels easy to browse and select, meanwhile, Apple employee acts as source of knowledge not as sales, to provide help based on individual’s demands. Customers manage self-servicing by consulting the on-site staff and well as digital service to complete transactions. They will co-create their own experience based on cohesive Apple brand design and offerings, at the same time, derive value based on their own context and background.

Co-Creation (Process)

Co-Creation Process is mentioned very few times, it is different to Value Co-Creation, as it refers to the activities of engaging network of business suppliers, customers, makers and other business stakeholders in the creation of service and product. Where Co-Creation Process is used, it is close in meaning to collaboration process.
1.2 Under-explored Potential of Smell as Embodied Experience

Smell, along with other senses, plays an important part in human cognition. In Embodied Cognition⁶, it’s understood that human beings perceive the world through their senses. We rely on our senses to understand our world. Our motor system, perception system and how we interact with the environments shapes our cognition and ultimately decisions. The underlying reasons why our decision making can be pre-empted by sensory stimulation is related to how our brain processes sensory inputs. Daniel Kahneman, well known cognitive scientist and author of a best-selling book Thinking, Fast and Slow⁷ has written about unconscious brain. Kahneman bases his research on dual processing of the mind, the implicit unconscious mode working in auto-pilot mode that is fast, intuitive and emotional, as it has developed through long history of evolution; conscious rationale mind that is slower, more deliberative and more logical.

With the advancement in embodiment cognition, marketing researchers and practitioners are actively exploring how consumers are making decision by taking into consideration of multisensory experience and emotional impact under our conscious knowing. In the book Unconscious Branding ⁸, Van Praet⁹ writes that "the unconscious mind is holistic, highly perceptive, and multisensory". Our brain experiences more than what we can report and reflect rationally. He considers "brand as association of memory, and chemically driven shortcuts", consumers are prompted by emotional response deeply embedded in previous experience and these are the strongest motivation to make

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⁷. Daniel Kahneman, Thinking, fast and slow (Macmillan, 2011)
⁹. ibid.
1.2. Under-explored Potential of Smell as Embodied Experience

There are many who have created impacts on consumers through inclusion of sensory as part of marketing or branding practice. Martin Lindstrom\textsuperscript{10}, expert on multisensory branding writes about how brand can be empowered through multisensory stimulation such as touch, visual, smell. He claims that five-sense branding to create associations between the product and our sensory stimulation, so that the product appeals to us emotionally and pre-empts our decision-making. For example, leathery car smells are diffused to create the impression of new car. Lindstrom illustrated how Starbucks create comfort and pleasant experience for customers through the design of interior, aroma of coffee can. In addition, scented ambient space are becoming more popular in urban cities all over the world: ION shopping mall in Singapore has its unique sweet signature smell, Hirake shopping mall in Tokyo has developed special smells on every department floor. Many luxury hotels such as Mandarin Hotel and others have their own signature smells to connect customers with the brand\textsuperscript{11}. Singapore Airline also uses branded fragrance as part of in-flight experience.

I found that there is still a great gap between current practice of multisensory practice even though academics in marketing are recognizing the potential of embodied cognition with multisensory experience (Krishna et. al \textsuperscript{12}). Existing deployment of smell have only started to explore the addition of smell as part of product or as part of ambience. In terms of smell as ambience, it has become a trend to incorporate smell as part of the space design, however it’s slowly losing the competitive edge as more and more commercial space are adopting the same approach and getting difficult to create unique

\textsuperscript{10} Martin Lindstrom, “Brand Sense: Build Powerful Brands through Touch, Taste, Smell,” 

\textsuperscript{11} Etc. Branding, Bloomberg Business Week, Jun 21 -27 2010

impression based on bespoke smells. Overall, the engagement of sensorial experience as embodied cognition is has not been explored in real applications. In my research, I hope to create interaction with smell as that engages our mind and memory, and how the interaction may impact the value experienced by customers.

1.3 Designing Sensory Interactions with Digital Technologies

Digital technologies have advanced in past decades and reaching all aspect of life. Mark Weiser, has created radical vision of Ubiquitous Computing based on his work at Parc Xerox in early 90s. Ubiquitous Computing advocates for the future where computers disappear in all the objects that surrounds people in daily life. Through decades of development and advancement in computer technologies and interaction design, much of it has become a reality. In the book Everyware: Downing Age of Ubiquitous Computing published in 2006, Adam Greenfield described smart furniture, smart city, wearable technologies, networked street signs, sensors embedded into everyday objects that becomes "Everyware". With plenty of information technologies and prototypes available in our hands, the author ponders on the future of what value will be created with the prototypes aiming to change our lifestyle and what kind of relationship we are creating for the users in particular context.

The development of technologies has also seen combination of technology as design material. Renowned media artist and researcher John Maeda,

author of Creative Code, headspeared the efforts to create programs that allows designers to easily program visual effects. In 2001, his students Ben Fry and Caesey Reas at MIT Media Lab Aesthetics Group created Processing program\textsuperscript{17}, an open source graphic programming language designed for non-programmers, designers. It has been a constant inspiration of what computer technologies can enable designers to achieve. This program enabled designers and artists to use iterative logic, complex computations easily and enable them to be creative with making computational animations and visualisations. In the mean time, Professor Tom Igoe and Professor Daniel O’Sullivan from New York University, ITP Program co-authored the book on Physical Computing\textsuperscript{18}. Physical Computing considers how to build software and hardware systems that interacts with the physical and analogue world by consider how to create expressions from human perspective. Tom Igoe’s second book Making Things Talk\textsuperscript{19} took very hands-on approach to illustrates use of physical computing in art and design projects, that opens the computing knowledge to a wider audience of creative and designers in the field of Computer Human Interaction. The coupling of physical environment mediated with computer digital technologies creates a different world where it is possible to sense human behaviors in everyday life and the data can be used to make things move in the physical world, and create other possible changes and expressions.

With emerging technologies, ease of embedding sensors into everyday objects, the ability to program various sensory output, relationship between human experience and digital technologies are converging. Bill Moggridge, co-founder of IDEO, the most famous design firm for creating digital experience, published the book \textit{Designing Interactions}\textsuperscript{20} in 2007. He defines Interaction

\textsuperscript{17} Processing https://processing.org/
\textsuperscript{18} Dan O’Sullivan and Tom Igoe, \textit{Physical computing: sensing and controlling the physical world with computers} (Course Technology Press, 2004)
\textsuperscript{19} Tom Igoe, \textit{Making things talk: Practical methods for connecting physical objects} (" O’Reilly Media, Inc.", 2007)
Design as a discipline that combines understanding of human and subjective matter with digital technologies. Researchers and designers are starting to make work that are beyond conventional information processing system that makes our life more efficient. Renowned HCI researcher and interaction designer Bill Gaver is an early explorer of designing interactive experience of poetic qualities. Gaver has addressed non-goal oriented interactions, which he calls ludic engagement\textsuperscript{21}. For example animation illumination are displayed as the historical trail of tableware; as well as Drift Table that creates a looking glass effects of moving images depending on the weight of objects on the table. The notion of poetic and playfulness are explored using digital technologies as design material. Gaver’s research starts to reveal that how digital technologies can be powerful to engage our mind and everyday life.

Within the understanding that digital technologies are for the service of creating better human experience, HCI researchers and Interaction designers find it necessary to use sensory as a bridge to connect digital technologies with human experience. In one of the chapters called Multisensory and Multimedia in Interaction Design, Moggridge ponders upon multisensory design to break away from the heavily visual and device based interaction. At the same time, incorporating senses also broadens interactions beyond GUI. Dorong, Tanja et al\textsuperscript{22} reviewed applications of ephemeral materials, and they are looking for applications that uses non-traditional material that incorporate rich and multisensory perceptions, such as water, fire, soap bubbles or plants.

Recently there has been more development in smell related technologies and applications. The capacity of digital technologies to make interactive ambience a reality is possible, control of ambience, sensing behaviors with more


\textsuperscript{22}Tanja Döring, Axel Sylvester, and Albrecht Schmidt, “A design space for ephemeral user interfaces,” in Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction (ACM, 2013), 75–82
1.3. Designing Sensory Interactions with Digital Technologies

reliabilities are precedents to the development of mature technologies in interactive ambience. In research as well as in commercial area, control of dynamic ambience of lighting and smell is available. Philips Hue\textsuperscript{23} explored atmospheric feeling that is created by LED lights, and enable smart phone control of distributed lighting elements over network. This not only allows personalization of lighting, but also different moods and atmospheric feelings are explored through use of color and light. In fact architect and designer Roosegaarde challenged aesthetics of digital technologies through lighting design \textsuperscript{24}.

Figure 1.1: Artistic Design of Lighting and Ambience


Currently, interactive ambience involving smell is emerging, related to existing telecommunications and tele-presentation. Bodnar et al\textsuperscript{25} has created an application AROMA where it uses smell to indicate ambient awareness of text message. By comparing olfactory notification to visual and auditory notifications, the paper showed that the olfactory notification creates least disruption therefore suitable as ambient awareness medium. However the efficiency is

\textsuperscript{23} Philips Hue http://www2.meethue.com/en-us/products/
\textsuperscript{24} Roosegaarde, Dune, 2006-2012, https://www.studioroosegaarde.net/project/dune/info/
\textsuperscript{25} Adam Bodnar, Richard Corbett, and Dmitry Nekrasovski, “AROMA: ambient awareness through olfaction in a messaging application,” in Proceedings of the 6th international conference on Multimodal interfaces (ACM, 2004), 183–90
1.3. Designing Sensory Interactions with Digital Technologies

Figure 1.2: Digital Control of Lighting and Smell

Source:
Left: Philips Hue
https://www.studioroosegaarde.net/project/dune-4-2/
Right: Scentee
https://scentee.com/

lower due to less training and unfamiliarity with olfacotyr cues. More work related to interactive smell are used to enrich digital experience, Stephen Brewser et al. 26 uses smell for searching digital photo libraries, on-demand stimulation of smell in virtual games enhances fidelity of gaming experience27. This means interactive control of smell is maturing, but direct relevance to ambience design and creation of imagination is yet to be explored. Latest developments in smell diffuser technologies are emerging as well. Scentee is mobile app supporting mobile communication using smell (see Figure 1.2 on the right), it’s a product from a company called Chatperf. It has made platforms and programming environment for developers and designers to create new type of mobile applications and games using smell.

Sensing technologies are also advanced to be deployed in real context and scenario. With technologies propelled by Physical Computing, companies like Sparkfun28 are making sensors easier for designers to manipulate and covers

sensors in various ranges. Technologies are getting into the hands of designers more easily to design situation and scenarios that is not foreign to everyday users, that can easily be understood in everyday situations. Little Bits\textsuperscript{29} targets users that has zero or very basic level training of electronics, and are modular platforms that are easy-to-use, electronic building blocks, allowing people to create all kinds of invention. It includes sensors such as pressure, and actuators such as motors to release their creativity with electronic tool.

With maturing of technologies, researchers are more concerned about what kind of experience and scenarios can be created and what are the values created using digital technologies. It is an emerging trend that HCI is developed to address more human concern. Through this research, I hope to bring integration of digital technologies in the smell interaction area into the commercial setting, and discovering scenarios and applications that creates value.

1.4 \textit{Scented Pebbles} Creates Interactive Lighting and Smell to Enhance Value for Commercial Space

Through integration of sensory design and digital technology, \textit{Scented Pebbles} creates experience of smell and lighting interactions as part of co-creating experience for customers. It leverage on potential of interaction of senses to engage our mind, and designs interactions that address characteristics of smell and ambient lighting as peripheral interactions.

\textit{Scented Pebbles} gives service provider an interactive ambience tool to connect to their customers on sensorial level and create experience that matters to individual consumers in their own personal context. Through co-development of prototype and scenarios by engaging business suppliers and customers, it

\textsuperscript{29} Little Bits http://littlebits.cc/ a platform of easy-to-use electronic building blocks for creating inventions large and small
expands value specific to customers’ contextual background, known as *value-in-context*. By enhancing the value-in-context of each customers, it ultimately enhances value for commercial space. In my research, I have integrated *Scented Pebbles* in real commercial space, it shows the research process of discovering and creating the value of interactive ambience in commercial space. The design illustrates how interactive sensorial experience can benefit customers, as part of the co-creating value in commercial space.
Chapter 2

Literature Review

The research proposes co-creating experience through digital interactive experience of lighting and smell ambience in commercial space such as lounge, cafe and co-working space, where it provides social, playful and experiential benefits for customers, as they personalize and interact with the ambience. The literature serves as tool to understand how interactive sensorial strategy could provide value for business suppliers through value-in-context.

The literature review aims to address the three main topics:
1) Value Co-Creating Experience
2) Sensory Design and Impact on Consumers
3) Interactive Sensory Experience

Therefore we will look into the following disciplines: Brand and Value Co-Creating Experience, Neuroscience Consumer Study, Sensorial Design, and finally Interaction Design. The following topics will be discussed: the theoretical framework of how value is created with customers to enhance brand value, why business suppliers is part of the value creation and how can interaction design play a part in creating values; how our mind is influenced by sensorial stimuli and why interaction of senses might appeal to consumers;
Digital technologies and interaction to engage senses and challenge the un-
conscious mind, and most importantly, how that can be applied to designing cus-
tomers’ experience.

2.1 Brand and Value Co-Creation

Notion of co-creating experience has suggested that the value gained by cus-
tomers from the brand is defined phenomenologically according to customers’
context. This has challenged the definition of brand equity as company owned
value, owned and managed by company. In 90s, David Acker\textsuperscript{1}, a marketing
professor at University of California-Berkeley, defined the first widely accepted
brand model. He defined brand equity as a set of brand assets and liabilities
linked to a brand name and symbol, which add to or subtract from the value
provided by a product or service. In Acker’s model, brand equity consists of
brand awareness, brand loyalty and brand associations and perceived quality,
which add value to the service provided by the brand.

Although branding could be defined as the company owned equity, its value
is largely determined by consumers of the product, how consumer perceive
the value in their subjective mind will affect brand loyalty, brand awareness,
brand associations, and perceived qualities, all aspects of brand equity. Many
researchers who study customer value have geared towards experience based
and customer focused direction. Sweeny and Satour categorized the value
perceived by customers into functional value, emotional value, and social value.
Holbrook regards customers as experience seeking, and derives consumption
experience such as fantasy.

In a society where differentiation of goods and service is diminishing by
advance of technology and information, brand value lies in the experience

of individual customers and emotions produced by the experience. Bern H. Schmitt, extends brand experience to explicitly address feelings, cognition and behavioral responses triggered by brand related stimulus. He also constructs experience dimensions including sensory components to measure the brand experience. In his view, experience has an inherited economic value to the consumers and can be charged with premium costs. As quoted in Shmitt’s article, successful brands such as Disney, Nike are built upon the brand experience factor, to stage and orchestrate experience that affects people’s sensory and emotional response.

In contract with the view that business supplier still takes the dominant position in creating value and customers as the passive receiver to participate in service, customers are thought of co-creator of value. In 2004, Service Domain Logic, author Vargo defined new perspectives of the economic system. In this ecosystem of value creation, customers and business suppliers are considered as "actors" in the system, there maybe other actors, resource providers, designers and stakeholders. In the new system, business suppliers are no longer thoughts of as producers of value, who "staged experience" and create economic value of experience, however, they are thought of co-creating the value for customers as service beneficiary.

Based on the value co-creation view, how value formed in customers’ mind is conceptualized as value-in-context. In the Service Dominant Logic, author Lusch and Vargo states ten foundational premises that defines the co-creation view. The 10th foundational premise of service-dominant logic has specifically addressed the value experienced by the customers: "... value is always uniquely and phenomenologically determined by the beneficiary...". Value arises while consumers use the services or products in a certain context based on their social environments and lifestyle. At the same time, the producer of the service

2.1. *Brand and Value Co-Creation*

or products does not prescribe the value, however, the value is determined during customers’ experience based on their contextual backgrounds. The phenomenological value encompasses emotional value, experiential value that is processed by our subjective mental mind.

*Value-in-context* broadens the definition of value beyond the functional value and emotional value developed during the service transaction, the value refers to the value emerged from service interactions, and strongly related to customer’s contextual background. Heinonen\(^3\) proposes the customer’s perspective of value creation. He expands the experience of customer from the service experience to the dynamic and ecosystem that encompass the social, biological, psychological and mental life of customers.

Helkkula\(^4\) discusses value derived by customers as "value-in-experience". It emphasis on the phenomenological view of customers, how individual customers derive value with broader context of their everyday lived experience. He adopted Woodruf Smith’s view that a person’s experience includes perception, imagination, thought, emotion, desire, volition and action. Based on holistic perspective of experience, he added indirect experience as part of the experience of customers, such as before and after experience, imaginative experience from social encounters i.e. word of mouth, as part of holistic and lived experience. He has discussed the following aspect of value. Firstly, what is value in the experience. Secondly, what can be accepted as evidence regarding value in the experience? And thirdly, what methods and techniques should be adopted for collecting data about value in the experience. This helps to identify narrative methods for documenting the evidence of value with a broader context.

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3. Heinonen, Strandvik, and Voima, “Customer dominant value formation in service”
4. Helkkula, Kelleher, and Pihlström, “Characterizing value as an experience: implications for service researchers and managers”
2.1. Brand and Value Co-Creation

Besides theoretical explorations, academics are collaborating with industry to illustrate the power of co-creating experience. Professor Payne, Professor of Marketing at University of New South Wales in Australia, has authored influential books on Relationship Marketing. He has conducted workshops and uses many real world examples to illustrate the value co-creation and its relevance to relationship building. He conducted case study with the City Car Club in Helsinki, Finland, and conducted workshop to redesign its car rental service. The value co-creation is implemented in three stages, customer acquisition, stabilization and enhancement. During customer acquisition, customers are more convinced of the value of the membership, effective communication, conveying the emotional message and benefits of car sharing v.s. car owning. In the stabilization phase, short tutorials are provided as well as convenient way to book car rentals online. At the enhancement phase, the company collects customers’ feedback and use that to enhance their service and relationship with the customers.

By using a relationship experience perspective, Payne emphasizes on increasing opportunities of interactions and dialogues among supplier and customers, i.e. getting feedback from customers, providing learning point for customers. He uses the concept of encounter design to consider the process of both customers and suppliers are interacting and co-creating experiences. By supporting customer’s emotional attachment to the brand, helping them to learn about the reasons to stay loyal to brand, and providing trials, knowledge sharing, and self-service activates to support their actions, it connects customers through emotions, cognition and behavior dimensions.

Gentile discussed what kind of value is created in the co-creation process.

2.1. Brand and Value Co-Creation

The customers have their own expectations and perceive value from the experience. Both Gentil and Payne share the view that experiential value such as sensorial emotional value is what influenced customers’ perception and value creation process. Payne holds the view that emotional value will inform the cognitive process and vice versa, that will ultimately change user’s behavior, these are reinforced throughout all possible point of encounter design.

Rodrigues and Hutlens et al.⁷ points to the future direction of incorporating multisensory approaches to co-create value for customers. Hutlens argue that sensory marketing stimulates human mind in a highly subjective and individualized manner, to produce cognitive, emotional and other value-based benefits, is able to provide intangible value such as brand as image. In the paper, they present the view that multisensory approaches express brand through sensorial strategies, it creates symbolic, hedonic and cognitive values for consumers.

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2.1. Brand and Value Co-Creation

Hutlens’s research was originally in Sensory Marketing. In Hulten’s recent study\(^8\), consisting of interviews with experts and managers in multisensory branding such as Abercrombie and Fitch, Apollo, Gina Tricot, Starbucks, Whole Foods and Culinary Arts and Meal Science at Orebro University. A sensory marketing model is proposed in relation to co-creating experience. The Sensory Marketing takes its point of departure in the human mind and senses, where mental flows, processes and psychological reactions take place and result in a multisensory brand experience. It is proposed value of service as a brand image, emerges when interactions occur through the customer’s sensory experience in the value-generating processes.

The review of value-in-context put emphasis on how value is created with regard to individual background. Experience in the sense can be expanded to the holistic experience but not only the ones directly deals with the transactional experience. For example, Helkkula discussed the lived and imaginary experience across time and space. Payne talked about the relationship experience that is includes all kinds of customer encounter. In this section, it is discussed that customers are considered as actors to integrate resources creates various value-in-context. Customers’ value is derived, through experiential value, considering their relationship with business supplies throughout all encountering moments and touchpoints, and there are new opportunities for value created with multisensory strategy. Next session will focus on how co-creation value is created involving multiple stake holders.

2.1.1 Dynamic Relationship between business suppliers, customers and others

The relationship between stakeholder and customers have changed drastically with the notion of co-creation. Business supplier proposes value to customers

\(^8\) Hultén, “Sensory marketing: the multi-sensory brand-experience concept”
focusing on how to support their value-in-context. Value proposing is a new concept that requires the business supplier to focus on customers’ experience and innovate by integrating resource, collaborate with other actors in the system, stakeholders, makers, customers and propose value to customers (actor-beneficiary). In PF6, Vargo stated, the enterprise cannot deliver value, but only propose value. In his later clarification of the statement, he stated: "The firm can offer its applied resources and collaboratively (interactively) create value following acceptance, but cannot create/deliver value alone." In later refinement of his theory, Largo\(^9\) also mentioned again about co production. It is through collaboration and co production not only with actor beneficiary, but also with other stakeholder that value are proposed to customers.

Venkat Ramaswamy\(^{10}\) uses the concept of "joint agential experience", to urge design of engagement platform. Through the Starbucks example, he explained how the brand and enterprise could provide artifacts, tools, design as their offering for customer to co create their own experience, personalized for each individuals in various situations. At the same time, in sustainable coffee supply, the supplier can also involve the consumer community to reinforce the fair-trade image. This is called the joint-agential experience. He talks about technology-enabled augmentation of physical goods and retail environments, along with pure digital services, purposefully designed as brand engagement platforms. Therefore, business suppliers no longer are considered as producer of experience but are considered engagement platform providers, and service provider who allows customers to integrate their services and create their own experience.

Christian Grönroos, professor at Hanken School of Economics Finland, is a leading researcher in Relationship Marketing and Service Management. In

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2.1. Brand and Value Co-Creation

his article, Professor Grönroos 11 offers detailed analysis of value co-creation process. He supports the view that value co-creation process is where mutual value is expanded together by suppliers and customers. Grönroos therefore proposes that interaction of both suppliers and customers are at the heart of value co-creation, the customer acts as a co-producer, and the interaction enables a merged, coordinated process. In provider’s sphere, the suppliers are considered as value facilitator, to provide potential value. In the customers’ sphere, it is where value can be created in different time and space, and turned into real value-in-use. In the joint sphere, the author argues the value is created as value-in-interaction. The provider may influence the customer’s value creation process and serve as a co-creator. It forms a platform for joint value co-creation.

Grönroos argues that value is all-encompassing, in contrast to the view that provider’s value only produced as value-in-exchange. i.e. the overlapping part of supplier sphere and customer sphere in Figure 2.3 upper illustration. Creation of value may exist in different temporal and spatial setting, for example, in a car purchase context, the value may rise when customers think about buying a new car before the transaction takes place; and value of family holiday may include multiple purchases at different point, or new friendship, memories, and cultural experiences and learning processes achieved during the vacation. At the same time, value creation cannot just be value-in-use, as it only considers consumer’s perspective. Therefore the value creation must involve all stages from design, development, what thought of as the creation stage towards the usage stage.

Payne12 touched upon the managerial perspective and basically termed business supplier as facilitators the resource integrators. Value co-creation

2.1. Brand and Value Co-Creation

Figure 2.2: Illustration of Value Co-Creation Process from interaction with customers and service provider.  

Source: "Critical service logic: making sense of value creation and co-creation." Grönroos et al.

Process starting with business owner using design, services all resources possible to encourage desirable outcome, known as business propositions, while customers will create value during consumption. The customer’s value creation process can be defined as a series of activities performed by the customer to achieve a particular goal. Managers are considered as facilitators of experience rather than producer of experience, and should attempt to engage user at any stage, relational experience instead of transactional experience. The superior propositions will be able to create revenue, word of mouth as brand value output for business supplier.

Researchers are continuously seeking answer how to actively explore business supplier’s role how to co create value, how can managers, business sup-
2.1. Brand and Value Co-Creation

Designers facilitate value creation, more actively seeking value. In my thesis, I have adopted Payne’s view on value co-creation process, with business supplier proposing the value through co-development of Scented Pebbles, and the value-in-context will be evaluated in the commercial setting when the experience is taking place. At the same time, the value co-creation not only refers to the creation stage, but also during the experience, where the customers interact with the ambient experience and co-create experiential value.

2.1.2 Co-Creating Value through Co-Development, Customer Journey

In view of the phenomenological definition of value co-created by consumers and the dynamic network and relationship between multiple stakeholders, I look for methods that can convey the customer’s contextual background in designing the interactive ambient experience.

Instead of creating value directly through making of prototype, it is clear that creating service and artifacts that could be integrated to customers’ contextual life would ultimately make them derive the value. In this regard, prototype is created as a form of expression to allow designer and client to propose value, it is not seen as the end result. I have followed certain methodologies to look closely into customers’ contextual perspective. In this section, I will discuss some design methodologies that are in line with the Service Domain Logic in order to propose the consumers’ value-in-context.

Elizabeth Sanders, is pioneer in participatory design and consulted for industry firms Xerox, 3M, Coca-Cola to name a few in the past twenty years in diverse area such as consumer, office and medical products, spaces, systems, and interface. She explored the benefits of participatory design for co-creation and co-chaired the online design journal - Codesign: International Journal of CoCreation in Design and the Arts. In her work, she often advocates creativity
2.1. Brand and Value Co-Creation

in customers and their natural desire to balance consumption with creativity. She mapped out changing role of customers from customers, customers, users, and participants to adapter and co-creators in last twenty years, and defined designers’ role at the end of the evolution as interpreters of people’s needs and dreams and not just the creators of artifacts\(^{13}\).

In Sander’s article, *Information, Inspiration and Co-creation*\(^{14}\), prototypes are thought of dream enabler, where the prototype is not judged by how fine-tuned it is, but how imaginative and generative it allows the user to be. Elizabeth calls it "prototype are moving to the fuzzy front end". In order to understand customers' experience, Sanders recommend designer not only to Listen to what people say and Watch what people do, but allow people to Make, the ambiguity and visual nature of the tools allow people to be creative.

Moving closer to 2011, more examples and case studies are presented to illustrate benefits of collaboration with customers and business suppliers in service design\(^{15}\). Collaborative with customers and business supplier is shown to better understand service’s demand side, users’ and customers’ needs and its supply side technologies and process, in order to develop successful services. It is expected that co-design with customers and business supplier can achieve the benefits, reducing costs, increasing well-beings, and making organization of innovation process more effectively. The author has conducted three case studies in health design for elderly, telecomm design with children, and Logistic Service design with employee. Through the three case studies, Konings demonstrated that the collaboration approach can create benefits for service such as: Better fit between service and customers' needs, higher quality of service and more differentiated service, and result in satisfactory and

\(^{13}\) Elizabeth B-N Sanders and Pieter Jan Stappers, “Co-creation and the new landscapes of design,” *Co-design* 4, no. 1 (2008): 5–18  
\(^{15}\) Marc Steen, MAJ Manschot, and Nicole De Koning, “Benefits of co-design in service design projects,” *International Journal of Design* 5 (2) 2011, 53-60, 2011,
stronger loyalty in long term. As they discovered in elderly home design, co-design approach helped them to discover customers' needs beyond researcher’s or designer’s original assumptions.

Customer Journey Mapping\textsuperscript{16} is a technique to understand consumer’s flow of experience and is useful to discover all customer interactions, including both on-stage and off-stage interactions. For example, interacting with the sales person would be on-stage, while checking finance is off stage. It is recognized that both on-stage and off-stage interactions affect the overall experience. Customer Journey Mapping is a method that encourages business suppliers and designers to consider the entire experience of customers rather than focusing on the transactional moments. Research found that companies that enhance the entire experience rather than focusing on the individual touch points create more success in enhancing their customers’ loyalty. It is adopted by famous design consulting company such as IDEO and Adaptive Path\textsuperscript{17}.

In light of customers as value co-creator and new notion of prototype as idea enabler, I’ve adopted the value co-creation approach, where value proposing is made through co-development with business supplier. After sketching technologies and initial designs, the prototype is presented and demoed to business supplier. This helps to pull the design towards their business goal. I further researched customers’ needs through customer journey mapping, and fine-tune the designed to create better value-propositions. Design methodologies of contextual inquiry, customer journey mapping are used in the design process, in order to create experience that reflect the individual experience of customers. Touch points of interactive ambience and its potential values are discovered through contextual inquiry, demo feedback and user testing in the actual commercial space.

\textsuperscript{16} N De Koning, Customer journey: Experience your customer’s journey. Retrieved October 30, 2010

\textsuperscript{17} Our Guide to Experience Mapping by Adaptive Path
http://adaptivepath.org/ideas/our-guide-to-experience-mapping/
2.2 Sensory Design and Impact on Consumers

The above review introduced value co-creation view to reflect the consumers’ role as value co-creator. This gives opportunities to create interactions and highly individualized experience that changes based on consumer’s own experience. Ramaswamy advocates for the brand value co-creation through human experiences by the brand engagement platforms in the form of digital service, design of artifacts through interactions. He supports the view that the design of all services and encounters should aim to create value outcome and engagement of the consumers.

Value-in-context provides new perspective of how value is created in users’ mind, and provided new opportunities for peripheral sensorial engagement and experiential design for branding, in order to create value that is personal, individual, tuned towards customers’ own intention and goal. This points to further research in engaging human senses and create experiential values. Current strategies still focus on digital experience or online experience. Some researchers have created an outlook for involving human senses in creating create value that is personal, individual, tuned towards customers’ own intention and goal, however no real applications has been put forward yet. My research aims to bring co-created phenomenological value of customers through interaction with their senses of smell and lighting in the physical environment.

2.2 Sensory Design and Impact on Consumers

In my thesis, I focus on building ambient environment and multisensory experience that will impact customers unconsciously. In this section, I review current practice in sensory marketing and design specially using olfactory cues and look into neuroscience study of human mind to gain deeper understandings of how human senses impact our mind.

There has been a great interest in marketing for olfactory cues due to its power to connect with our emotions to elicit memory and create associative
meaning to products. Professor Charles Spence is an experimental psychologist specializing in multisensory studies at Oxford University. He surveyed use of multisensory atmospherics\textsuperscript{18}, and analyze how sensory cues influence consumers’ behavior through affect and cognition. The affective dimension refers to if the customer feels positive or negative of the stimulation. The cognitive dimension refers to the associative meaning of the sensory cues and whether it can create direct behavioral effects. As an example of affective impact of olfactory cues, Samsung introduced a signature honeydew melon scent into its store to match the green color scheme; and Sony uses exclusively designed fragrance of vanilla and mandarin orange to relax customers and make them feel it’s a nice place to be. In terms of cognitive impact, olfactory cues could evoke customers’ thoughts related to the products or brand. For example, retails releases scent linked to a given holiday. It is also documented that scents related to gender preference received double boost, whereas sales reduced when the scents used are reversed. The development of signature fragrance not only create positive affect but also relate to the brand’s meaning. However, it is also pointed out that the development cost for signature scent is high and the investment in diffusion system is quite significant.

Professor Aradhana Krishna is world pioneer in sensory marketing. Her work tries to understand consumer psychology underneath the sensory marketing phenomenon. In the article *Sensory marketing, embodiment, and grounded cognition*\textsuperscript{19}, Krishna embraces the understanding of human mind as situated, experiential and embodied. Together with social psychologist Schwarz, they stated that human experience the world through their senses, sensory information and accompanying subjective experiences plays key role in human cognition and action. Therefore, facilitating or impairing a person’s bodily response

\begin{footnotesize}

\textsuperscript{19} Krishna and Schwarz, “Sensory marketing, embodiment, and grounded cognition: Implications for consumer behavior”
\end{footnotesize}
to a stimulus also facilitates or impairs the person’s subjective experience of
the stimulus. Krishna illustrated the effect of mental stimulation, text advertisement
is presented to test subjects to trigger mental stimulation of either a
single sense or multiple senses, and have subjects tastes a food, the food tastes
better when it encompasses several sense modalities. Krishna also talked about
multisensory as subconscious trigger. In terms of smell, ambient smell and
product associative smell are used to trigger memory and acting as metaphors
to facilitate better understanding for brand personality. Engaging with users’
multisensory brain will pull the subconscious trigger of customers, allowing
them to self-generate product attributes related to their own experience or
memory and therefore is a more powerful tool.

The situated cognition view of Krishna in sensory marketing design can
be further enriched by the understanding of human mind from neuroscience
perspective. In 2002, Daniel Kahneman has won a Nobel Prize in Economics
for his work on dual-mind theory. His work recognizes the implicit mind as
important part of decision making for human. The implicit processing of the
mind is produced by the oldest part of the brain that deals with memory, as-
sociations, while the explicit processing of the mind makes rationale decisions,
our implicit brain has been evolved for much longer period of time and takes
charge of our decision making in auto-pilot mode. The implicit mind is also
known as unconscious mind, as the implicit processing occurs below conscious
knowing and only appears as certain feeling or emotions. As the implicit mind
has evolved over much longer time since evolution, so it has a much greater
power than we used to estimate. It includes thought processes, memories,

Based on Daniel Kahneman’s dual-mind theory, Peter Steidl proposed
model of conscious Thinking Mind and unconscious Doing Mind of consumers

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20. Daniel Kahneman and Amos Tversky, “On the psychology of prediction,” Psychological
Review 80, no. 4 (1973): 237
2.2. Sensory Design and Impact on Consumers

in his book Neurobranding. Peter Steidle’s model, our unconscious Doing mind assigned value and meaning to external stimuli such as advertisement, packaging etc, it may or may not create an association in our memory. When making a purchase decision, consumer may use Thinking Mind to analyze the situation or completely bypass this stage and instead using Doing Mind to make the purchase. The non-conscious Doing Mind is the key driver in purchasing process. Neuroscientists have been trying to decode the pathway of why and how human makes decision about product and service. Neuroscientists and marketing experts joined force in understanding consumer behaviors using fMRI techniques. And it confirms that consumers are guided by their unconscious goals, and these goals guides the decision making process before the action happens. Understanding what is driving consumer’s unconscious goal is very important for neuroscience branding, to activate unconscious goal, to maintain interest of the unconscious goal.

Harvard Business School Professor Zaltman Gerald suggested that 95% of the time, customers make decision based on unconscious mind. He wrote about deep metaphors as unconscious basic structures of human thoughts that affect how people process and react to information or a stimulus. To probe people’s unconscious deep metaphor, he developed Zaltman Metaphor Elicitation Technique (ZMET) by using imagery in one-to-one interview. Professor Zaltman joined forces with neuroscientist Kosslyn to file patent of Neuroimaging as a marketing tool, to validate if a stimulus such as advertisement, communication or product evokes a certain mental response such as emotion, preference or memory.

Sensory experience has an alternative path-way to our unconscious mind through mental imagery. The experience of mental imagery is like perceiving sensations, but without actual experiencing it. Discussion of mental imagery

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originated in philosophical study of mental status and is described as "to have a perception-like experience triggered by something other than the appropriate external stimulus; so, for example, one might have "a picture in the mind's eye" or "a tune running through one's head" in the absence of any corresponding visual or auditory object or event. One of the examples is in Proust's writing, where he uses detailed description of his own sensory experience to trigger the imagery in reader's mind. Proust's work is described as having the most sensory details and can make reader feel as if they are at the same place with him. He didn't only use sensory to trigger his own memory, he uses sensory to trigger the sensory imagination in his readers. Mental imagery can be formed by self-introspection or with proper stimuli. In Proust's case, he uses intricate and rich descriptions of sensations to trigger the similar experience in reader, so that they appear as if experiencing the visual imagery and olfactory imagery. Studies show that visual mental imagery can be controlled. For example, instruction can be given to retrieve long-term memory and working memory to form imagery.

As mental imagery is evoked as sensory experience in working memory, researchers in cognitive science believed that it has different processing of language and symbols. The way we process language and symbols are known as discursive processing, it is more detached from internal sensory experiences. On the other hand, mental imagery process is more like "picturing" and evoked as sensory experience in working memory. It concerns concrete sensory representations of ideas, feelings, and memories, often evoked in the

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2.2. Sensory Design and Impact on Consumers

form of multisensory experience, and it permits a direct recovery of past experiences\(^{27}\).

However, whether mental imagery has internal representation like pictures or like descriptions, has gone through historical debated. In recent years, with modern technologies of fMRI and others, brain scientists have finally been able to test hypothesis regarding mental imagery. Kosslyn proposes "quasi-pictorial" theory\(^{28}\) and claimed that internal representation of mental imagery is pictorial, while others like Pylyshyn think that internal representation of mental imagery is like any other discursive thought, like language and symbols. Kosslyn has showed brain-imaging evidence that there are shared neural systems in visual mental imagery and perception, when performing mental imagery tasks such as distorting and transforming orientation of shapes. Kosslyn’s theory proves that visual mental imagery involves reactiving visual representations in long-term memory and using them to construct representations in working memory; these representation can then undergo further processing, for example, by reinterpreting or transforming them. Therefore mental imagery has been accepted as conceptually distinctive way of representing information, a way that is very much like picturing and not like describing.

There have been many applications of mental imagery in commercial applications, and it is well-studied in print and multimedia platforms. For example, online tourism advertising includes a variety of external stimuli such as interactive photos, animation, video clips etc to evoke mental imagery of potential customers. Through study of online website with 252 participants, Lee at al. revealed that the mental imagery construct strongly influence on the attitude of potential customers\(^{29}\). Once customers have the experience of being

\(^{27}\) John C Yuille and Michael J Catchpole, “The role of imagery in models of cognition,” Journal of mental imagery, 1977,

\(^{28}\) Stephen M Kosslyn, William L Thompson, and Giorgio Ganis, The case for mental imagery (Oxford University Press, 2006)

transported, they will generate cognitive belief about the product or service that is beyond logical persuasion. Escalas\(^30\) answers the question: "By what mechanism does mental simulation enhance persuasion?" Narrative structure of mental simulation provides explanation for its effects on attitude and intentions. Narrative transportation leads to persuasion through reduced negative cognitive responding, realism of experience, and strong affective responses. The article gives a review of mental stimulation and narrative transportation and author develop hypothesis and confirms result using print advertisement experiment.

Understanding of imagery offers new perspective in consumer behavior such as consumption experience\(^31\). Hirschman Holbrook\(^32\) refers to mental imagery as imaginative construction of reality. They developed hedonic consumption theory to captures multisensory experience, fantasy and emotional response as consumer behavior. In their research, mental imagery defines how the product is seen in the consumers' subjective reality, beyond its objective context. They also refer to it as pictorial imagery. Multisensory experience will generate internal mental imagery "as experienced". Fantasy imagery can put consumers in imaginary scenarios and historical imagery can relate consumers to their past experiences. The imagery offers self-entertainment, gratification, and stimulation. Pre-consumption imagery that provides experiential pleasure such as browsing and shopping, post-consumption generates memory and is important for decision making about future consumption activities.

Based on the review, sensory experience is an important part of making sense of the world and how our mind make decisions. We have looked into

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\(^31\) MacInnis and Price, “The role of imagery in information processing: Review and extensions”

2.3 Interactive Sensory Experience

cognitive study of mental imagery to understand sensory processing, emotion, and how it affects decision-making in an unconscious way. We’ve also discussed the rise of sensory and unconscious mind in branding. Sensory stimulation can guide imagination and unconscious thoughts to generate belief and value. Neurobranding has built understanding with evidence that human beings are sensory wired and more influenced by irrational mind than rational mind.

The potential of sensory interactions especially with olfactory remains an under-explored area in commercial area. Human being’s innate tendency to be influenced by bodily experience are better understood in cognitive processing brain science now with the new neuroscientific tool; at the same time, the consumers as sensory wired and unconsciously connected are well understood. Despite the neuro-scientific evidence for unconscious mind and mental imagery, there are limited applications in applying smell interactions in commercial and retail setting, partially due to the challenge to control the sense of smell. The current review of sensory marketing and ambient environment has focused on the affect and associative meanings created by signature smells. Most of current sensory approach does not go beyond product embedded multisensory and ambient multisensory category, such as including interactive and digital technologies and communications in creating sensory experience. The complexity of creating sensory imagery could be brought about by application of digital technologies and open up new area for ambient interactions, in creating interaction with their mental imagery and explore their unconscious goal. Due to lack of literature evidence in design of smell, interviews with practitioner will be introduced in Chapter Three.

2.3 Interactive Sensory Experience

My research focuses on the future of using sensing technology and creating interactive ambience of lighting and smell to create value-in-context for cus-
2.3. Interactive Sensory Experience

tomers. This section will start with the role of sensory design in creating fulfilling interactive experience, influenced by cognitive embodiment. In addition, it is also important to show how to express atmospheric feelings and influence imaginations through interactions; the applications combining smell interactions and outlook of combining smell and digital technologies are discussed.

Proliferation of technologies has greatly influenced human experience and has been developed in the last ten years. Design of digital experience is looking into Cognitive Science, Neuroscience to engage the mind beyond the brain to create cognitive embodiments. Ellen Do\textsuperscript{33}, director of CUTE Center, National University of Singapore, highlighted three areas: Tangible Interaction, Augmented Learning and Embodied Experience to encourage embodiment of technologies and applications in everyday life. By creating unique combination of sensing, media fusion and putting in various context of use, it creates future of embodied experience. It calls for technologies that engages all human senses and integrate with our everyday life. Technologies are created such as hugging devices to transmit communication between distant partners, and digitization of smell that will enhance the immersive experience.

HCI researchers are drawn into sensorial experience to address human feelings emotions and imaginations. In the book \textit{Technology as Experience}, John McCarthy and Peter Wright\textsuperscript{34} explicitly calls for the integration of all senses to create fulfilling interactive experience "the lively integration of means and ends, meaning and movement, involving all our sensory and intellectual faculties is emotionally satisfying and fulfilling". They’ve written about the enchantment of technology\textsuperscript{35} - "being charmed and delighted" "connotation of

\textsuperscript{34} John McCarthy and Peter Wright, “Technology as experience,” \textit{interactions} 11, no. 5 (2004): 42–43
2.3. Interactive Sensory Experience

being bewitched and delighted and caught up and carried away”.

Bill Gaver is known for creating poetic and playful engagements as introduced earlier. In one of his projects, he has incorporated smell in the form of essential oil to express connection between two distant partners. He designed Scent\textsuperscript{36}, where one person handles the picture frame, it will trigger the heating element on the other side and vaporizing essential oil. The fact that the smell of the essential oil will stay for a while will represents the thoughts between one another to linger in the space before it fades away. Gaver aims to use smell interactions to convey mood and emotion rather than to exchange particular information, allowing loose mapping of meanings without clear definitions. The use of senses opens up playful, poetic elements in interactive systems.

In CHI conference 2016, a highly recognized conference for HCI, a multisensory workshop is organized by Marianna Orbit, Nimesha Ranasinghe and Charles Spence for "Touch, Taste, Smell User Interfaces: The Future of Multisensory HCI"\textsuperscript{37}. They call attention of HCI researchers in creating meaningful application, context and scenario for multisensory stimulation. In an earlier article by Marianna Orbit, she invited participants to share smell stories and explore opportunities for smell interactions beyond development efforts and evaluation of users' smell perception of single smell stimuli. In an effort to call for attention in experience more than technology developments, she analyzed the smell stories categorized six areas for desirable future smell experience, and invited HCI researchers to come up with smell experience ideas, which includes smell-enhanced storytelling, such as collaboratively adding smell to represent shared memory; or smell trail in an environment to guide people into the space. She encouraged ideas that goes beyond use of single smells such


2.3. Interactive Sensory Experience

as layering smell and dynamic distribution of smells to create meaningful experience. Within Sussex Computer Human Interaction, Lab, Marianna Orbit developed applications surrounding many smell, taste and touch interactions. Andreas Riener et al developed smell delivery devices to build non-disruptive effects of smell into the in-car notification system.

Mei Kei Lai\textsuperscript{38}, young researcher from Macau Polytechnic University and PhD graduate from Keio University Media Design Program recently explored smell interactions in family environment, and categories various smells used for children-parents interactions related to family events and memories. She designed digital artifacts that can be incorporated into daily encounters.

Current interaction designs to address the mind and imagination only make use of visual senses and tactile senses, and seldom use olfactory sense due to difficulty in countability. However, olfactory sense has higher affordance to impart feelings and reaches deeper side of human consciousness\textsuperscript{39}.

In recent years, there are lot more breakthrough in terms of interaction with smell as novel applications. Scentee released developers’ toolkit and individual scent cartridge to allow people to add smell to their messages and notifications on demand. An open source development project Olly\textsuperscript{40} is released by Foundry to allow DIY enthusiast to make their own desktop diffusion system, connected to social networking messaging applications. A leading diffuser company @aroma has recently created a product design called "duo" that allows users to select smells and timing of the diffusions, creating customizable options for daily use\textsuperscript{41}.

\textsuperscript{38} Lai Mei Kei, “Ludic odour: designing a digital artefact with smell at bathing for family bonding (Thesis),” 2016.
\textsuperscript{39} Joseph LeDoux, \textit{The emotional brain: The mysterious underpinnings of emotional life} (Simon / Schuster, 1998)
\textsuperscript{40} Olly http://www.ollyfactory.com/
\textsuperscript{41} Personal Peizo Diffuser Duo https://www.at-aroma.com/duo/
2.3. Interactive Sensory Experience

Figure 2.3: Mood Light Application in Music Bottle

*Source: musicBottles by Irishi Ishii*

http://tangible.media.mit.edu/project/musicbottles/

Lighting is a material that has been extensively used for artistic expression and architectural design. Traditionally, architecture employs natural lighting to represent atmosphere and define characteristics of space. The stained glass art was used by the greatest artists such as Chagall in employing natural light and colors for awakening the spiritual feelings. In the modern day, Artist Olafur Eliasson creates artificial lighting installation to mimic sunset in Tate Museum, his lighting design signifies moments in the day and people are greatly affected by such atmosphere. More recently, architects and designers have explored innovative use of lighting for modern architecture \(^{42}\) \(^{43}\).

When used as ambient or mood light, lighting shares similar sensibility to create implicit information rather than direct informational exchanges. It is often used to signify other interactions. In Hiroshi Isshi’s work Music Bottle, dynamic lighting compositions are rear-projected onto table’s surface to show the change of music composition triggered by manipulations of the bottles. When bottle cap is taken off, there is a blinking of light, and when change of music is introduced, new tone of color is blending in to the color palate.

Commercial products that incorporate smart technologies have advanced


2.3. Interactive Sensory Experience

and allowed easy control for designers. Philips light explored smart phone control of distributed lighting elements over network with control of lighting in terms of hue, brightness and contrast. In addition, it explored atmospheric feeling that are created by LED lights. Researchers discuss interactive lighting in terms of motivation of control and context of control\textsuperscript{44}. Dzmitry Aliakseyeu\textsuperscript{45}, researcher at Philips Lighting Research concern about role of lighting introduced peripheral interaction with light. He pointed out that being non-obstructiveness, lighting is considered as a natural medium for being controlled via peripheral interaction, and also a suitable medium for providing feedback in this highly connected world.

Enabling multisensory experience is one of the key areas in HCI to integrate further into our daily experience. By enabling multisensory experience, and designing for whole body, it offers opportunity for us to engage with users’ phenomenological experience, as human beings are "sensory wired". With much attention to incorporate the human senses, however, the sense of smell has not been explored deeply as a main interactive medium. It’s unique quality has just started to catch the attention of researchers. Many explored the use in VR as ways to make the experience more real. Little attention was drawn on the evocative power of smell to evoke imaginations and interact with our mental processes. Some starts to look for ways to integrate smells in everyday playful interactions. With maturing of technologies to actuate senses and attentions to call new context for sensory design, creating interactive ambient experience of light and smell can provide new ways to engage the mind and create sensorial imagination. My research will apply interactive ambient design in commercial setting that provides phenomenological value for consumers.

\textsuperscript{44} SAM Offermans, HA van Essen, and JH Eggen, “User interaction with everyday lighting systems,” Personal and Ubiquitous Computing 18, no. 8 (2014): 2035–55

2.4 Research Contribution

As reviewed, value co-creation, experience-centric approach are changing landscape of branding. Value-in-context has been pursued by many researchers to establish competence and create differentiation for service brand. Although many employed technological solutions to engage customers for collaboration and co-desgining activities, there are many other opportunities exists throughout the customers’ experience of the product and service, especially in terms of co-creating experience in order to support their activities and co-create value. It has also been pointed out that incorporating sensory strategies as part of brand experience will allow customers to co-create value that is personal, tuned towards their own contexts. However, the detailed sensory strategies have not been put forward. In my research, we create prototype *Scented Pebbles* that augment the ambient experience and allow customers to co-create the experience. *Scented Pebbles* aims to enhance brand value where the brand becomes the experience (Prahalad 2004). It leverage on smell and lighting’s capability to influence our unconscious mind, creating an interactive experience that engages user’s mind, so that they would create an experience that is personalized, fit with their own contextual situations.

The review on sensory impact of consumers gives a thorough view of how sensory processing could engage with our unconscious thinking and create sensorial imaginations. Current sensory strategies only relates to our psychological response to stimulations, how it creates affective effects or produce pleasant feelings. It is not yet explored how we use sensory especially smell to engage with our sensorial imaginations. With digital technologies and interaction design, we hope to use interactive ambient experience to engage customers with sensory imaginations and guide their unconscious feeling.

Lastly, HCI field has pushed to incorporate sensorial design in order to achieve enchantment of technology. However, sense of smell has not been se-
riously considered as main medium for interaction, despite its potential to create poetic experience. The main body of work related to smell stays in the development stage to create better technologies rather than creating more meaningful experience. *Scented Pebbles* brings interaction of smell to the foreground, with accompany of mood lighting, it creates interactive ambience that better supports customers’ activities in the commercial space.

In this thesis, we explored the value for customers in commercial space created by interactive ambience of lighting and smell. By sensing customers’ behavior, *Scented Pebbles* becomes the tools that can let suppliers easily provide consumers’ personalized sensory experience, and therefore allowing customers to co-create experience through interactive ambient experience.
Chapter 3

Design

My research aims to explore interactive ambience of lighting and smell in co-creating value for customers in commercial space. By sensing customers’ behaviours, smell and lighting are responding accordingly. The interactive ambience creates moments of encountering such as relaxing, social and playful as value-in-context for customers. In the commercial space, the interactive ambience can enhance the experience of the commercial spaces and attracts customers.

The concept of Scented Pebbles is designed to support the thesis claim that interactive ambience of lighting and smell in co-creating value for customers in commercial space. Scented Pebbles creates adaptive ambience of smell and lighting based on customers’ contextual information in the space. Customers’ behaviors, i.e. relaxing, having a coffee with their friends, can be sensed through embedded sensors in the form of everyday objects in commercial space, such as sofa seats, or coffee coasters. Based on the sensor data, group of Scented Pebbles is coordinated to generate programmed sequence of smell, which smell to generate and when. The interaction with ambience provide better feelings and atmosphere. For example, when the user sits on the sofa and leans back to the cushion, the embedded sensor in the cushion sends the sensor information to the group of Scented Pebbles. Scented
Pebbles determines the state of user and creates a programmed sequence of smells. The group of Scented Pebbles are coordinated together to generate the programmed sequence of the smell, which smell to generate and when. Each Scented Pebbles also shows the lighting color to indicate which smell is being released, while fading-in and out to create nice ambience for the relaxation.

Scented Pebbles aims to create value-in-context for the customers in the commercial space. It is brought to commercial space such as co-working space and cafe to see how it might support customers’ behaviors in real context. Through interview and discussion with business supplier as well as customer journey mapping of customers, Scented Pebbles is redesigned to better support customers’ context of use in the specific venue. It is redesigned to reflect the experiential needs of customers in the commercial space, for example creating better ambience and support ordering service in the cafe, and supporting social interaction in the co-working space.

This chapter presents concept design of Scented Pebbles as the following: Section 3.1 Describes the design concept and approach of Scented Pebbles; Section 3.2 Describes the basic system Scented Pebbles; Section 3.3 Describes the Interaction of Smell and Lighting through Smell Study and User’s Behavior in Simulated Environment; Section 3.4 Presents how Scented Pebbles is integrated into two commercial spaces; Section 3.5 Presents the final experience design of Scented Pebbles for two commercial spaces.

3.1 The Concept and Approach

The concept of Scented Pebbles is to design digital artefacts to create adaptive ambience of smell and lighting for commercial space. It takes smells to the foreground of interaction, and enhance people’s experiential value related to their contextual background, i.e. when they want to relax with a nice ambience, or
create light-hearted and playful interactions while having a coffee with others. The smell and lighting is programmed to suit each situation of the user, so that they get a co-creating experience through the interaction.

Exploring Aesthetics with Digital Artifacts

Scented Pebbles explores aesthetic form of digital artefacts. It takes efforts to make Scented Pebbles individual modules with compact unique forms. The decorative form makes it much easier to be integrated with commercial space. Section 3.2.1 shows the design of Scented Pebbles and integration with digital technologies. The design of Scented Pebbles achieve both decorative form with functions.

Exploring Narrative Capacity of Smell
3.2. The System

It also explores characteristics of smell to connect with human imaginations and subjective experience. Section 3.2.1 shows the initial smell study as prior study before designing of the system and interactions, and it inspired the thematic design of smells.

Implicit Interactions

Overall, design of Scented Pebbles embraces implicit interactions, where the interaction is not always at the foreground of attention. It creates atmosphere and feelings and therefore goes between the conscious and unconscious knowing.

3.2 The System

Scented Pebbles system is designed with individual modules of Scented Pebbles networked together to create programmed sequence of lighting and smell. It takes external inputs such as users’ behaviors or direct interaction with Scented Pebbles, in order to create output of smell and lighting. The section will describe the modular design of each Scented Pebbles and the how they are networked together. In addition, it will present the integrated design of Scented Pebbles.

Scented Pebbles takes people’s contextual information as input such as their behaviors or how they directly interact with Scented Pebbles. Sensors are embedded in the commercial environment related to their activities and behaviors in the space. There are also sensors embedded inside Scented Pebbles modules to sense gestural information. How user’s behaviors are sensed and what kind of smell and lighting are triggered accordingly will be discussed more in details in section 3.3.2 as part of the interaction design based on the system.
3.2. The System

3.2.1 Individual Scented Pebbles Module

Each Scented Pebbles module emits two kinds of smell, and displays full color spectrum of RGB lighting. It also senses user’s gestural control and receives and sends the data to the other Scented Pebbles modules on the network. Each Scented Pebbles individual module is capable of digitally controlling two diffuser drivers, emitting light with RGB superbright LEDs. Local communication module is embedded to receive and send signals to other Scented Pebbles on the network. In addition, sensors are embedded to detect direct interaction with the Scented Pebbles such as tilting and touching.

Arduino Fio is used to digitally control smell and lighting output, receive sensor data, as well as communication with the Xbee Wi-Fi module. Arduino Fio is directly compatible with Xbee, and LED lights. For smell control, a digital to analogue circuit is designed, using digital signal to control analogue circuit, and external power is supplied for two diffusers.

Digital Smell Diffuser

In order to trigger smell digitally, ultrasonic diffuser is used due to its low power consumption, and relatively easy to integrate with digital circuit. It basically creates a high frequency vibration that turns liquid into vapor form.
3.2. The System

In order to embed it in a small unit type, it is studied how to induce liquid onto the ultrasonic piezo and release the vapour directly into the air.

Following technologies are considered for digitally control the smell: For example, Squair from @Aroma explored the aesthetics of their diffuser device, powered at 110V. It is found that the oil container is of very small sizes with piezo header, with swappable design, the size limit is due to the electronic unit which is hidden in the device.

Despite the small size of Squair, the only limit is the power consumption. It is noticed that the low power humidifier uses the same piezo mechanism to release smell and can be powered using usb port. A light weight driver is the sourced to be used for Scented Pebble deployment.

A suitable range is found for delivering scent within 1m range. It’s a good range to be detected in close proximity and at the same time will not fill up the space immediately or come off as too strong. It will only gradually fill up the space and will dissipate given time and light ventilation. Smell samples are tested with digital diffusers. The following setting is used to create gently diffused aroma with detectable smell.( Power supply 5V Power range at 1.5 2.0W, Mist Output: 30 100ml/h )
3.2. The System

![Figure 3.4: Existing commercial products using piezo vaporisor](image)

A small liquid container is designed to reduce the size requirement of the prototype. (See Fig. 3.7)

**LED Lighting**

Tri-color superbright LEDs are used as they can be driven directly by Arduino’s digital pins. A full color spectrum can be displayed. Smooth transition of colors can be programmed in Arduino.

**Wireless Communication**

XBee is directly compatible with Arduino. They are setup for broadcasting mode so that they are able to send and receive all signal from the network.

**Sensing**

Several sensing methods are explored, i.e. Tilt Sensing, Capacitive Sensing to create natural and direct interaction with *Scented Pebbles*.

**Tilt Sensing**

ADXL335 (on board) three-axis accelerometer is used to detect tilt. It has three degrees of freedom, if the range exceeds in any of the direction, it is considered tilted. At the same time, the program is made to update its current orientation. So that when user hold the *Scented Pebbles* in their hands, the orientation will be reset automatically, and won’t cause switching of smell to happen constantly, even if it’s away from original orientation.
3.2. The System

Capacitive Sensing

Capacitive sensing is experimented by embedding wires into the case of Scented Pebbles cover so that the non-conductive ABS material covered with wax becomes conductive material and hence sensitive to touch. Although the initial experiments of touch sensing is successful, it is found that it needs constant calibration to reset threshold value for detecting "touch", which is not possible when user is touching the Pebbles. Especially when piezo is activated internally this cause unstable value for capacitance. We have also looked into capacitive sensor provided by Sparkfun, however, it is hard to differentiate the action of "tilting" with "touching", as sometimes users would hold the Scented Pebbles while tilting, so I have eliminated the capacitive sensing for interactions.

3.2.2 Scented Pebbles Network

Multiple Scented Pebbles are coordinated over the network by a light-weight server. The server takes inputs in several ways from sensors embedded in Scented Pebbles, as well as from external sensors in commercial environment.
3.2. The System

Based on the inputs, the server send out the programmed sequence of smell and lighting patterns to Scented Pebbles. For example, which smell is activated from which Scented Pebbles for how long; what specific lighting color is displayed for each Scented Pebbles.

Coordinate Group of Scented Pebbles

With network of Scented Pebbles, an algorithm can control the programmed release of smells. At the same time, the lighting can exhibit interesting patterns through multiple units of Scented Pebbles modules, i.e. The synchronization of can indicate special events, and individual Scented Pebbles can light up with different colors to indicate the combination of smells. Section 3.3.3 show more details what kind of smell combinations and lighting design is achieved by coordinating multiple Scented Pebbles

Notified states of other Scented Pebbles

Each Pebbles on the network is notified what other smells are being activated. This helps to know if the group of Scented Pebbles has reached a special state, i.e. for example a special combination of smells have been triggered, then the lighting reacts accordingly.

3.2.3 Integrated Design of Scented Pebbles Module

Scented Pebbles is integrated as light-weight and aesthetically designed modules, so they can be integrated easily in the commercial space. Although Scented Pebbles are digital artifacts, it is designed to have decorative qualities. It takes the notion that the digital control will disappear into the background, and users can naturally interact with the objects to control the smell and lighting. An organic shape is chosen for exploration, as it is inviting for people to directly interact with it. It is decided to create a non-gadget appearance. Putting together with slightly variant forms, they forms a consistency
3.2. The System

Figure 3.6: Communication of Environment Artifacts, *Scented Pebbles* and Servers on the Wireless Network

in looks and achieve the decorative look. This decision poses some challenges for designing the digital artifacts.

3.2.3.1 Initial Design

I have experimented with various organic shapes as container for Scented Pebbles. By using slightly varied shapes, it creates cohesive looks when several Scented Pebbles are put together. The shape is inviting for users to touch, feel and directly interact with.

*Scented Pebbles* structure is developed in 3D program to accommodate for the water container, digital components, and batteries.
3.2. The System

3.2.3.2 Refined Design

Many aspects of prototype is refined, for example, improved ultrasonic piezo placement, layered design to improve internal water proofing, network expansion to accommodate external sensors, and finally PCB board production.
3.2. The System

To have better water proof between the liquid container and electronics, a layered design is used. (see Figure 3.8 ). There will be an acrylic layer separating the electronics parts from the liquid container.

**Liquid Container**

![Liquid Container Image]

Figure 3.9: Improvements of Liquid Container and Piezo Placement

Instead of attaching piezo closely to the liquid container, it is now attached right under the outlets of vapours. This avoid vapours trapped inside the cover which may cause condensation. As there is some distance between the piezo and liquid container, cotton rods are used to guide the liquid to the piezo. Placement of liquid container must be exact so that when the cover is enclosed, the cotton rods will be placed directly underneath the ultrasonic piezo. (See Figure 3.9 )

**PCB Board**

The basic function of each Scented Pebbles remains the same, with only changes in networking, so only change is made to the program of Arduino baord. In terms of hardware, it is stablised, therefore a PCB board version of the circuit is produced for stable performance of Scetned Pebbles unit.
3.3 Interaction Design with Smell and Lighting

The initial interaction design inspired by smell study to allow users to explore different combinations of smell and themes. The refined interaction design look into further users' behavior in simulated environment, such as in hotel lounge, and create lighting and smell that can support their behaviors in the commercial space.

3.3.1 Supporting Exploration of Smells

3.3.1.1 Smell Study

Smell is treated as the main material for interaction in our research. Story telling and narrative nature of smell has been documented and put in practice by perfumers. In order to understand about how people interact with multiple smells, we have conducted a smell study inviting participants with no professional training in smell to blend multiple smell samples to represent a scenario or theme. This approach has also been conducted by designers and perfumers to create DIY perfumes, and the study would like to explore the use of common type of smell samples, and whether it can be applied to everyday users. We also interviewed perfume maker and observed scent designers to gain some field knowledge about perfumes and smells.
First of all we conducted a study to investigate whether smells creates a sensory imagination and how average person interact with multiple smells. Participants are NUS students aged from 18-25. 10 non-artificial smell samples are given to participants at random from 27 samples. After which, they are asked to combine 4 smells to create a scenario and write a description about it. Below is sample of the narratives developed by participants.

"Fresh Breeze theme with smell of Jasmine and Salt Sir reminds me of very pure, healing and relaxing feelings."

"Home theme with the smell Chocolate, Coffee and Herb Oil reminds me of home."

"Bliss theme with smell of Jasmine and Sunshine reminds me of country cottage, early morning and calming feeling."

"Sunshine After the Rain theme with smell of Rain and Sunshine reminds me of the sunshine and rainy scene, but it will feels better if the Rainy smell is less strong."

This demonstrates that average person have the capability to imagine certain narrative and scenario using multiple combinations of smell. At the same time, the process of recalling scents and interacting with smell will inevitably trigger past experience and it’s a very personal experience.

**Interview with Perfume Maker**

It is consistent with various observations and interview with perfume maker that process of making scent will trigger past experience and release their imagination.

When asked about if perfume creates narrative, "Perfume has a narrative, it changes over time, I create perfumes that has the change in mind" - Interview with Perfume Maker who holds regular scent making workshops with enthusiasts, 2012, Singapore, Arab Street (Perfume District)
Observation at Olfactory Exhibition

It is observed process of making scents and how it relate to personal experience at showcase of Olfactory Workshop Exhibition, National Design Center, 2015 Jun 14th. Workshop participants are presented with components of perfume, i.e. Ocean, Floral, Musky etc to create their special blend. During the process, recordings are made, they talk about why they choose particular smells and what kind of imagery they want to create, sometimes it has symbolic meanings, and sometimes it is very pictorial.

"the ingredient reminds her of bath beads that I found in mom’s room, when I squeeze the beads, the smell bursts out, and it’s such a luxury to find and use them .... I want to create the image of the Great Gastby, Champagne and Pearly, imaging the dance and costumes are great inspirations" from workshop participant, creator of Stolen Luxury

"I want to create a simple imagery of Restful Morning, it reminds me of morning on holiday in tropical weather, so I use Aqua, Tropical to create my smell" from workshop participant, creator of Restful Morning

The narrative feature of smells and especially how people combine differently with smells are key to the design of Scented Pebbles. I used the thematic approach for designing smell, discussed in the next section.

3.3.1.2 Initial Interaction Design

Based on the smell study, interaction is design to support exploration of smells. User can create various combination of smells by tilting the individual Scented Pebbles module. Theme is also defined with combination of smells, so when pre-defined theme is triggered, a synchronization of lighting pattern is displayed. For example with three Scented Pebbles, users can tilt each Scented
3.3. Interaction Design with Smell and Lighting

Pebbles to activate either one of two smells in each module. When the pre-defined theme is created, i.e. Botanic Blend of Salty Air, Forrest and Green Tea, then all the Scented Pebbles will show synchronization of color in lighting. When users are not activating the pre-defined theme, then each individual module will show the color of activated smells on each Scented Pebbles as three different colors.

Free Exploration of Smell Combinations

Users can tilt each Scented Pebbles to switch between two different smells. When interacting with multiple Scented Pebbles together, it automatically creates a combinations of lighting and smell. Each Pebbles will display the associated lighting of smells. They will each show different colors. See associated colors of smells in Fig.3.12.

Activating Pre-defined Themes

When user’s combination matches with the pre-defined theme, the lighting color of the theme is displayed for all Scented Pebbles. See pre-define theme in Fig.3.13.

Figure 3.11: Left: Sunday Showcase at Marina Bay Sands, Singapore, 2014. Right: TEI Art Exhibition, Stanford University, 2015
3.3. Interaction Design with Smell and Lighting

3.3.2 More about Smell

Material of Smell

Since the design explores the narrative of smells to construct a theme, I need to go beyond the limited selections of essential oils that are on the market today. I've explored various types of smells. For example, commercial powdered beverages, that can be easily dissolved in water: hot chocolate, honey lemon, tea, various quality fruity infusion tea are used as they provide characteristic fruity smell such as passion fruit, wild berries, christmas tea etc. Some fragrance company like Demeters starts to focus on everyday smells rather than the complicated mix, so these can be used for our purpose to provide "raw materials " for making the theme of smells. We use both commercial fragrance such as Demeters and @Aroma to provide components of smell rather than pre-mixed smells. See Figure 3.12

Thematic Design of Smell based on Smell Study

Based on the initial smell study, I find the exploring behaviors of users is intriguing. Through exploration of multiple combinations of smell, they can create association with their own experience and create strong impact to their imaginations. This is both evident in our study and is part of perfumer’s practice. It is learned that Perfumers takes in time as part of the smell design (volatility) Scented Pebbles is designed to support interacting with multiple combinations of smell. Please see next section on Designing with Smells. The Scented Pebble is able to support combinations of smell as well as programming of time sequence of smell

3.3.3 More about Lighting

Lighting is designed as aesthetic element of ambience and can be used to represent theme that is created in the space. It also acts as feedback of interaction.
3.3. Interaction Design with Smell and Lighting

<table>
<thead>
<tr>
<th>No.</th>
<th>Smell</th>
<th>Source</th>
<th>Associated Colors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coconut</td>
<td>Coconut Juice</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ocean</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Forrest</td>
<td>@Aroma</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Bamboo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Chocolate</td>
<td>Hot Chocolate Made from Powder</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mint</td>
<td>@Aroma</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Enoki Pine</td>
<td>@Aroma</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Japanese Matcha Tea</td>
<td>Match Tea</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Redbeans</td>
<td>Redbean Soup</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Cherry Blossom</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Christmas Tree</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Rain</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Salt Air</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Green Tea</td>
<td>Actual Green Tea with Loose Leaves</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Honey Lemon</td>
<td>Honey Lemon Tea - Twinings’ Teabag</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Cinnamon</td>
<td>Essential Oil</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Wet Garden</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Snow</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Grass</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Chamomile Tea</td>
<td>Teabag Twinings</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Sunshine</td>
<td>Demeter Fragrance</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Fruity (Passion fruit tea)</td>
<td>Passion Fruit Twinings Teabag</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.12: Definition of smell and associated colors

It is used to indicate associated colors with the smell, as well as the theme color when multiple smells are combined together. With six tri-color super-bright LED lights, it is possible to light up each Scented Pebbles and show
3.3. Interaction Design with Smell and Lighting

<table>
<thead>
<tr>
<th>Theme</th>
<th>Smell Combination</th>
<th>Individual Smell Associated Colors</th>
<th>Associated Theme Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool Beach</td>
<td>Coconut (#1) Ocean (#2) Salty Air (#13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunday Afternoon</td>
<td>Chamomile Tea (#20), Sunshine(#21), Fruity (# 22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japanese Hotspring</td>
<td>Enoki Pine (#7), Japanese Match (#8), Cherry Blossoms (#10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter Xmas</td>
<td>Xmas Trees (#11), Cinnamon (16), Mint (#6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botanic Blend</td>
<td>Salt Air (#13), Forrest (#3), Green Tea (#14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relaxing Blend</td>
<td>Chocolate(#5), Honey Lemon(#15), 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.13: Definition of themes and associated colors

the full range of color spectrum. The brightness of light can also be manipulated to show the animated effects of fading in and out of any colors. The transitioning effects and synchronized effects can be used for various parts of interactions.

Indicating Activated Smell

When Scented Pebbles are releasing smells, each Scented Pebbles will show an associative color to indicate the smell.

Indicating Change of Smells

When the smell is changing on the same Pebbles, the lighting will transit between two colors.

Displaying Theme of Smells

When group of Scented Pebbles are displaying a theme, all the Scented Pebbles are synchronized to show the same color of light that represent the theme.

Indicating Important User Interactions
3.3. Interaction Design with Smell and Lighting

The synchronization of animated light can be used to indicate significant events of interactions or user behaviors. For example in the case for social interactions, when two players are synchronizing their actions, two Scented Pebbles are synchronized together to show transition of same color pattern.

3.3.4 Supporting User’s Behaviors in Simulated Environment

Various behaviours in the commercial space is explored and scenarios of corresponding lighting and smell and lighting is designed. For example, when it senses that customers are relaxing on the sofa, it auto-plays a relaxing theme of smells (i.e. a selection of Botanic Blend Theme in a timed sequence), allowing users to sit back and relax while enjoying the subtle change of smell accompanied by breathing lighting animations. The coffee coasters is networked with Scented Pebbles to sense if two people are having a drink together. Then Scented Pebbles will create synchronized lighting and smell to excite the users and encourage them to have social interactions. Sensors within Scented Pebbles can also allow user to directly interact with Scented Pebbles and create personalized ambience according to their own preference.

3.3.4.1 Simulated Environment

Simulated environments are setup to investigate the user behaviors and their interactions with Scented Pebbles. Various sensing mechanisms are created to coupling the integrated smart device with behaviors of users. This creates engagement with the user to the Scented Pebbles with the environment. By sensing the customers’ behavior, it creates a platform where users’ intention and behavior can will change the output of lighting and smell. A general demo is designed to illustrate how physical actions such as lifting objects, placing objects, presence of people may change the lighting and smell effects. A
simulated environment such as hotel lounge is setup, to illustrate how user may interact with the smell and lighting to enhance their lounge waiting experience.

![Hotel Lounge Scenario with Scented Pebbles](image)

Figure 3.14: Hotel Lounge Scenario with *Scented Pebbles*

### 3.3.4.2 Refined Interaction Design

**Relaxing**

When user is relaxing, a smell combination of Sunday Afternoon is released.

Sensing of Relaxing Behavior: Pressure sensor is embedded in the cushion so that it will sense pressure when user lean against the cushion at the back. Threshold value is tested so that when it is exceeded, a command is sent to all the Scented Pebbles on the network. For each environment, the threshold
3.3. Interaction Design with Smell and Lighting

Figure 3.15: Sensing User’s Behaviors

has to be reset and pre-tested before installation. The current implementation uses wired connection between the sensor and server, and wires are carefully run through the seam of the sofa. As the wires may introduce capacitance, so it requires some testing of threshold value before installation.

Output of Smell: Chamomile Tea, Sunshine, Fruity for 5 mins

Output of Lighting: All Pebbles Fading in and out of Sunday Afternoon color (See Fig 3.13)

Reading

When user is reading, a highlight note of Mint is released every 30 sec-
3.3. Interaction Design with Smell and Lighting

onds, on top of the background smell of Sunday Afternoon theme. Sensing of Reading Behavior: Pressure sensor is embedded beneath the magazine stack, so when book is lifted, the pressure value will decrease, this will send a signal to all the Scented Pebbles on the network.

Output of Smell: (See Fig 3.16)

Highlight smell = Mint

Background smell = Sunday Afternoon Theme (Chamomile, Sunshine, Fruity)

Output of Lighting:

All Pebbles Fading in and out of Sunday Afternoon color (see Fig 3.13). Whenever Mint is released, the Pebbles releasing Mint smell will turn associated color to Mint (See Fig 3.12 for associated color of smells)

![Timeline of Smell Changes for Reading](image)

**Figure 3.16: Refined Smell Interactions**

**Drinking**

When user puts cup down on the coffee coaster, a highlight note of Ginger is released, on top of the background smell of Sunday Afternoon theme.

Sensing of Drinking Behavior: Pressure sensor is embedded underneath the table cloth, when user is drinking, the pressure value decreases, this will send
3.4 Interviews and Customer Journey Mapping in Commercial Space

a signal to all the Scented Pebbles on the network. A coaster version is also made, where the user may trigger the drinking mode by placing cups on the coaster where pressure sensor is embedded.

Output of Smell:

Highlight smell = Ginger

Background smell = Sunday Afternoon Theme (Chamomile, Sunshine, Fruity)

Output of Lighting:

All Pebbles Fading in and out of Sunday Afternoon color (see Fig 3.13). Whenever highlight smell i.e. Ginger is released, the Pebbles releasing Ginger smell will transit to its associated color (See Fig 3.12 for associated color of smells)

Exploring

The exploring behaviors is supported when user starts to tilt the Scented Pebbles. The exploring interactions (section 3.3.1) is integrated as part interactions.

3.4 Interviews and Customer Journey Mapping in Commercial Space

The prototype development takes an interesting turn by bringing Scented Pebbles to commercial places, this is the stage where value proposing is occurring by talking to the business suppliers and co-develop the idea. After the basic idea is presented in demo form, the designer will analyze the result in the form of customer journey mapping, and redesigned the experience based on the finding. This section will present process of discovering opportunities of
3.4. Interviews and Customer Journey Mapping in Commercial Space

Scented Pebbles, through interview demo with the business supplier as well as the customer journey mapping.

Based on value co-creation, business owners and space managers are regarded as resource integrators and create potential benefits for customers. In this case, the resource integrator (manager) will adapt the Scented Pebbles towards their goal by integrating with their context of use and goal. Scented Pebbles enables such approach by bringing the prototype to the client and define contextual goal of customers, after that new version of Scented Pebbles is proposed with refined interaction scenarios based on the original basic infrastructure of the system.

Collaboration with business supplier is the key in the design process of Scented Pebbles. By involving the business owner, the designer get a realistic account of what the space is created for, and what the customer’s contextual goals are in the space. This starts with a general prototype demo to space owner as a probe to get initial reactions from owner in the space. Structural interviews are conducted to find out the following: How interaction can be related to consumers’ behaviors, in order to enhance customers’ brand experience? How to engage with consumers in co-creating ambience experience? Based on the contextual inquiry, a refined design is proposed and implemented.

Customer Journey Mapping is the method applied to get the understanding of experience from customers' point of view. It is important to review all interactions of supplier and customers and find out what the suppliers have already achieved in creating the ambience and desirable environment, and finding out what how can Scented Pebbles enhance value that is related to the customers’ experience.

Selection of Space

Prior observations and interviews are conducted to select space that values the experiential elements, and which can be enhanced through Scented Pebbles.
3.4. Interviews and Customer Journey Mapping in Commercial Space

For this stage of research and capabilities of developing interactions, I choose cafe and co-working space. For cafe, emotional, aesthetics and sensorial values are important to cafes to create a feeling or atmosphere for the customers and differentiate their service. For co-working space, it provides sharing office space for members to socialize and work together even thought they are from different companies and backgrounds. The experiential value is essential for co-working space to differentiate from each other in terms of style and community. I can leverage on social, creative elements of *Scented Pebbles* to enhance its brand experience.

3.4.1 Work Central

*Scented Pebbles* is exhibited at InnovFest conference in 2016 May. At the exhibition, I was looking for potential partners to co-develop and test the concept. A co-working space invited me for testing in their space, where they create work space for start-ups and looking for installations that are creative and inspiring. We started exploring the co-working space and conducted structural interview in both Work Central.

Work Central is a collaboration space that provides work space for start-ups. It aims to create creative and social environment where members can exchange ideas, make connections and work creatively. Work Central is in search of creative and playful interactions to engage their users, they are looking for sensorial simulations that can refresh their members in the space.

Interview with Manager

Interviwee: Silvia

Background: Manager of Work Central

Experience at Work Central: 3 years
3.4. Interviews and Customer Journey Mapping in Commercial Space

Designer: Please introduce Work Central and what you try to create for your members.

Silvia: We would like to provide an experience for our members of the space; they can create their own experience, use the library, office, social space at their will. And we have different packages that allows members to sign on to different rental services. Most importantly, we would like to host them so that they can work creatively and strengthen their communication. When they open their mind, there is a synergy flowing, our space should allow that creativity to grow for members as individual and as a group.

Designer: What would you like Scented Pebbles to create in your space?

Silvia: We like to explore the subtle interactions. Not only will diffusers adds on a hint of the moods in various part of our shared space, but also it creates interactions that allows members to communicate to each other on casual topics, and create ice-breaking effects. As we have type of spaces, for example, library, lunch space for casual meetings, and work space, we would like to see various explorations of interactive experience in different sapces.

Initial Demo and Feedback

Based on the interview, a demo is setup in the social interaction area of Work Central, where members will have light interactions during lunch hour, or have meetings. Members are encouraged to have conversations and brainstorms with members from other companies and discover ideas together, so we thought it’s a potential location to install Scented Pebbles for ice-breaking and create opportunity for interactions.

We explain the idea that by putting the senor pads on the sofa or on the table area, once members sit down at the sofa or putting their cups, different
lighting and smell patterns could be triggered. This evoke interests to create a social game scenario at Work Central to encourage interaction among members.

![Demo at Work Central](image)

**Figure 3.17: Demo at Work Central**

### Customer Journey Mapping

The day in the life of members in the space varies based on their agenda of the day and what kind of spaces they subscribes for. Work Central creates regular events that attracts members to join, it provides knowledge targeting at their members to broaden social opportunities and share knowledge. For members of the space, the activities can be planned pretty organically, since the social area is open to all members whereas other space depends on different subscription scheme, it is a space where people can mingle across teams and across companies. Work Central attracts like-minded people who are interested in innovation and creativity. Conversations and collaborations may form through the social bonds they make with each other.

#### 3.4.2 **Hangars Co-Working Space**

Hangars space is a startup co-working space within National University of Singapore. It is similar to Work Central in attracting startups and organizing regular events for networking. It aims to create a social, creative and refreshing communal space for startup members and public visitors. This is where it will
create serendipitous encounters, wind down from their daily work at their desk, and where new ideas sparks.

Interview with Managers

Interviewee: Managers at Hangars, National University of Singapore

Hangars work space is mostly occupied by startups and the memberships are taken by mostly developers. They would like to make use of time as much as possible for work, so even though a lot of features are created for them to be creative and outspoken, most of them stay at their desk. When they step out of the office space, they would like to take a breathe from their work, relax
3.4. Interviews and Customer Journey Mapping in Commercial Space

and refresh themselves. Their days are pretty intense. The visitors come from across many departments in the universities and from other companies who would like to invest in the technologies or would like to join the entrepreneurship program. It is important to establish the brand image that it’s a creative innovative place and engaging, at the same time it also offers developers a comfortable and convenient working space.

Customer Journey Mapping

Figure 3.19: Hangars Space: Entrance, Sofa Area, Hotdesk, Workspace

Hangars space regularly hosts events organized the university or its external partners, targeting start-up community. It’s located in the university complex with a standout design creates feelings of airfield runway. It catches the eyes of visitors immediately once they enters the building. The bulletin board at the entrance advertises events so anyone walks by can be notified of upcoming events, they are welcomed to walk into the open space to discover what’s going on what kinds of projects are taking place in the university-wide start-up community.

After visitors enters the space, there is a relaxing sofa area, often taken by invited guests of members working in the space, while waiting for business meeting or events. They can explore posters of other projects posted on the stand. Members will show their guests in the space and there are dedicated meeting rooms for business meetings.
3.4. Interviews and Customer Journey Mapping in Commercial Space

Figure 3.20: Customer Journey Mapping for *Hangars*
3.4. Interviews and Customer Journey Mapping in Commercial Space

The dedicated work space is only accessible to members who are registered with the university, they pay a subsidized fee to use the space and university supports their activities by providing networking opportunities and working space. The working space is separate from the open space area requires access cards to enter. As most members are developers, they will spend their time at desk and take a break during lunch hours or for coffee break in the open space area. They may mingle with external visitors during their break time and if there is a networking event going on. When there is no events, members can relax in the sofa area or choose to discuss matters with their colleagues in the shared working space.

There are shared working space that is free to be used by the public, mostly utilized by event attendees during their workshops. As the space is open to public, university students and staff from nearby departments can use it for casual meeting and make use of the shared working area that is provided free for visitors.

The activities of the day shifts from day to day depends on whether there is an event or not in the space.

3.4.3 Sunset Way Cafe

When *Scented Pebbles* is brought to Sunset Way Cafe, owner of the space is interviewed to get a sense of what type of space he likes to create. The owner likes to create Comforting, Relaxing, Easy-going environment in a quiet neighbourhood. Facing direct competition by chain coffee roasters right next door, he likes to keep old customers and would like to give customers a sense that they belong, sometimes customizing their orders or coming up with new recipes.
3.4. Interviews and Customer Journey Mapping in Commercial Space

The style of Sunset Way cafe is defined as relaxing, easy going, and creating a homy feeling for the neighbourhood customers. It needs to establish its own unique characters and signatures in order to compete with other new comers.

Interview with Owner

Interviewee: Mark, Owner of Sunset Way Cafe

Experience at Sunset Way: 8 years

Interviewer: What would you like Sunset Way to be for your customers? What is special about it? Owner: I would like to create a relaxing atmosphere for my customers, they walk in here, they can feel at ease, doing their work, staying for some time, they come here after picking up their kids, having snacks, they may also come here to work on a working table. I provide plenty of space for that as well.

Interviewer: I noticed that you have artwork displays, doodling wall, pictures of your customers on the fridge. Is if part of your design of your coffee shop?

Owner: I want to make my customers feel at home, I cannot afford very expensive and fancy interior designs, however I always add things to make it home-like, and enjoyable. Drawings, photos, my sister’s home made cookies, these additions are what makes the difference from other shops. Interviewer: If you would like to create an atmosphere for your customers, what will it be? Think about a scenarios, a theme, and smells? Owner: I prefer to have natural smells, I particularly like forest, because we are located in a green neighbourhood, a bit hidden away from the traffic, and has plenty natural reserved rain forest, I would like to recreate that feeling for my customers. Something fanciful will be the smell of snow, it’s very refreshing.
3.4. Interviews and Customer Journey Mapping in Commercial Space

Interviewer: Which part would you like to improve on? I’m facing direct competition with some chain coffee shops, they invest in better machines and very well designed, I’d like to create a unique experience for my customers.

Initial Demo and Feedback

It is demoed to the owner that upon serving the coffee, a change of smell will be triggered. And when user sits down at the sofa, a special smell combination will be triggered. When user holds the Scented Pebbles, there will be a change in smell. They can make their own combinations.

In the Sunset Way Cafe, the owner likes to have smell and lighting that can reminiscent of soothing natures outdoor environment as an ambience for his cafe. And when his customer lean back on the sofa, the thematic lighting and smell will play to match the drink they’ve order, customers may also choose some pre-mixed combination of smells or lighting according to their own preferences.

User may personalize their ambience by "ordering" thematic ambience, this type of personalizing is important in co-creation their own experience and value. In terms of business, the cafe now can further differentiate their service by providing additional value of customizing the ambience following drink order, and. In addition, Scented Pebbles can be used to program unique themes of the cafe, matching with the brand of the shop, to create its brand image.

Customer Journey Mapping

Customers are welcomed to sit down at the table by the owner, and presented menu to order drink or food. Special requests can be accommodated by the owner, usually he will come up with customized menu for kids and asking for special dietary requests from the customers. After food is served by the
owner himself, guests can relax on the sofa or do some work on the table, the
owner has a music list that create comfortable ambience in the space.

In the morning time, the cafe gets busy from regular customers ordering
breakfast.

In the afternoon there are quite a lot of moms picking their kids in the
schools nearby and may stop by to get a bite or drink. There is a kids corner
where children can read books and doodle at the small table.

It’s interesting to look at key moments for creating smell and lighting
interactions 1) Welcoming 2) Ordering

3.4.4 Artistry

Artistry is a space that attracts creatives and is part of a design consulting
company. The customers are arranging client meeting here or for work. It
is important for the cafe to provide an atmosphere that can stimulate their
creative energy as well as become a comfortable place for them to work in.

Interview with Owner

What kind of atmosphere are you creating for your customers? Is smell
something you consider? What kind of atmosphere is created at your cafe?
3.4. Interviews and Customer Journey Mapping in Commercial Space

It is a cafe that caters to creatives, the design agency sits right on top of the cafe and remains good relationship to each other. For examples, designers can regularly display their artwork which inspires customers in the cafe. The cafe is experiential in natures and holds events for musicians at night who needs venues to perform. At other times, events will occur and regular mix-o-logists are invited to the space. Creativity will sum up the general atmosphere of the space.

**Customer Journey Mapping**

Customers are received by one of the barrister when they come into the cafe, the venue has expression of creativity and attracts local artists and designers
3.4. Interviews and Customer Journey Mapping in Commercial Space

Figure 3.23: Customer Journey Mapping for Artistry

and located among several design creative agencies in vicinity.

The venue has expression of creativity and attracts local artists and designers and located among several design creative agencies in vicinity. Passers-by maybe attracted by the exterior including wall murals and advertisement of local music pop-up events, there are also outdoor seating available that renders a relaxing and laid back atmosphere.

Customers are received by one of the barista once they come into the cafe, they will be lead to a table and presented menu for ordering. Once they are ready, they may go up to the counter or ask the waiter to take the order. The space is decorated with artworks that are updated frequently, some artworks are for sale, while waiting, customers can browse the artwork and walk around.
3.5. Integration of Scented Pebbles in Commercial Space

the space when it’s not crowded. While some customers are looking for a place to work while enjoying a cup of coffee, the cafe is frequented by visitors from nearby agencies who are having business meetings in a casual location. As the cafe also locates directly beneath a creative agency and have certain partnership with the designers who displays their artworks, so they also bring their work partners here to discuss work during coffee time or lunch time. As the space has a lot of characters, people who visit the space with their friends may also take picture of the surrounding and post their photos on social networking sites as well. Barista here try to create an environment where customers can unwind from their office and provide a creative vibe in the space. Customers will feel stimulated by the artwork and people in the space, in addition to having a great cup of coffee and light lunch there.

3.5 Integration of Scented Pebbles in Commercial Space

3.5.1 Redesign for Hangars

The space is designed for bringing start-up companies together and providing innovative environment for them. The key of is to create social moments and opens up for playful interactions. At the same time, it can provide relaxing moments when needed. Therefore I have created new social interactions, i.e. when it detects synchronized motion of two players using coffee coasters, it create special combination of lighting and smell. And it also senses if users are in relaxing mode, if they are lying down in the lounge sofa area, then an automatic sequence of botanic theme is played automatically. Direct interaction with Scented Pebbles to create personalized ambience is also supported. The following illustrates how three units of Scented Pebbles could support the various experience of customers.
3.5. Integration of Scented Pebbles in Commercial Space

<table>
<thead>
<tr>
<th>Pebble</th>
<th>Smell 1</th>
<th>Smell 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pebble A</td>
<td>Citrus</td>
<td>Hinoki</td>
</tr>
<tr>
<td>Pebble B</td>
<td>Passion Fruit</td>
<td>Green Tea</td>
</tr>
<tr>
<td>Pebble C</td>
<td>Forrest Smell</td>
<td>Jasmine</td>
</tr>
</tbody>
</table>

Table 3.1: Selection of Smells for *Hangars*

Selection of Smells for *Hangars*

1/ Make sure that at least three smells used for relaxing experience are on separate pebbles, so that when user experience it, all pebbles’ lighting are activated.

2/ Two pre-defined smells will be used for the exploration, make sure those two combinations of smells are blended nicely. They do not necessarily have to come from all different pebbles but makes a nice combinations. It’s better if those combinations can be related to the space. And the two combinations can create some level of contrast.

3/ For Hangars space, relaxing and mutual smells are selected. As it’s a working space, so the smells selected cannot be overly flowery or feminine.

Relaxing Experience

When customers are relaxed on the sofa, they do not actively interact with the Scented Pebbles. Instead, an auto-play of smell sequence with a soothing combination is created with fading in-out of light animation to accompany the changes in smell (See Table 3.2). The subtle changes in ambience can keep their peripheral awareness of the movement of lighting and smell.

Behavior Trigger: Pressure sensor is embedded in the sofa, when user activates the pressure sensor relaxation starts. It will automatically time-out after
3.5. Integration of Scented Pebbles in Commercial Space

10 mins. If user is still on the sofa after 5 mins, the relaxation will continue. (See Fig 3.24)

**Social Experience**

Social interaction is created with two Scented Pebbles. When both player is putting their coffee on the coaster at the same time, a synchronized transition of colors is displayed on both Scented Pebbles. If only one of the coaster is triggered by the player, then only one of the smell is released, while both Scented Pebbles display the associated lighting color for the smell released. (See Table 3.3)

**Behavior Trigger:**

The pressure sensor is attached to the coaster and two coasters are used to detect two players. When two coasters have both sensed the pressure beyond threshold, Scented Pebbles display the smell and lighting for both players. When only one coaster has sensed the pressure, it only triggers one single smell with associated lighting.

**Exploring Experience**

Based on the original functions of the Scented Pebbles, users can tilt Scented Pebbles to switch between two smell. By directly interacting with three Scented Pebbles, they can create the combination of their own preference. (See Table 3.4)

Exploration mode can be experienced by multiples users. They may create a personalized ambience or create a shared ambience.

**Behavior Trigger:**

Under Rest Mode (i.e. when Scented Pebbles is timed out from Welcoming Experience or Ordering Experience), when user tilts Scented Pebbles, it triggers Exploring Experience.
3.5. Integration of Scented Pebbles in Commercial Space

Figure 3.24: Sensing of Relaxing, Social and Exploring Experience in *Hangars*
3.5. Integration of Scented Pebbles in Commercial Space

Programmed Smell and Lighting Output

Smell and Lighting output are programmed differently for each experience. Please see Table 3.2, Table 3.3 and Table 3.4 for details of smell and lighting output.

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxing</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>Orange Color Fading in-out every 15 secs (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Green Tea Smell (0-5mins)</td>
<td>Cyan Color Fading in-out every 15 secs (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Forrest Smell (0-2mins)</td>
<td>Green Color Fading in-out every 15 sec (0-2 mins)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jasmin Smell (0-2mins)</td>
<td>Yellow Color Fading in-out every 15 sec (3-5 mins)</td>
</tr>
</tbody>
</table>

Table 3.2: Output of Lighting and Smell for Relaxing Experience in Hangars
### Table 3.3: Output of Lighting and Smell for Social Experience in Hangars

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Players in Synch</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>Transiting from color Orange to color White (15 s), Then transiting from White to Orange (15 s) Looping</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Green Tea Smell (0-5mins)</td>
<td>Same as Above</td>
</tr>
<tr>
<td>Player 1</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>Fade in and out of color Orange</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>No Smell</td>
<td>Same as Above</td>
</tr>
<tr>
<td>Player 2</td>
<td>A</td>
<td>Green Tea (0-5mins)</td>
<td>Fade in and out of color White</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Forrest Smell (0-2mins)</td>
<td>Same as Above</td>
</tr>
</tbody>
</table>
3.5. Integration of Scented Pebbles in Commercial Space

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Defined Theme: Tea Time</td>
<td>A</td>
<td>Hinoki (0-5mins)</td>
<td>All Green Fading in-out every 15 sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Green Tea (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Jasmin (0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Pre-Defined Theme: Summer Forrest</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>All Violet Fading in-out every 15sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Passionfruit (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Forrest (0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Free Exploration</td>
<td>A,B,C</td>
<td>Any Combinations other than the predefined theme, i.e: Hinoki, Passionfruit, Jasmin</td>
<td>Each Pebbles showing the associative color of smells. Fading in out every 15 sec (0-5mins)</td>
</tr>
</tbody>
</table>

Table 3.4: Output of Lighting and Smell for Exploration Experience in Hangars

3.5.2 Redesign for Artistry Cafe

It is learned from the interview and demo session that the main focus is on the greeting service and ordering service. The owner from Sunset way cafe remembers all the customers in the neighbourhood and knows their order and preference without asking, providing a customized experience. Similarly, Artistry creates a creative ambience for designers in the area, providing artwork and objects for exploration. Therefore, Scented Pebbles is redesigned to support customers’ greeting and ordering experience, and supports their exploring behaviors in Artistry cafe.
3.5. Integration of Scented Pebbles in Commercial Space

Selection of Smells for Artistry

<table>
<thead>
<tr>
<th>Artistry: Selection of Smells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pebble</td>
</tr>
<tr>
<td>Pebble A</td>
</tr>
<tr>
<td>Pebble B</td>
</tr>
<tr>
<td>Pebble C</td>
</tr>
</tbody>
</table>

Table 3.5: Selection of Smells for Artistry

Welcoming Experience

When customers sit down at the table, they will enjoy a welcoming ambience. The ambience will represent the characteristics of the cafe. The system will generate a programmed sequence of smells (see Table 3.6), and lighting color will accompany release of smell on each Scented Pebbles.

Behavior Trigger: Pressure sensor can be setup on the seat or on the floor near the seating area. It will sense the presence of people when they sit down or step onto the sensor on the floor. The welcome ambience will be played for 5 mins after they sense the presence of people.

Ordering Drink

When the barista brings customer’s drink onto the table and place it on the coaster, it plays a special sequence of smell and lighting designed for the drink. (see Table 3.7)

Behavior Trigger: The coaster is specially designed so that the pressure sensor embedded in the coaster senses when a cup is putting on it. It will last for 5 mins after the cup is placed onto the coaster.

Exploring Experience
3.5. Integration of Scented Pebbles in Commercial Space

People can explore different smells in the Scented Pebbles by tilting them directly. They will explore different combination of smell as well as the predefined themes. Following is a list of smell selection and pre-defined themes designed for Artistry. For Artistry, The Cool Breeze theme and Sunday Afternoon is designed to created (See Table 3.8). A simple visual guide is given to the user so that they can understand which smell is being released and which theme is pre-defined.

Behavior Trigger:

Under Rest Mode (i.e. when Scented Pebbles is timed out from Welcoming Experience or Ordering Experience), when user tilts Scented Pebbles, it triggers Exploring Experience.
3.5. Integration of Scented Pebbles in Commercial Space

Programming of Smell and Lighting for Artistry

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welcoming</td>
<td>A</td>
<td>No Smell</td>
<td>Bright Yellow Fading in-out every 15 secs (0-5mins) for all Pebbles</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Sunshine (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Ocean (0-5mins)</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.6: Output of Lighting and Smell for Ordering Experience in Artistry

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering</td>
<td>A</td>
<td>Fruity (0-5mins)</td>
<td>Associative color of Fruity Smell fading in-out every 15 secs for 5 mins</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Sunshine (0-5mins)</td>
<td>Associative color of Sunshine Smell fading in-out every 15 secs (for 1 mins)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Ocean (0-5mins)</td>
<td>Associative color of Ocean fading in-out every 15 secs (for 1 mins)</td>
</tr>
</tbody>
</table>

Table 3.7: Output of Lighting and Smell for Ordering Experience in Artistry
3.5. Integration of Scented Pebbles in Commercial Space

**Artistry: Exploring Experience**

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Defined Theme: Cool Breeze</td>
<td>A</td>
<td>Coconut (0-5mins)</td>
<td>All Green Fading in-out every 15 sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Salty Air (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Ocean (0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Pre-Defined Theme: Sunday Afternoon</td>
<td>A</td>
<td>Fruity (0-5mins)</td>
<td>All Violet Fading in-out every 15sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Sunshine (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Chamomile (0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Free Exploration</td>
<td>A, B, C</td>
<td>Any Combinations other than the pre-defined theme, i.e.: Fruity, Sunshine, Salty Air</td>
<td>Each Pebbles showing the associative color of smells. Fading in out every 15 sec (0-5mins)</td>
</tr>
</tbody>
</table>

Table 3.8: Output of Lighting and Smell for Exploration Experience in *Artistry*

![Figure 3.25: Transiting and Sensing of Welcoming, Ordering and Exploring Experience in Artistry](image-url)
Chapter 4

Evaluation

The aim of the evaluation is to assess in real business context how Scented Pebbles could enhance value for customers. Scented Pebbles is expected to create moments of encounters that generate experiential value for customers. Through sensing their behaviours, it can create desirable ambience of lighting and smell that matches their intentions. For example, when user leans back on the sofa, it generates a pre-programmed sequence of lighting and smell, letting them relax with the ambience. When it detects two people are having a drink, it creates light-hearted social game through smell interactions. In this evaluation, it is aimed to reveal from an experiential point of view if the expected values have been experienced by the customers.

I have brought Scented Pebbles into the real business context with a specific design goal in mind. For example, in co-working space, Scented Pebbles can help the members to socialize and encourage playful engagement with their co-workers. In the Artistry Cafe, it enables users to freely explore different combinations of smell (and feel stimulated and playful at the same time). Customers enjoyed the changing ambience according their behaviors. The interactive experience supports with their intentions, such as creating social interactions, relaxing, personalizing their ambience.
4.1 The Method

4.1.1 Developing Experience Criteria for Evaluation

A set of criterias is used to evaluate the experience of customers in commercial space. Gentile has proposed components of customers’ experience in co-creational view as Sensorial Emotional Cognitive Pragmatic Lifestyle Relations. I have used Gentile’s scale as a guide.

In addition, I have also developed criteria that is related to the space. It is important to examine whether the experience created by Scented Pebbles could better enhance the value of the customers, especially those related to the business goal of the business supplier. Through the interview with business suppliers, it is extracted the key criteria for their business. For example, in the cafe space, they’d like to create a welcoming feeling for the customers and let me feel relaxed and have a sense of personal space. While in the co-working space, it encourage the members to socialize and create playful engagement with visitors and their co-workers. It is expected that through the co-design and customer journey mapping analysis, Scented Pebbles provides experiential value that matches with the space, and create enhancement in those areas. Therefore, Social, Personalization, Playfulness, Relaxing are part of the crieteria for evaluation.
4.1. The Method

Severn-point likert scale is applied to these criteria to provide an overall account of how does user evaluate the experience.

4.1.2 Interview and Contextual Inquiry

In addition to the questionnaires, open-ended questions and semi-structured interviews are used to gain further insight from the user about their experience. For example, what is their detailed account of the interactive experience. And according to their ratings, ask why they have given higher score to part of the experience, as that maybe where the highest value is.

Some of the sample questions asked was: "Why have you ranked higher score for social interactions or personalization of ambiance, is that the most enjoyable part of the Scented Pebbles experience?" "You have ranked high score for Playfulness, why do you think it’s important for the space and have you experienced it with Scented Pebbles?" "How well do you think Scented Pebbles work with the space? Why?" "How do you describe the sensorial experience?"

4.1.3 Subjects’ Contextual Background

From co-creating experience point of view, value is determined from customers’ perspective. According to Payne and other, it is The customers themselves use the artifacts, technologies provided by the business supplier to create value that is relevant to their lifestyle and wellbeing. Therefore, not only is the questionaires and interviewed designed to probe into users’ subjective experience, but prior interviewers are designed to understand what kind of experience are customers seeking by visiting the commercial space. For example, if members are looking for a space to work, why choosing co-working space instead of standard office space? Potential answers maybe that they needs the social interaction from like-minded people. Frequent visitors are invited for the user study, their
understanding of the space is gathered in quick interview. After that it is analyzed what kind of experience do they achieve by interacting with *Scented Pebbles*. *Scented Pebbles* experience helps them to create a better experience of the space by supporting their goals.

## 4.2 Process

First of all, users are given a quick interview about the goal of coming to the space, and asked to evaluate the experience of the space. It is used to understand user’s original background and their own context, and see if *Scented Pebbles* has helped them to enhance their experience of the space.

Secondly, the users will be briefed about how they could interact with *Scented Pebbles*. As it is not possible to create an organic flow of the entire user experience, I will give them the instructions before each mode of interactions, for example: relaxing experience is triggered when they lie down on the sofa, social experience detects the synchronization of coffee cups on the coaster and how they can trigger different combination of smell for exploring experience. Users are also given some time to freely explore the interaction with the *Scented Pebbles* after initial guide.

After experiencing *Scented Pebbles*, users are invited to answer the questionnaires, at the same time, I will ask some structured questions and well as follow up with open-ended questions after the interactions.

## 4.3 Evaluation in *Hangars* Space

### 4.3.1 User Profile for *Hangars* Space

To be able to assess how *Scented Pebbles* may add value to the experience for the users in the space. Tests are conducted with the members in the space,
or visitors who come here for workshop/meetings. Members from the space, employees in the other labs are invited to the space. 3x2 pair of users are tested in the bench area for the social games. 3x1 single users are tested in the sofa area for relaxation and personalization.

![Figure 4.1: Environment Setup in Hangars](image)

### 4.3.2 Environment Setup

For social interactions, *Scented Pebbles* are placed on the hot desk where visitors and members can share the space. It is close to the water room, so it’s a convenient location where they may grab a cup of coffee together after a session or during lunch break.

For relaxation, *Scented Pebbles* are placed the coffee table in the sofa area.

*Materials*
4.3. Evaluation in Hangars Space

1. Coaster embedded with sensor x 2
2. Server
3. *Scented Pebbles* x Three Modules
4. Sensor pads embedded under the sofa
5. Coffee mugs x 2
6. Smells:
   - Citrus (essential oil from @ Aroma),
   - Hinoki (essential oil from @ Aroma),
   - Passion Fruit (teabag from Twinings, dissolved in water),
   - Green Tea (loose tea leaves, dissolved in water)
   - Forrest (Fragrance from Demeters),
   - Jasmine (essential oil from Bodyshop)

For arrangements of smells in each Scented Pebbles, see Fig.3.1

7. Questionnaires (See Appendix A)

### 4.3.3 Documentation of Experience

Three kinds of experience are tested for participants as designed for Hangars space: Relaxation Experience, Social Experience and Exploration Experience. The smell and lighting sequence is summarized in Table 4.1 Table 4.2 and Table 4.3.
4.3. Evaluation in Hangars Space

### Hangars: Relaxing Experience

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxing</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>Orange Color Fading in-out every 15 secs (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Green Tea Smell (0-5mins)</td>
<td>Cyan Color Fading in-out every 15 secs (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Forrest Smell (0-2mins)</td>
<td>Green Color Fading in-out every 15 sec (0-2 mins)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jasmin Smell (0-2mins)</td>
<td>Yellow Color Fading in-out every 15 sec (3-5 mins)</td>
</tr>
</tbody>
</table>

**Table 4.1:** Output of Lighting and Smell for Relaxing Experience in Hangars

### Hangars: Social Experience

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Players in Synch</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>Transiting from color Orange to color White (15 s), Then transiting from White to Orange (15 s) Looping</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Green Tea Smell (0-5mins)</td>
<td>Same as Above</td>
</tr>
<tr>
<td>Player 1</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>Fade in and out of color Orange</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>No Smell</td>
<td>Same as Above</td>
</tr>
<tr>
<td>Player 2</td>
<td>A</td>
<td>Green Tea (0-5mins)</td>
<td>Fade in and out of color White</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Forrest Smell (0-2mins)</td>
<td>Same as Above</td>
</tr>
</tbody>
</table>

**Table 4.2:** Output of Lighting and Smell for Social Experience in Hangars
### 4.3. Evaluation in Hangars Space

#### Table 4.3: Output of Lighting and Smell for Exploration Experience in Hangars

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Defined Theme: Tea Time</td>
<td>A</td>
<td>Hinoki (0-5mins)</td>
<td>All Green Fading in-out every 15 sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Green Tea(0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Jasmin(0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Pre-Defined Theme: Summer Forrest</td>
<td>A</td>
<td>Citrus Smell (0-5mins)</td>
<td>All Violet Fading in-out every 15 sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Passionfruit (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Forrest (0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Free Exploration</td>
<td>A,B,C</td>
<td>Any Combinations other than the pre-defined theme, i.e: Hinoki, Passionfruit, Jasmin</td>
<td>Each Pebbles showing the associative color of smells. Fading in out every 15 sec (0-5mins)</td>
</tr>
</tbody>
</table>

User 1: Frequent Visitor

*Enjoys aesthetics of smell changes and synchronization with light*

**Contextual Background**

User 1 is a frequent visitor of the space. With her office upstairs, she often use the sofa space for casual meeting with her colleagues or visitors. For her job role, she also organizes events for researchers and this is one of her selected venue for organizing events.

**About the Experience**

User 1 have experienced the relaxation experience fully for 5 mins (See Table 4.1 for details). She tried to create her own combination of smells by tilting the *Scented Pebbles* directly. She explored all the individual smells:
Citrus, Hinoki, Passion Fruit, Green Tea, Forrest, Jasmin in each Pebbles for 10 mins and try to mix and blend with different kinds of smells.

The user is attracted to how lighting changes according to the smell and the way she could personalize the ambience based on her own preference. She is appealed to how lighting changes according to smell, and this gives her the overall impression that "it’s a unique experience".

**Questionnaire and Results**

Among all experiential aspects, the user ranked Aesthetics as very important, even though it is not listed as one of the criteria.

From the results, it shows that Relaxation and Innovativeness are what stands out for her in the *Scented Pebbles* experience. It appeals to her that lighting and smells creates synchronized pattern. She gives top score for the idea of "The lighting and smell changes according to my behavior appeals to me", much more than it could create social engagement. The user prefers personal usage of the interaction with smell and lighting, and feels it’s very "innovative", and would like to personalize the ambience, it makes her feel relaxed and enjoyable. She makes suggestion to create prototypes that use better material such as ceramics to reflect her demand of aesthetics taste. The unique use of smell and lighting in interaction also impressed her. During the experiment, it is expected that the user will give higher score for playfulness, however due to the low amount of smell used on the day, she couldn’t detect different smells clearly, so playfulness is not apparent for her experience.

**Contextual Inquiry**

In the follow-up interview, it was asked if she has personal interests with diffuses, as she was commenting a lot on the intensity and choice of smells. She mentioned that she keeps a diffuser in her office, and change the smell to refresh her mood. So personalization of the ambiances is appealing to her.
4.3. Evaluation in Hangars Space

It was asked why she considers Aesthetic as very important. She explained in her job role, she wants to choose event space that can immediately attracts the attendees and leaves a strong impression. So that’s why Aesthetics, Creative and Inspiring is one of the top qualities she is looking for in a space like Hangars. She mentioned that with projects like Scented Pebbles, there is an opportunity to enhance the aesthetics of the space through lighting and the look of the decorative items.

User 2 and User 3: Member and Visitor

*Enabling social interactions*

**Contextual Background**

User 2 is member of Hangars space and User 3 is visitor from upstairs. They used to work as colleagues and are both invited to join the user study.

**About the Experience**

The users have tried out the social interactions with the coffee coasters. They are shown that triggering the coasters at the same time or individually could release different patterns of lighting and smell. The two users are invited to create a shared ambience that both of them would appreciate.

They actively engage in conversations with each other discussing about different smells being triggered. The fact that it takes two person to create the interactions give people a chance to relate to each other, especially their subjective experience of smell, what do they think each smells are.

**Contextual Inquiry**

It was asked if they have enjoyed their experience if they can see project like Scented Pebbles as part of their co-working environment. They have commented that as the work style is pretty intensive in the members only space, having something like Scented Pebbles and having a gaming experience will
4.3. Evaluation in Hangars Space

encourage members to step out from their space and interact with others, whether it’s co-workers or other event attendees during the break. And that creating an ambience together helps them to know a little bit more about each other, so it’s something that they liked about the interactions.

User 4: Junior Manager

*Creating personal space and feeling playful*

Contextual Background

User 4 is a young intern who just joined the management team for Hangars. She aims to meet with like-minded people and work in an environment that will facilitate creative thinking. She also likes to use fragrance and familiar with blending with essential oils.

About the Experience

User 4 tried out the relaxation experience and exploration experience. She has also tried out the social experience with assistance of the researcher.

Among all experience, User 4 is drawn to the personalization of ambience. She spent around 15 minutes with mixing the smell and trying to figure out what kind of aroma is used. She commented that the smells would ultimately blend nicely together, otherwise it feels like a clash. "The smell when light turns Cyan feels like a spa salon and extremely soothing. The smell when the light turns Orange blends well with the smells when light turns Cyan on the other pebbles, which emits citrus smell. However if she has tilted the Pebbles on the other side to trigger the Jasmin smell, the overall blend feel out of balance." It is also observed that she enjoyed the playful process of blending smells together as she spends quite some time with it.

She was intrigued by the idea of socialization, and thinks it has potential. She has rated 6 out of 7 for being social, and 7 out of 7 for being playful.
The current implementation with coffee coaster is not as satisfying. She has mentioned that the interaction with the coaster may distract her from the main interaction with smell. We have asked an open question of what kind of interaction does her foresee in creating natural social interactions, she suggested the behavioral interactions, when people are sitting closer to each other or may create the change in smell.

**Questionnaire and Result**

It can be seen from the data that playfulness, personalization, social interaction is ranked as the highest score for this users' experience. In items f/ "I like the fact that I can personalize the ambiance and choose smells according to my preference" Her score is 6 out of 7.

**Contextual Inquiry**

It was asked why she has ranked personalization as having the very score. She mentioned that co-working space is all about sharing the space, but sometimes having personal space is also important. So the idea of creating personalized ambience with *Scented Pebbles* appeals to her.

**User 5 and 6: Managers**

*Create social interactions and feeling relaxed*

**Contextual Background**

User 5 and User 6 are part of management team and invited to try out the *Scented Pebbles* in pairs. They have both mentioned that they preferred the work space not to be scented or sensorial, just adequate lighting and proper smell is good for them.

**About the Experience**
4.3. Evaluation in Hangars Space

As they have experienced the social game, it does appeal to them that this could encourage people to have experience together that is not strongly related to work, that they could create encounters through sensorial interactions. Even though they don’t think there is a lot of potential in having different smells in the space, they do feel relaxed in the lounge sofa with the smell gives relaxation high score after the experience.

User 7 and 8: Visitors from Office Upstairs

Appealed to social interactions

Contextual Backgrounds

They are co-workers in the same office located above the Hangars space. They have attended some events in the Hangers but seldom comes to Hangars.

About the Experience

Users are attracted by the potential of Scented Pebbles to create social interactions. During the interaction, they also exchanged Scented Pebbles with each other and see if they agree about how they feel about the smells. They also provided some suggestions how they wish the smell and lighting could be triggered by synchronization of different actions other than putting the cups onto the coasters. They are intrigued by how smell interactions can open up people’s mind and share conversations together.

Contextual Inquiry

Both users are not familiar with the space although their office located closeby. It is the first time visit for both of them. They likes the space for its openness and social opportunities provided for visitors. Upon experiencing Scented Pebbles, they feel like more playful and more social interactions are encouraged.
4.4 Evaluation in Artistry Cafe

4.4.1 User Profile for Artistry Cafe

Artistry is coffee shop co-run with the design agency. Designers from Chemistry as chosen as target users. As the user study subjects are experienced users, meaning they designed smart applications have provided design critique as profession, so they are invited to provide projective suggestions to imagine the scenarios and provide evaluations accordingly. Two users have provided standard questionnaires and answers, and some of them are invited for further discussions when time is allowed. In addition, the manager and barista of the space is invited to provide their viewpoint on the concept.

4.4.2 Environment Setup

_Scented Pebbles_ are setup on the communal table at Artistry Cafe. Server is placed on the chair and Wizard of Oz method is used for generating welcoming ambience, i.e. designer control the generation of ambience when user comes near to the seat.

**Materials**

1. Coasters embedded with sensor
2. Server
3. _Scented Pebbles_ x Three Modules
4. Sensor pads embedded under the sofa
5. Coffee mugs
6. Smells:
   - Sunshine (Fragrance from Demeter),...
4.4. Evaluation in Artistry Cafe

Salty Air (Fragrance from Demeter),

Chamomile (Teabag from Twinings, dissolved in water),

Fruity (Teabag from Twinings, dissolved in water),

Coconut (Fresh coconut juice),

Ocean (Fragrance from Demeter)

For arrangement of smells in Scented Pebbles (see Fig.3.5)

7. Questionnaires (See Appendix B)

Figure 4.2: Setup of Scented Pebbles in Artistry Space

4.4.3 Documentation of Experience

Three kind of experience is tested for participants, Welcoming Experience, Ordering Experience and Exploration Experience. The smell and lighting sequence is summarized in Table. 4.4 Table. 4.5 and Table. 4.6.
4.4. Evaluation in Artistry Cafe

Programming of Smell and Lighting for Artistry

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welcoming</td>
<td>A</td>
<td>No Smell</td>
<td>Bright Yellow Fading in-out every 15 secs (0-5mins) for all Pebbles</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Sunshine (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Ocean (0-5mins)</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.4: Output of Lighting and Smell for Ordering Experience in Artistry

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering</td>
<td>A</td>
<td>Fruity (0-5mins)</td>
<td>Associative color of Fruity Smell fading in-out every 15 secs for 5 mins</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Sunshine (0-5mins)</td>
<td>Associative color of Sunshine Smell fading in-out every 15 secs (for 1 mins)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Ocean (0-5mins)</td>
<td>Associative color of Ocean fading in-out every 15 secs (for 1 mins)</td>
</tr>
</tbody>
</table>

Table 4.5: Output of Lighting and Smell for Ordering Experience in Artistry
### 4.4. Evaluation in Artistry Cafe

**Artistry: Exploring Experience**

<table>
<thead>
<tr>
<th>State</th>
<th>Pebble</th>
<th>Activated Smells (Activation Time)</th>
<th>Lighting Color and Pattern (Activation Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Defined Theme: Cool Breeze</td>
<td>A</td>
<td>Coconut (0-5mins)</td>
<td>All Green Fading in-out every 15 sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Salty Air (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Ocean (0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Pre-Defined Theme: Sunday Afternoon</td>
<td>A</td>
<td>Fruity (0-5mins)</td>
<td>All Violet Fading in-out every 15sec (0-5mins)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Sunshine (0-5mins)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Chamomile (0-5mins)</td>
<td></td>
</tr>
<tr>
<td>Free Exploration</td>
<td>A,B,C</td>
<td>Any Combinations other than the pre-defined theme, i.e: Fruity, Sunshine, Salty Air</td>
<td>Each Pebbles showing the associative color of smells. Fading in out every 15 sec (0-5mins)</td>
</tr>
</tbody>
</table>

Table 4.6: Output of Lighting and Smell for Exploration Experience in *Artistry*

**User 1: Frequent Visitor**

*Enjoys the exploring experience and peripheral interactions*

The user likes the look and feel of the smart device, and she thinks that it gives a very different feeling to other smart device she encounter with, it provides a different language for interaction, and feels more personal and is attractive to interact with. She would also like to see the interaction where people can just freely explore and use daily objects to interact with the system. (for example, simple pressure sensing of any weights on the table may trigger different effects).

She commented on the way *Scented Pebbles* makes her feel, that the way lighting fade and fade out makes her feel that the object is alive.

"The fading in and fading out of lights are really relaxing, and it’s with the smell, and effect of diffuser to create fume. The way light is fading in
and out, and the evaporated fumes gives me the impression that this object is "alive".

"For now the look and feel encourages people to interact, touch, hold in the hands to see how it’s different. It does not always engage my attention, I can have conversation while interacting with it, and may trigger some interesting interactions while talking to a friend."

She thinks that the way it’s currently designed with coaster may make it more mechanical, due to the material used, it does not have the finished look, so she may not naturally like to interact with it.

"What attracts me is that it’s not a gadget but more organically designed, it’s really different to our day to day phone interaction, computer interactions, it definitely break away the normal interaction routines and gives a pleasant feeling of the environment."

"It definitely makes feel relaxed, and the sensing part may work when people put objects on the table. So it’s another layer of serendipitous interaction, instead of a particular game, it can be just something that people can explore in their hand and with other object at will."

The idea of placing the Scented Pebbles at night time attracts her, and she mentioned putting the Scented Pebbles at the bar counter, and people will pay more attention to the lighting and smell effects at night, and bar counter provides the opportunity to interact with it.

"There is a possibility where this can enhance the existing mood, or add a little more sensorial impression to the creation of special cocktails and dish as an art form."

**User 2: Baristar**

*Likes addition of smells for welcoming the guests*
4.4. Evaluation in Artistry Cafe

About the Experience

The baristar is showed welcoming experience of Scented Pebbles, how the lighting changes with smell. And that the smell can be pre-programmed to suit the shop’s characteristics. They are also shown how customers can interact with the coasters to trigger different smells as part of the ordering experience. Finally they are invited to try out the exploration of different smell by tilting the Scented Pebbles.

Contextual Inquiry

There are few baristars serving customers at the same time. They are people oriented and frequently chat with the customers in addition to getting their orders. When knowing that customers are coming for casual meetings, they often introduce themselves and like to get to know them in person.

She mentioned that the shop is considering adding lighting and smell at night to attract customers. It will be nice if the system could be triggered when customers comes into the store.

"Are you thinking of adding lighting and smell in the space?""Yes definitely, we’d like to add lighting and putting incense on the outside of Artistry to attract people at night, as people might think we are closed, and we need something to liven up the atmosphere, for example when people passes by."

Baristar is not familiar with interaction but is intrigued by the playfulness of the interactions." I can tilt this to select smell? " - smiled and definitely enlightened. When suggested we are able programming the lighting animations and how the smells can accompany that, — "like how lighting is dancing to the music?" She responded.

"How about people are able to personalize their experience?""I’m little concerned about the durability, and what may happen if children comes and
break this apart. You have to make sure people don’t break it. Other than that, it will be nice to be able to customize according to different event and situations in the shop, as we have different pop-up events going on, and a menu to select from”

**User 3: Frequent Visitor**

**Enjoys creating personal ambiance**

**About the Experience**

The user spent quite some time with the exploring experience, with the purpose to create her own personal ambience. She also tried interacting with the coaster but mentioned that she prefers more natural interactions rather than through coffee coasters.

**Contextual Inquiry**

This user is a frequent user to Artistry and thinks it’s a good place to connect with other creatives, and appreciate the food and music in the shop. She likes the smell, the color of the light and how the lighting is changing with the smell and synchronized. She is slightly not used to interacting with the coaster and the coaster trigger is not responsive every time, so it seems a bit mechanical.

As her office is upstairs, she prefers to use it in her office, where she can set her own ambience by selecting the smell, she would also like to use it for her personal yoga time. And other people in the same Yoga studio may also use a different personal ambience setter to provide their own private ambience. She quickly suggest that it might be something that Yoga studio is providing for the customers. She suggested different interaction method such as the subtle interaction such as sensing the mood or placing a timer throughout the day so the smell could change.
4.4. Evaluation in Artistry Cafe

To her *Scented Pebbles* creates sensorial and relaxing moments, and the fact that she can personalize and change the ambience appeals to her, but it may not match with her experience in the cafe, which can be reflected in the following graph. And she said it would be more suitable to create personalized ambience in her office, or as a portable device she can carry to use at Yoga class. In a space like Artistry, as there are music playing and people chatting loudly, so it may distract her from interaction and she would like have it in a more personal and quiet space.

**User 4: Frequent Visitor**

*Enjoys the playfulness of interactions*

**About the Experience**

The user spends time exploring Scented Pebbles interactions. Rather than seeing the prototype as what it is, the expert user (designer) looks at the potential of using interactive ambience in commercial space and provided valuable insights. He mentioned the idea of "white space", where people are filling in time with their smart device or looking for something to intrigue them in the space. *Scented Pebbles*maybe able to fill the white space when people are waiting their order, or waiting for their friends to come, and interact with the *Scented Pebbles* to create moments of curiosity. It doesn’t have to serve any particular purpose but to allow them to freely explore. At the same time, it may also be used to alert them of special moments, when order is ready to divert their attention back to their original task.

**Contextual Inquiry**

The user thinks there is a lot of potential to make it more playful, not only through the coaster game, but also making it like instruments, or making the Pebbles modular combinations, and make it more easier for users to understand
how to combine the smells to create special effects. It may well be a very playful smell device for users to play with to fill the white space.

As an extension, the designer discussed with the user about possible application in long haul transportation, where this kind of device could be used, for example in airport lounges or on air, and special program can be set, for example if they need 20 minutes of relaxation before boarding, or waking up program before landing. The combination of relaxation and personalization provided opportunities for future applications.

He is positive about integrating *Scented Pebbles* in a space like Artistry and provided other ideas where the project can grow into.

### 4.5 Results and Analysis

Based on documentation of customers’ experience in each scenarios, this analysis gives an account of how if *Scented Pebbles* helps to enhance co-created value in each case.

#### 4.5.1 Hangars Co-Working Space

I have concluded some evidence for supporting social behavior, personalization of space and relaxations in the co-working space. First of all, enhancing social value stands out from the other experience, as the social interactions of smells brings people together in sharing their experience. The fact that smell has implicit information related to their personal experience plays a big part in the impact of the interaction. As it doesn’t convey explicit information such as visual and sound, it triggers the conversation and behaviors of sharing their own point of view for the users. Secondly, the personalization of ambience is also interesting for users especially those interested in creating fragrance and aroma as part of their personal space. It also leverages on users’ subjective
experience of smell, and allowing them to create their own customization of themes. However it could be further enhanced assisting them with the tools, for example, visual guide to find out more about the smell, and recording their own creations. Finally, it creates some relaxation effects for the user. The design intention is that users will appreciate that the space recognize their needs to relax and respond accordingly. However it is not clear from current evaluation whether user’s appreciation of the relaxing experience is due to the interaction with the smell or how it differentiate with just simply diffusing one single smell.

**Supporting Social Behavior**

Users experience social experience through interaction with coffee cups and coasters. They can use synchronized actions to trigger special patterns of lighting and smell, and encouraged to create a shared ambience/blend of smells together.

Users are intrigued about how different smells brought them together in joining conversations and give them a chance for social interactions. While creating an ambience together, they discuss preference of smell, what they think each of them think about the smells, they exchange the *Scented Pebbles* with each other, confirm the choices and try to make an ambience that both liked. Many appreciates the social interactions in the co-working space, as revealed by the interviews and rating of social dimension of the experience.

It is also revealed in the interview that interaction triggers such as coaster and cups may seems bit mechanical for use so users may not be able to enjoy the flow of interactions, it needs clear instructions for this to work. Some have mentioned that they would envision the special patterns of smell to be triggered by behaviors of users for example, when they move closer to each other, or when they hold the *Scented Pebbles* in the same way, that may not distract them away from the focus - *Scented Pebbles* and smells.
4.5. Results and Analysis

Supporting Personalization of Ambience and Feeling Playful

It is encountered that the personalization of ambience is appreciated by users who are familiar with smell and who uses diffusers and fragrance frequently. They would like to create personalized space using the ambience, User 1 mentioned she would like to create different mood using different smells different time of the day or different time in the week to refresh her working space, User 4 mentioned that she would like to create personal space in the share area. Both thinks that the interaction are playful and they are appealed by the synchronization of lighting and smell.

Supporting Relaxation

The managers of the space did not think that the sensory stimulation would be helpful to the work space, however they have enjoyed the experience and think it’s very relaxing. It would have some potential for the members working inside the dedicated space, as they usually have very intense work hours in front of their personal desk, this is where they can come and relax. Many other have commented that interacting with smell and lighting in general creates a relaxing feelings, as can be seen from the rating of the relaxing dimensions of the experience. However it is not clear whether the relaxation is due to the interaction or due to the smells alone.

4.5.2 Artistry Cafe

In the Artistry cafe, the exploring experience stands out as creating potential value for users in the space. The experience of discovering different kinds of smells with accompany of light is appreciated by many users and they think this could fit well with the Artistry cafe, as it encourages people to explore and find new inspirations from objects and artworks around them. On the sensorial level, users can not actually differentiate the subtle changes of smells
from a distance so the welcoming ambience does not create a strong impact. For the ordering experience, it appeals to the user as a concept and may work well in a space that is less crowded and focus on creating signature drinks. In Artistry cafe, where the coffee smell is dominated and sometimes crowded, it is difficult for users to appreciate the sensorial experience as part of their order.

**Supporting Exploring Behaviors**

It is found that the test subjects likes the explorative interaction with *Scented Pebbles*. While they have the meal, they continue playing with *Scented Pebbles*. Some suggested using *Scented Pebbles* during waiting time. User 1 has commented that the design of lighting and smell is very inviting for her to touch and hold the *Scented Pebbles* in her hand and therefore it encourages peripheral interactions when she is having conversations of when she is having the meal, it helps her to feel relaxed and refreshed. During the interview, she has mentioned that "The fading in and fading out of lights are really relaxing, and it’s with the smell, and effect of diffuser to create fume. The way light is fading in and out, and the evaporated fumes gives me the impression that this object is "alive". " For now the look and feel encourages people to interact, touch, hold in the hands to see how it’s different. It does not always engage my attention, I can have conversation while interacting with it, and may trigger some interesting interactions while talking to a friend."

At the same time, User 4 commented that he would like to explore Scented Pebbles as "it can fill in the white space while people are waiting for their friends or waiting for their orders".

**Potential as Part of the Service**

It is difficult to for users to experience the ordering experience. In this experiment, Wizards of Oz method is used where I showed users how the *Scented*
4.6 Conclusion

Pebbles could create different themes when putting it on different coasters. To be able to test this interactions fully, it has to be integrated into the real service. For example, visualization of different themes of lighting and smell can be introduced on the menu, and a control interface can be implemented for Barista to trigger release of smell and lighting sequence once the order is ready. During the evaluation, little feedback is gained about the ordering service, however it is encouraged from manager of the space to try this out and it should be attempted in future development (see Chapter 5 Conclusions on Future Directions) Some of the users also suggest incorporating the smell experience for special events such as mixologist, where people expect to be intrigued by sensory simulations. A more suitable place maybe a darker and more exclusive dining environment where an intimate and sensorial experience could be staged.

4.6 Conclusion

In this chapter, I have demonstrated some experiential evidence that Scented Pebbles has the potential to enable co-creation value through interactive ambience. There are some experiential evidence favoring the social interactions in co-working space, and exploring behaviors in artistry cafe. It is also appreciated to create personalized ambience based on combinations of smell as an overall value-add in the public commercial space. It can be seen that Scented Pebbles creates experiential benefits to the user due to interaction with smell. There are parts that requires further investigation, for example, whether programmed sequence of smell generates a more engaging experience than simply diffusing the smell, and what are the unconscious effects through the interactions. It would require further tests to compare the interactive ambience and non-interactive ones, and to designer further tests to investigate the unconscious effects of the interactions. Further evaluations are required
4.6. Conclusion

to understand full potential of interactive ambience in co-creating value for customers in commercial space.
Chapter 5

Conclusion

5.1 Conclusion

Researchers in Human Computer Interactions are exploring new horizons of engaging human senses. As technology advancements have been proliferated in recent years, it enables wide range of digital technologies to integrate smell in interactive experiences. As reviewed in Chapter Two, researchers are looking forward to the future of Multisensory HCI. In CHI conference 2016, Marianna et al has called for meaningful application, context and scenarios for multisensory stimulation. In particular, smell has attracted much attention as well as posing challenges on how to create meaningful experiences.

My research attempts to address smell interactions and bring potential value of interactive design of smell in commercial settings. With a perspective on co-creating experience, it opens up opportunities of building interactive ambience of smell as part of service design. I have developed Scented Pebbles and integrated it into two commercial spaces. With initial experiments and evaluation, customers’ experiential value is shown as co-creation value. It is the beginning of building interactive ambience of smell as part of service design.

I believe that the integration of research into the real context of application is a powerful way to show the impact of design. By deploying the initial
5.1. Conclusion

concept in the real business case, I have learned that collaboration with business partners, analysis of customers’ experience helps to define and discover experiential value of interactive ambience in commercial setting. I’ve also customized the design based on the interview and analysis, in order to expand the co-creation value through interaction of lighting and smell.

First of all, the collaboration approach to involve business partner helps to get realistic account of how to use interactive ambience to improve the experience of customers. Each business has its own vision created through its existing experience design and services. Through discussion and interviews, it is possible to identify area that are crucial to the business, and what can be improved with smell and lighting. It is important to show early prototypes and demo business supplier, so that they understand the potential of lighting and smell interaction and be part of the value-creation.

Secondly, by studying the customer’s behaviors and their experience in the actual environment, the interactive ambience can be designed to effectively support their intentions. Customer Journey Mapping is used to create an experience flow of customers from their perspectives. Interactive ambience is ultimately designed to enhance their experience and support their activities. For example, it is important to support members’ relaxation time and social interactions in Hangars co-working space, while in Artistry, it is important support ordering experience and explorative behaviors.

Finally, the interaction design is customized for each commercial space. In my thesis, I have designed different types of experience based on the basic functions and infrastructure of Scented Pebbles. Namely, relaxing experience, social experience and exploring experience for Hangars co-working space; welcoming experience, ordering experience and exploring experience in Artistry cafe are designed. By expanding the value towards customers’ needs, it is able to create value-in-context and ultimately achieve loyalty of customers.
5.2 Future Directions

*Scented Pebbles* is only the beginning of integrating interactive ambience of smell and lighting into commercial space. There are many ways where the project could evolve in order to deliver better experience.

**Opening up Co-Creation Process to Other Partners**

It is encouraged from co-creation process to integrate other actors in value-creation system. Besides business supplier and customers, other partners such as fragrance designers, diffuser makers can be part of the value-creation process. Based on the basic system of layering smells with time sequence and design of interactions according to user behaviors, the value of interactive ambience can be further expanded. For example, the layering and timed sequence of smell could be designed to better associate with the space. It is observed that fragrance designers such as (NoseWhoKnows http://www.nosewhoknows.com/) are opening up their practice not only for branded perfumes, but scenting for public events, workshop and education program. Fragrance companies like IFF and Demeters are also creating raw materials of smell such as aroma of library, aroma of ocean rather than branded fragrance. Furthermore, aroma device companies such as @Aroma (https://www.air-aroma.com/diffusers) are looking into smart control of diffusers. In the future, there will be lot of potential to collaborate with fragrance specialists and companies as well as device company in creating better experience with interactive ambience.

**Application of Scented Pebbles in Other Commercial Spaces**

By bringing *Scented Pebbles* prototype system to each different context, various applications can be extended from basic prototype of *Scented Pebbles*. More opportunities can be explored by conducting further value proposing to potential collaborators and business suppliers.
5.2. Future Directions

I have met with team from Unilever retail lab at InnovFest 2016, where public demo is shown to conference attendees. They are attracted by the interaction triggered using user’s behaviors, i.e. release different scents when objects are lifted from the table where pressure sensors are place. The demo is initially designed for a cafe scenario, and we discussed the possibility of further developing Scented Pebbles as ambience generator in the retail environment. They are also interested in the compact size of the diffuser and how the sensing and scent diffusers can be integrated into the retail environment, i.e. shelving or larger display area.

The existing diffusing techniques deployed by Unilever involves release of scent with atomizer (spray type) with pressing of buttons, initiated by the customers. Directly spaying product smell may mis-represent the product, as the spray can be too strong and does not represent the smells encountered by customers when they are using the products in natural conditions. It also lacks level of natural interaction with the customers.

![Figure 5.1: Demo of Scented Pebbles with Unilever Products at Retail Lab](image)

It is proposed that Scented Pebbles can create interactive ambient zone, where customers may interact with mock products embedded with sensors. The smell can be achieved by layering the product smells with those customers
associated with in their daily life. For example, a theme of smell and lighting can be designed to represent moments in the day: i.e. fresh lemon laundry day experience. Customers may lift different mock products to trigger activation of different themes. With layering of smells to present themes, customers can connect the brand to their own experience by exploring the themes and discover new products through smells.

As part of the discussion, I was introduced to the Unilever Retail Lab where many technologies such as near field technologies, smart phones, and facial recognition is being tested to create better retail experience. It is possible to test out embedding sensor in the retail lab, and collaborating with their in-house fragrance department to achieve interactive ambience in future retail.

**Further Integration with Smart Devices**

Scented Pebbles is developed with the potential to be expanded with network of sensors embedded in the environment. It also adopted the Xbee wireless network that is compatible with iPhone or iPad connections. In this section, it is discussed the future possibilities and scenarios created with iPhone and iPad control and improvement on network.

**iPhone and iPad Control**

Although Scented Pebbles leverage on smell and lighting interactions, it will strengthen the complete experience if some visual information and smart control is enabled through smart devices. It is discovered that users would like to know about selection of smell and the sequence when they are experiencing the interactions. It will help to display selection of smells visually in order for them to have a clear understanding of the interactions. Further more, users can use the smart device to control sequence of smells, and record their creations like a play-list of smell sequences. On the other hand, it may also provide better control for the business supplier, to manage themes of lighting.
and smell, and monitor what kind of themes are created in their space, and further edit and improve the interactions as well as the themes of smell and lighting.

Many commercial space for example hotels, restaurants are increasingly incorporating smart device as part of their service. In this thesis, it is attempted to incorporate the interactive ambience as part of the ordering experience. As many restaurants have used digital ordering using iPad control, it would be much easier to create interaction with Scented Pebbles. For example, user can place an order of lighting and smell ambience as they are ordering special items for dinner. In hotel scenarios, they may also choose special themes of lighting and smell when they during waking-up time, and even pre-order the ambience and select the type of smells as apart of their room booking to personalize their space.

**Improvements on Sensors and Network**

Currently, a light server outside Scented Pebbles collects all the sensor data. With the availability of smaller microprocessors such as RFduino, it is possible to eliminate the need for external server. For example, both the sensor and RFduino can be integrated as modular sensor unit and send sensor data to Scented Pebbles directly. RFduino is also possible to differentiate between each other with different address, therefore, Scented Pebbles will be able to recognize which sensor data it is easily without implementing complicated algorithm for differentiating the sensor datas.

With improvement on network, Scented Pebbles can be embedded in environment easier and creates more possibilities to interact with the future of smart environments.
5.2. Future Directions

5.2.1 Final Conclusions

This thesis has shown potential value of interactive experience of lighting and smell with perspective on co-creating experience. It is hoped that co-creating experience will be developed to engage with customers’ senses through interactive technologies, creating the connectedness and engagement that is gradually missing in our everyday life. Instead of being replaced by technologies, it is hoped that through smell interactions, digital technologies can enhance our experience.

The co-creation approach is also inspiring in opening up collaboration with partners such as fragrance designers, diffuser makers, in addition to business suppliers and customers. Scented Pebbles can further evolve as a development tool for fragrance designer to enhance value of interaction. The role of interactive design of smell will emerge to design smell based on users’ behavior and activities. In terms of users, they may also contribute to the creation of interactive ambience, and associate meaning and their personal background with the space. The dynamic engagement of various partners will enhance value of interactive ambience.

I believe that interactive ambience with co-creating perspective is a growing area where new experience and scenarios can be developed. In this thesis, the value-in-context in supporting social interactions and exploring behaviors has started to emerge. With further integration in real application and a value-co-creation mindset to collaborate with other partners, the interactive ambient experience will take place to support our lifestyle.


Bibliography


Bibliography


Appendix A

Questionnaire for Hangars

**Part 1. About the Space**

*Before trying out the Scented Pebbles, please answer the following questions:*

1. Could you describe what you understand about the brand of this working space?

2. How important do you think following quality of experience in the working environment, on a scale of 1-7. 1 being least important, 7 being most important

<table>
<thead>
<tr>
<th></th>
<th>Least Important</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Most Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative</td>
<td></td>
<td></td>
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<td></td>
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What is not mentioned above but important to you as quality of the space?

3. Could you give some examples about other place that is similar to this? Other places to work than visiting *Hangars* for example.

4. How is this place different from other examples given above? How do you benefit by visiting *Hangars*
Part 2. Scented Pebbles Experience (Qualitative)

Please answer the following after interacting with Scented Pebbles

1. Could you comment on the smells you have experienced?

2. How about the blending experience?

3. How about when you are interacting with Scented Pebbles with another player?

4. How do you think Scented Pebbles integrate with the space?

Part 3. Further Analysis on Scented Pebbles Experience (Quantitative)

Please rate 1-7 of following statements: 1 being strongly disagree, 7 being strongly agree

<table>
<thead>
<tr>
<th>(Strongly Disagree)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 (Strongly Agree)</th>
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</table>

a. Sensorial Value

The smell appeals to me. □ □ □ □ □ □ □

The lighting appeals to me. □ □ □ □ □ □ □

The synchronization of lighting and smell appeals to me. □ □ □ □ □ □ □

b. Interaction Value

The lighting and smell changes according to my behavior appeals to me. □ □ □ □ □ □ □

It appeals to me that the interaction is very playful. □ □ □ □ □ □ □
c. Social Value

The interaction lighting and smell create social engagement appeals to me.

It appeals to me that it allows me to interact with another player.

d. Relational Value

The interaction makes me feel connected to the space.

e. Innovativeness Value

The interaction feels innovative and this is appealing to me.

The interaction makes me associate creativity with the place.

f. Unique Value

I like the fact that I can personalize the ambience and choose smells that I like.

g. Emotional Value

I feel ________________ while using Scented Pebbles
Can you rate your experience of using Scented Pebbles based on the following? (1 being most important, and 7 being least important)

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What is not mentioned above but important to you as quality of the experience with Scented Pebbles?
Appendix B

Questionnaire for Artistry

**Part 1. About the Space**

*Before trying out the Scented Pebbles, please answer the following questions:*

1. Could you describe what you understand about the brand of this cafe?

2. How important do you think following quality of experience in the cafe, on a scale of 1-7. 1 being least important, 7 being most important

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What is not mentioned above but important to you as quality of the space?

3. Could you give some examples about other place that is similar to this? Other places to visit for lunch or coffee break rather than visiting Artistry for example.

4. How is this place different from other examples given above? How do you benefit by visiting Artistry
Part 2. Scented Pebbles Experience (Qualitative)

Please answer the following after interacting with Scented Pebbles

1. Could you comment on the smells you have experienced?

2. How about the blending experience?

3. How about when you are interacting with Scented Pebbles with another player?

4. How do you think Scented Pebbles integrate with the space?

Part 3. Further Analysis on Scented Pebbles Experience (Quantitative)

Please rate 1-7 of following statements: 1 being strongly disagree, 7 being strongly agree

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c. Social Value
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d. Relational Value
The interaction makes me feel connected to the space.

e. Innovativeness Value
The interaction feels innovative and this is appealing to me.

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f. Unique Value
I like the fact that I can personalize the ambience and choose smells that I like.

g. Emotional Value
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