

# **Exploring the Potential Emotional Effects of Scent on Product Experience**

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Graduate School of  
Science and Engineering  
CHIBA UNIVERSITY

(千葉大学審査学位論文)

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## **Abstract**

The smell is thought to have design potentials, as it has unique relationships with human emotions and memories. Also, it is said that products eliciting more positive emotions have many benefits. Based on this, the thesis aims to explore the potential emotional effects of scent on product experience.

It started with an experimental study, using different scents (sweet orange, peppermint, and in the control group, no scent) as the starting point of the product experience of the orange-shaped lego-like toy blocks. Here, we did not find noticeable effects of scents on people's likings and evaluations of the product, but some significant effects of scents were found on people's moods and likings for the scents. Next, we explored the scents' emotional effects on product experience by analyzing 25 smell-related consumer products and experiences from the perspective of Don Norman's 3 Levels of Emotional Design, to find its effects under real-life conditions. By doing so, we found 3 patterns, based on which we discussed the possibilities of applying scents to product design. As revealed here, the olfactory display is a potential medium to utilize the effects of scent. However, it is still not prevalent compared with its audiovisual counterparts. Therefore, we further examined the roles of scent in product experience from a habit-forming perspective, by comparing four different representative olfactory display devices. It also revealed the limitations unique to smell that we may encounter when applying scent. Then, we also discussed the challenges and opportunities in fulfilling the potential effects of scent in the post-Covid-19 world, as the design paradigm has begun to shift.

In conclusion, the thesis has shown that the scent has many potential effects, including making people feel good, improving the first or overall impression of the product or experience and making it more memorable, and even conveying information. When applied appropriately, it should make the product experience elicit more positive emotions and increase its emotional values, so it is necessary to avoid some phenomena that may be negative, such as olfactory adaption due to the scent lingering, and the unintentional scent mixture. Also, the issue of sensory dominance should be overcome so that user experience enhanced by the scent can be fairly attributed to the scent of smell. In today's world that has been more stressful especially due to the outbreak of COVID-19, the potential effects of scents should be valued and fulfilled more.

**Keywords:** Scent; Product Experience; Product Design; Emotional Design

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# Chapter 1

## Introduction

We used to say that we can shut the eyes, close the mouth, put our hands over the ears, but we cannot block off the nose since we have to breathe. It seemed that our noses keep exchanging airs with the outside world and detect the latent information from the olfactory stimuli for us. However, the outbreak of the COVID-19 pandemic has changed things tremendously, including the way we breathe in some cases due to the recommendation of mask-wearing in public spaces. The unprecedented situation has led to mixed feelings and emotions that many people may have never experienced before. Because of the restrictions on many activities which used to be normal, people have spent more time at home, where people can breathe at ease in most cases.

Although remaining as one of the least explored senses by design researchers, the smell is thought to have design potentials, as it has unique relationships with human emotions and memories. Considering the smell can prompt immediate and emotional responses [1], such characteristics of scents should have the potential of playing certain roles related to human emotions. If we know how to use scents to evoke more positive user emotions and apply it to product or experience design, the product experience may provide more positive emotions to the users, which can produce many benefits. As shown by many evidences, people who experience positive emotions regularly would function better and obtain better life outcomes [2]. In addition, users are more likely to form attachments to products with emotional values, which may extend such products' lifecycles and reduce the environmental impact. Besides, the awareness of the scents' emotional effects may make people pay more attention to their emotional wellbeing against negative feelings, contributing to a less stressful society. In today's world that has been even more stressful due to the outbreak of Covid-19, it is increasingly worthwhile to explore the potential emotional effects of scent on product experience. Hence, the main aim of the present research is to explore the potential effects of scent on product experience.

To start the thesis, we will introduce the general background and the overview of the thesis in Chapter 1.

## 1. General Background

### 1.1 Smell, as a sensory modality

How do we smell? Generally, olfaction, or, the sense of smell is a form of chemoreception. Specialized receptor cells called olfactory receptors could detect chemicals in the environment when the vaporized odor molecules floating in the air reach the nostrils and dissolve in the mucus. The mucus is on the roof of each nostril, and underneath it, in the olfactory epithelium, there are millions of olfactory receptor neurons, which then send messages directly to a particular microregion of the olfactory bulb of the brain. The microregion, or glomerulus, that receives the information then passes it on to other parts of the brain. The “odorant patterns” produced by the activity in different glomeruli is then interpreted as smell by our brain. The general process of smelling goes as above, but besides this short paragraph, the whole pathways of olfaction are complex, from peripheral nasal airflow leading to odorant detection, to epithelial recognition of these odorants and related signal transduction, and finally to central processing [3], which are not the focus of the study and wont be discussed later.

The 2004 Nobel Prize in Physiology or Medicine was awarded to Buck and Axel “for their discoveries of odorant receptors and the organization of the olfactory system.” Their works have clarified how our olfactory system works and the basic principles for recognizing and remembering about 10,000 different odors [4]. The basis for our ability to recognize and form memories of so many different odors is formed by the large family of odorant receptors, which work in a one-to-many or many-to-one manner to encode individual odors [5]. However, in more recent works, Bushdid et al. have reported that humans can discriminate over 1 trillion olfactory stimuli, which makes it outperform the other senses in terms of detection and discrimination of different stimuli [6]. While humans often have difficulty identifying scents by name, our ability to distinguish among different scents and to recognize scents previously smelled is quite robust [7].

As for smell and memory, odor information is thought to be stored in long-term memory and has strong connections to emotional memory. Smell is thought to have the amazing power to vividly trigger the evocation of autobiographical experiences. This property has been referred to as the “Proust phenomenon”, for the French author, Proust made the connection between smell and autobiographical memories in his book, long before neuroscientists did so [8]. And it might be explained by the direct connections established by the olfactory bulb and piriform/olfactory cortex on two structures, the amygdala and hippocampus, which are involved in emotion and memory [9].

## 1.2 Smell in design

Product experience is defined by some researchers as “the awareness of the psychological effects elicited by the interaction with a product, including the degree to which all our senses are stimulated, the meanings and values we attach to the product, and the feelings and emotions that are elicited [10]”.

In the 1980s, the term emotional design came into play in Europe and North America. And from the 1970s, Kansei engineering spread in Japan [11]. Nowadays, we still attach importance to applying holistic design strategies to impact users’ feelings, impressions, and emotions.

As mentioned before, smell is thought to have unique relationships with human memories and emotions. For designers, using smell to enhance a consumer’s experience of products is one way to manipulate a product’s expression to influence how it is experienced. And when applied appropriately, smell in products would probably gain positive evaluations and contribute to the overall product [12], where such effects of smell on people’s evaluations might happen on emotional and sensory processes people are not aware of [11]. In addition, some studies demonstrated that product scent would increase memory for associated information [7].

Furthermore, attention should also be paid to the distinction between product scent and ambient scent, the latter of which here refers to the scents perceived mostly during the shopping stage [13]. Utilizing ambient scent, or other sensory experience to influence consumer behavior could be expressed as sensory marketing, which is defined by some researchers as “marketing that engages the consumers’ senses and affects their perception, judgment, and behavior [7]”. Stimulating the five senses in a marketing sense, either individually or collectively, could affect consumer behavior. For smell in sensory marketing, previous studies have shown that using conditioning smells could make stores better assessed by the consumers, and that good smell triggers memory and is effective in justifying the added value of goods, namely, smell and odor have a significant impact on perceptions of product quality and environment [14].

However, socio-cultural factors, as well as personal experiences and memories play an important role in deciding what would be evoked by an odor [13]. The effect of smell on product evaluation also varies in different kinds of products. Designers should not only pay attention to the cultural background where the targeted users come, but also consider the different product contexts. In addition, as one of the sensory properties of the product, smell should not be considered in isolation, since changing any one sensory property is likely to impact on the overall product experience [15].

## 2. This Study

### 2.1 Terminology

There are several words in English which can express the meaning of “smell”, mainly including “smell”, “scent”, “odor”, “aroma”, “fragrance” and “olfaction”. In this thesis, all of these words have been used. In some cases, the choice of different words is to avoid repetitive expressions. In other cases, the smell-related words were chosen according to the contexts. These words have subtle differences in the meaning, and in this thesis, we have interpreted and used them in line with the explanation as follows.

“Smell”, as a noun, refers to the ability to notice or recognize a particular smell by using the nose. Or it also refers to the smell that people sense through the noses. “Olfaction” refers to the sense of smell. “Scent” refers to a distinctive, often agreeable smell. In this thesis, we view the word “scent” as a relatively neutral expression. And the words “scent” and “smell” (as a noun) are in most cases synonymous. “Odor” also refers to a smell, but sometimes denotes an unpleasant smell. “Odorless” is used to denote something is having no smell. “Aroma” and “Fragrance”, both refer to pleasant smells. While “aroma” is often used for plants, food, and spices, “fragrance” is often associated with perfume and flowers.

This thesis has used the word “scent” for the title, because it is a relatively neutral expression of smell, which can cover the different “smells” studied in the thesis, and it has a less ambiguous denotation than “smell”.

### 2.2 Definition of the research scope

#### 2.2.1 Orthonasal smell

The sense of smell is thought to have two pathways: (a) orthonasal pathway (through the nose when we inhale or sniff) or (b) retronasal pathway (via the mouth and through a passage to the back of the nose when we eat or drink). In the thesis, we focus on the former orthonasal smell, which is sensed by people through the nose.

#### 2.2.2 Scent, as an output modality sensed by people

Speaking of scent technology, it may remind people about the technology of scent detection, such as the electronic nose, where the scent is interpreted as the input of the machine. However, it is outside the scope of this thesis. We would not focus on such technologies as the electronic nose, or machine olfaction.

Instead, the scent that this thesis aims to study is defined as a modality that people

can sense whether during the human-product interaction or during an experience. We would like to explore the effects of scents on people, people's emotions, and product experience.

### **2.3 Overview of the thesis**

The main purpose of the thesis is to explore the potential emotional effects of scent on product experience. It mainly consists of three studies, respectively described in Chapter 2, 3, and 4.

Chapter 2 is about an experimental study, exploring the effects of scents on product experience. Here, we used different scents (sweet orange, peppermint, and in the control group, no scent) as the starting point of the product experience of the orange-shaped lego-like toy blocks, and used a questionnaire approach to investigate the effects of aromas on product experience from several aspects. Although we did not find noticeable effects of different scents on people's degrees of liking and evaluations of the product, some effects of scents were found to be significant, including the effects on changes in people's moods, and their affective responses to the scents.

Different from the experimental context in Chapter 2, Chapter 3 has investigated the roles of scents in 25 smell-related consumer products and experiences from the perspective of Don Norman's 3 Levels of Emotional Design, to explore the potential emotional effects of scents under real-life conditions. From the analysis of the 25 samples, it has been revealed that scents are potential to have emotional effects in all the 3 Levels of Visceral, Behavioral, and Reflective. Further, we have identified 3 patterns of how scents deliver the emotional effects in smell-related products (experiences), based on which we have discussed the possibilities of applying scents to product or experience design.

Chapter 4 let us rethink the roles of scent in the product experience from a habit-forming perspective. Although the olfactory display is a potential medium to utilize the effects of scent (as revealed in the former chapter), it is still not prevalent, especially compared with its audiovisual counterparts. Based on this, we have examined and compared four different representative olfactory display devices to explore how to make such devices more habit-forming. This chapter has also revealed some limitations related to smell, which we may encounter when applying the scent.

In Chapter 5, we have discussed the new challenges and opportunities in fulfilling the potential effects of scent in the post-Covid-19 world where the design paradigm has begun to shift. In the end, we will have a general discussion of the whole outcomes and give a summary of the thesis in Chapter 6.

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# Chapter 2

## **An Experimental Exploration: Analyzing the Product Experience of the Toy Blocks with Different Aromas**

### **1. Introduction**

When interacting with products, we can see the product, touch it, hear the sound produced and probably smell it. Usually, more than one sensory system is involved, and all the senses are involved simultaneously [1]. Designers can manipulate the product information through all the senses to elicit the desired product experience [2]. Accordingly, the question of how to design for a holistic product or experience from a multisensory perspective has started to be seriously thought about. The sense of smell is thought to have great potentials, though it remains one of the least explored senses by design researchers [3].

Speaking of smell, fragrance might probably be one of the representative products, for which how it smells is the most necessary and important characteristic. Since it is difficult to communicate fragrance properties without directly smelling it, some researchers suggested that fragrance companies could make use of the colors of the fragrance fluid, the bottle, the packages and advertisements to communicate the properties of the fragrance experiences and hopefully evoke consumers' expectations as aligned as possible with the fragrance, on the basis of people's fairly consistent odor-color correspondences [4]. However, despite the efforts made by the fragrance industry, in our daily life, vision is not necessarily the first sense modality coming into play in our interaction with the products. On such conditions that smell is perceived before the visual stimulations, whether and how cross-modal correspondences between vision and smell still work remains to be investigated.

It is revealed by some studies that odors do not only show correspondences with colors, but also with shape and abstract symbols [4]. Suppose smell is the first sensory modality by which people perceive a product, then, what if the visual properties of the products are congruent or incongruent with the expectations elicited by smell? The

olfactory-visual congruity is expected to lead to more positive evaluations for the products, as the proper integration of information from different sensory modalities might contribute to an accurate and meaningful perception of the product [5]. However, researchers have found mixed results on the congruency of odors. Some found when presented with a congruent odor, products were evaluated more positively, while others found no effects of odor congruency on overall product evaluation [2]. With respect to the incongruity, contradictory sensory information may elicit ambiguity about product identity, thus having a negative effect on subsequent product evaluation [6]. However, some studies suggest it might not necessarily lead to negative effects. Berlyne(1971) suggest that a moderate degree of incongruity would be perceived as more pleasant than no congruity, while the pleasantness would decrease with the increase of the degree of incongruity [7]. Furthermore, incongruent sensory information may lead to a surprise reaction, followed either by positive emotions like amusement or interest or by negative emotions like disappointment or irritation [8]. It is worth noting that differences in the methods used in different studies may lead to contradictory findings on the effect of odor on product evaluation [2]. Therefore, for products that normally do not carry an odor, it is yet inconclusive whether, when and how adding smell to it could lead to better product evaluations.

In the present study, we chose to study on the orange-shaped lego-like toy blocks, which could stand for a simple example of multisensory experience. It involves looking at the orange blocks, touching each of the small blocks, following the accompanying instruction paper to build it, and hearing the sound of blocks' being connected to the others. However, as a plastic object, it was not equipped with a pleasant smell. Therefore, the present study applied aromas of sweet orange and peppermint respectively as the starting point for people's interaction with the toy blocks, where the aroma of sweet orange was expected to be congruent with the visual properties of the toy blocks. Meanwhile, with a smell that is relatively easy to identify and describe, the aroma of peppermint could be distinguished from the sweet orange by the smell, and was expected to be incongruent with the toy blocks. Here, the starting point means that we would ask participants to smell the aromas first before presenting them with the toy blocks; thus, supposedly the aromas would stimulate certain expectations. By doing so, we attempted to investigate the effects of aromas on product experience from the aspects of people's perception of the aromas and aroma-blocks combinations, affective attitudes towards the aromas and the toy blocks, and their evaluations of the toy blocks. In addition, people's moods and their willingness to get more interaction with the product were also investigated.

## 2. Method

We chose to study on the product of orange-shaped lego-like toy blocks; as indicated in Figure 2-1, it comprised several types of block pieces and required 125 pieces in total to build a complete orange shape with a width of 48mm and a height of 42mm. And we selected the aromas of sweet orange and peppermint as the smells. With no aroma on control condition, there were three groups with different aroma-blocks combinations in the present study. All of the participants would follow the same procedure. And several tools of measurement were utilized to indicate their moods, evaluations of the product, willingness to use the product and other necessary information for the study.

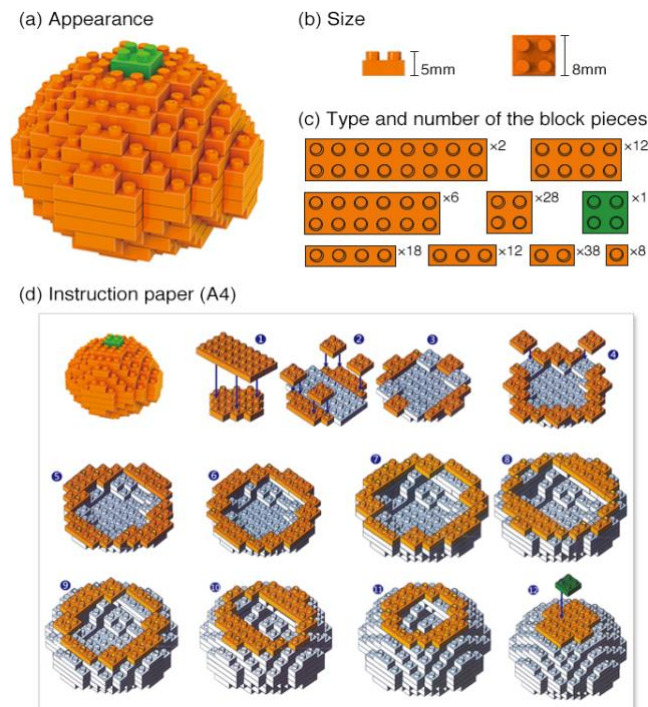


Figure 2-1: Overview of the orange-shaped lego-like toy blocks

### 2.1 Participants

72 participants (30 male and 42 female; ages ranging from 20 to 30 years old, mean 24.5) participated in the study. They were recruited among students who came from China mainland and studied in Chiba University. For all of the three groups, there were 10 male and 14 female. For control condition, participants ranged in age between 23 and 30 years old (mean age 25.3). For peppermint group, participants ranged in age between 21 and 30 years old (mean age 24.4). For sweet orange group, participants ranged in age between 20 and 28 years old (mean age 23.9).

## 2.2 Stimuli

We used the essential oils of sweet orange and peppermint from the same series of the same brand, GAIA NP, as the stimuli for the treatment groups, and odorless water for the control group.

The aroma samples were prepared in 150ml paper cups. A sheet of thin, white, odorless tissue would be folded into a square of 20 mm × 20 mm, and after adding one drop of essential oils to it, the tissue would be placed in each cup. Immediately after doing so, we would use the plastic wrap and a rubber band to keep the aromas away from escaping. In principle, each cup would be used no more than one time. And the aroma samples were prepared every night before the next day's experiments. For the control group, we prepared the paper cups following the same steps, but what we added to the odorless tissue was water rather than the essential oils.

## 2.3 Measures

The Profile of Mood States 2nd Edition - Adult (POMS 2-A) is a multi-dimensional assessment of transient and fluctuating moods, and enduring states of affect, in the form of a self-report questionnaire with adjectives describing an individual's mood, for individuals 18 years of age and older. In the present study, we chose 25 items from the total 65 items, representing the scales of Fatigue-Inertia (FI), Tension-Anxiety (TA) and Vigor-Activity (VA). An individual would rate the extent to which each adjective described his or her mood "right now" on a five-point scale. And the raw scores of each scale would be converted to standard T-scores for further statistical analysis. For later part of the thesis, we would term it as POMS for short.

The User Experience Questionnaire (UEQ) is a 26-item questionnaire, containing 6 scales of Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation and Novelty. Each item is a pair of contrasting attributes that may apply to the product, on a seven-point scale. The scale of attractiveness reflects an individual's overall impression of the product. Perspicuity reflects whether the product is easy to get familiar with and easy to learn how to use for individuals. Efficiency reflects whether users can solve the tasks without unnecessary efforts. Dependability indicated whether the users feel in control of the interaction. Perspicuity, Efficiency and Dependability are pragmatic quality aspects, namely, goal-directed, while Stimulation and Novelty are hedonic quality aspects. The scale of Stimulation reflects whether it is exciting and motivating to use the product, and Novelty indicates individual's attitudes towards whether the product is innovative and creative and whether the product catches the interest of users [9].

The Visual Analogue Scales (VAS) are self-report measures on which participants

were asked to draw a vertical line through a 100mm horizontal line to indicate their responses to specified questions. In the present study, each participant was asked to respond to the question “To what extent do you want to try this product with your own hands?” after they were presented with the toy blocks and to the question “To what extent do you want to continue the process just now, until you finish building the complete orange shape?” after the finish of the time-limited product experience. These ratings were used to represent participants’ subjective willingness to get more interaction with the product.

The last questionnaire was designed to measure each participant’s degrees of liking for the aroma and the product, as well as appropriateness rating for the aroma-blocks combination. It also aimed to gain more insight into how the participant perceived the aroma and the olfactory - visual (in)congruity. Participants would indicate how well they liked the aroma and the blocks separately on a 7 point scale from ‘-3 dislike very much’ to ‘3 like very much’. They also indicated how well the aroma and the toy blocks match on a 7 point scale from ‘-3 very inappropriate’ to ‘3 very appropriate’. After rating the degree of liking for the aroma, they were asked to respond to the question "What did you feel when smelling the aroma" by describing the aroma or their feelings in simple words. And after the appropriateness rating, they were asked to give the reasons why they made such judgments.

## **2.4 Procedure**

The experiment was performed in a well-aired room, with sufficient lighting and space. In the experiment, participants were approached individually. Upon arrival, participants would be seated for a short time to get prepared. Then after briefly introducing the experiment and getting participants’ sign consent, the experiment leader would ask the participants to fill out the first POMS (POMS\_0). After that, participants would be presented with the aromas in the paper cup. The experiment leader would remove the plastic wrap of the cup and hand the cup to the participants. After taking the cup, participants would be asked to smell the aroma in the cup for 30 seconds and to imagine that they were in the environment with this aroma. Then the orange-shaped toy blocks both in the form of finished orange shape and the form of scattered blocks, together with an instruction paper would be presented to the participants. After about 10 seconds of observation, they would fill out the second POMS (POMS\_1) and the first UEQ (UEQ\_1), and score their willingness to try the toy blocks in VAS\_1. Subsequently, they would have 12 minutes to follow the instruction paper and explore the blocks by themselves. During this process, the experiment leader might provide reasonable instructions to some participants in case that the variation in the degree of

product experience was too large. Within 12 minutes, none of the participants could finish the complete orange shape. After the time-limited product experience, participants would fill out the third POMS (POMS\_2) and the second UEQ (UEQ\_2), and indicate their willingness to continue building blocks until they finished the task in VAS\_2. The experiment would finish after they complete the last questionnaire about their likings for the aroma and the blocks and so on. The procedure was summarized in Figure 2-2. It is worth mentioning that an analysis of participants' building results was conducted. It revealed that as it took 125 (100%) block pieces to build a complete orange shape, the sampled 44 participants could accomplish 47 (37.6%) pieces on average, namely having reached the sixth piece in step 5 on (d) Instruction paper of Figure 2-1. The standard deviation was 19.2. The participant with the most rapid and the lowest speed finished 103 (82.4%) and 13 (10.4%) pieces respectively. It suggests that the proportion of the orange shape that each participant could complete within the same time varied considerably, which might cause individual differences in the subsequent evaluations. Nevertheless, such variation of individuals' degree of completion existed in each group, and no apparent differences were detected among the three groups, indicating that we cannot explain the group-level results by the task completion difference.

In sum, each participant would have to fill out the questionnaires three times. They first filled out the POMS\_0, which indicated participants' initial moods of fatigue, tension and vigor. After smelling the cup with or without the aromas and subsequently seeing the toy blocks, they answered the questionnaires for the second time. Therefore, POMS\_1 indicated participants' moods at the moment after they were presented with the blocks under the treatment; UEQ\_1 reflected participants' first impressions of the blocks before they explored the blocks by hand; VAS\_1 recorded participants' willingness to try the product right in front of them. It was after they explored and built the blocks by hand that participants filled out the questionnaires for the third time. Correspondingly, POMS\_2 and UEQ\_2 respectively indicated participants' moods and their evaluations of the blocks after the time-limited product experience; VAS\_2 reflected participants' willingness to continue the unfinished experience. And the last questionnaire also collected other important data for the experiment, as stated above.

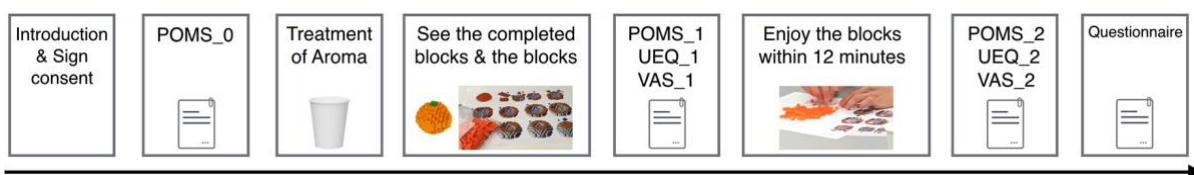


Figure 2-2: Overview of the experimental procedure for one participant

## 2.5 Data analysis

All of the quantitative data were first analyzed by separate ANOVAs with aroma treatment as the independent variable to check the effect of the treatment. Tukey's honestly significant difference (HSD) post hoc analyses were performed to test the significance of the differences between means. ANOVA was further performed with appropriateness rating as the dependent variable, with likings for the aroma and the blocks as well as their interaction as predictor variables. Stepwise regression was also performed to test whether we could predict people's willingness to get more interaction with the product based on their likings for the aroma and for the blocks. The SAS® University Edition was used for the statistical analysis.

The qualitative data consisted of participants responses of how the aroma and the olfactory - visual (in)congruity were perceived. The qualitative analysis was started by looking for themes in the responses from the two aroma treatment groups. Based on the semantic similarity, the responses were categorized into different groups.

## 3. Results

### 3.1 Degrees of liking for and matching between the aroma and the blocks

Separate ANOVAs were performed for each of the degree of liking for the experienced aroma, degree of liking for orange toy blocks, as well as appropriateness ratings for the aroma-blocks combinations, with Treatment as the independent variable. These analyses showed a Treatment effect for the degree of liking for aroma [ $F(2,69)=21.0$ ,  $p<0.0001$ ,  $r^2=0.38$ ] and for the appropriateness ratings for the aroma-blocks combinations [ $F(2,69)=4.8$ ,  $p<0.05$ ,  $r^2=0.12$ ], but not for the degree of liking for toy blocks [ $F(2,69)=0.14$ ,  $p>0.80$ ]. In Tukey's honestly significant difference (HSD) post hoc test, the degree of liking for sweet orange (2.04) was significantly higher than peppermint (1.08). And both of likings for the aroma in treatment groups were significantly higher than control group (-0.04). As for the difference among the appropriateness ratings for the three aroma-blocks combinations, the rating for sweet orange group (1.21) was higher than peppermint group (0.13) and control group (-0.13), and only the difference between the sweet orange group and control group was found to be significant (see Table 2-1). This analysis showed that in the manipulated experimental context, the aroma of sweet orange caused a higher degree of liking than peppermint. The results of evaluations for 'how well do the aroma and toy blocks match' roughly concur with the predictions that the aroma of sweet orange matches best with the toy blocks, though the mean appropriateness ratings were lower than expected. As for the liking for the toy blocks, whether there is aroma or not, as well as the aroma

type was not found important.

**Table 2-1: Means and Standard Errors for degrees of liking for aroma and blocks, and appropriateness rating**

	No Aroma (n=24)		Peppermint (n=24)		Sweet Orange (n=24)	
	M	SE	M	SE	M	SE
AromaLiking	-0.04 <sup>c</sup>	0.18	1.08 <sup>b</sup>	0.29	2.04 <sup>a</sup>	0.19
BlocksLiking	1.33 <sup>a</sup>	0.29	1.13 <sup>a</sup>	0.23	1.25 <sup>a</sup>	0.31
Appropriatenss	-0.13 <sup>b</sup>	0.29	0.13 <sup>ab</sup>	0.32	1.21 <sup>a</sup>	0.36

Note: <sup>a,b,c</sup> means scores with different superscripts were significantly different in Tukey's HSD test ( $p < .05$ )

Furthermore, ANOVAs were performed to investigate the relationships between the appropriateness rating and the degrees of liking, the results of which only showed a significant effect of the Aroma Liking  $\times$  Blocks Liking interaction [ $F(25,46)=1.86$ ,  $p < 0.05$ ] for the appropriateness ratings. Besides, it was showed in an interaction plot that when people rated their likings for the toy blocks as '3', the appropriateness ratings would increase as their degrees of liking for the aroma increase from '-2' to '3'. The number of the participants here who indicated that they liked the toy blocks very much was 12. This indicates that the contradiction or consistency between people's likings for the aroma and the toy blocks might also serve as a source for their judgments on whether the aroma and toy blocks match, especially when they expressed a strong affective attitude towards the toy blocks.

### 3.2 Perception of the aromas

In addition to the ratings for the likings and appropriateness as summarized in 3.1, the participants were also asked to describe their feelings about the aroma in the last questionnaire. Based on the semantic similarity, the responses of the participants in the two treatment groups were categorized into different groups. For the control group, most participants reported that they did not smell any aromas or that they did not feel anything special, so their responses were excluded from the semantic analysis.

The results were summarized in Table 2-2. As indicated, to describe their perceptions of the aroma, participants not only used adjectives to describe the sensory or functional features of the aroma, but also used some concrete images or scenes to represent their feelings, and some of the participants even reported the changes of their own physiological conditions. For the sweet orange group, about half of the participants mentioned some concrete images, including orange flavored candy or soft drink and mainly fruits or orange, to represent their impressions. As for the peppermint group,

half of the participants mentioned that the aroma evoked an image of Doublemint gum, which was a very popular chewing gum product in China, with some other participants mentioning peppermint flavor or candy. In both groups, some participants described that the aromas were relaxing. Overall, it is fair to say the images or expectations evoked by the aroma of sweet orange were closer to the reality of toy blocks from the visual aspect.

**Table 2-2: Participants’ responses to “What did you feel when smelling the aroma? Brief descriptions of the aroma or personal feelings.”, divided to four types, including the number of people that mentioned the items.**

	Concrete images	Concrete scenes	Sensory or functional aspects	Participants’ own conditions
Sweet Orange	8: Fruits or orange 3: Orange flavored candy or soft drink	1: A memory in a beauty salon was recalled where there was a super delicious orange candy. 1: Getting an orange soda in a hot summer. 1: Feels like a good harvest in clear and fresh autumn. 1: As relaxed as being at home. 1: Feels pleasant like eating oranges together with the family in the backyard.	6: relaxing 5: fresh 3: comfortable 2: peaceful 1: natural / energetic / refreshing / assisting concentration	2: excited 2: feel hungry 2: sleepy 1: delighted 1: familiar
Peppermint	12: Doublemint gum 5: Peppermint flavor or candy 2: Toothpaste or soup	1: Someone near me is eating peppermint candies. 1: Feels as eating a peppermint candy when being sleepy.	5: Relaxing and calm 4: Refreshing and cool	1: feel like chewing a gum.

### 3.3 Treatment and changes in moods

The POMS was utilized to investigate the effects of aromas on participants’ moods. For each subscale of the POMS, namely the mood of fatigue, tension and vigor, it was measured three times for each participant respectively at the beginning of the experiment, after being presented with the toy blocks under the treatment, and after exploring and building the blocks. All of the raw scores were converted to standard T-scores for statistical analysis. For the initial moods, separate ANOVAs and post hoc test (Tukey’s HSD) with Treatment as the independent variable were performed, revealing that the initial mood of fatigue of the control group was significantly lower than the treatment groups. Though the difference was not significant when testing the raw scores of the initial fatigue instead of the standard T-scores, this unexpected initial mood difference still implied that it might be inappropriate to compare the differences of scores over groups directly. Therefore, new variables were introduced by calculating the difference of mood scores between successive conditions for each participant. Here,  $\Delta$ POMS1 represented the changes in moods after participants seeing the toy blocks,

and  $\Delta$ POMS2 represented the changes after the product experience by hand, the results of which were contained in Table 2-3 together with the descriptive statics for the values of moods at each stage.

**Table 2-3: Means and Standard Errors for moods at each stage and changes in values of moods**

	No Aroma (n=24)		Peppermint (n=24)		Sweet Orange (n=24)		
	M	SE	M	SE	M	SE	
0	Fatigue-Inertia	38.08 <sup>b</sup>	0.75	42.04 <sup>a</sup>	1.43	42.04 <sup>a</sup>	1.61
	Tension-Anxiety	39.38 <sup>a</sup>	0.73	41.38 <sup>a</sup>	1.48	39.42 <sup>a</sup>	0.75
	Vigor-Activity	60.08 <sup>a</sup>	1.76	54.42 <sup>a</sup>	1.72	60.63 <sup>a</sup>	1.99
1	Fatigue-Inertia	37.42 <sup>b</sup>	0.67	40.88 <sup>a</sup>	1.40	38.63 <sup>ab</sup>	1.20
	Tension-Anxiety	38.42 <sup>a</sup>	0.61	41.67 <sup>a</sup>	1.43	38.96 <sup>a</sup>	1.07
	Vigor-Activity	60.21 <sup>ab</sup>	1.89	53.38 <sup>b</sup>	1.99	61.42 <sup>a</sup>	1.95
2	Fatigue-Inertia	39.58 <sup>a</sup>	0.75	40.58 <sup>a</sup>	1.12	40.46 <sup>a</sup>	1.65
	Tension-Anxiety	41.38 <sup>a</sup>	1.08	41.58 <sup>a</sup>	1.32	42.67 <sup>a</sup>	1.26
	Vigor-Activity	56.71 <sup>a</sup>	2.14	55.96 <sup>a</sup>	1.91	59.29 <sup>a</sup>	1.86
$\Delta$ 1	Fatigue-Inertia	-0.67 <sup>a</sup>	0.45	-1.17 <sup>ab</sup>	0.87	-3.42 <sup>b</sup>	0.69
	Tension-Anxiety	-0.96 <sup>a</sup>	0.80	0.29 <sup>a</sup>	1.28	-0.46 <sup>a</sup>	0.93
	Vigor-Activity	0.13 <sup>a</sup>	1.06	-1.04 <sup>a</sup>	1.04	0.79 <sup>a</sup>	0.76
$\Delta$ 2	Fatigue-Inertia	2.17 <sup>a</sup>	0.76	-0.29 <sup>a</sup>	1.22	1.83 <sup>a</sup>	0.92
	Tension-Anxiety	2.96 <sup>a</sup>	0.81	-0.08 <sup>b</sup>	1.13	3.71 <sup>a</sup>	1.34
	Vigor-Activity	-3.50 <sup>b</sup>	1.70	2.58 <sup>a</sup>	1.40	-2.13 <sup>ab</sup>	1.42

Note:0=POMS\_0, 1=POMS\_1, 2=POMS\_2,  $\Delta$ 1=POMS\_1-POMS\_0,  $\Delta$ 2=POMS\_2-POMS\_1, Fatigue-Inertia, Tension-Anxiety, Vigor-Activity were abbreviated as FI, TA, VA in the article. <sup>a,b</sup> means scores with different superscripts were significantly different in Tukey's HSD test (p<.05)

To investigate whether aromas would function on participants' moods, separate ANOVAs and post hoc test (Tukey's HSD) with Treatment as the independent variable were performed for the changes in values. These analyses showed a Treatment effect for  $\Delta$ FI1,  $\Delta$ TA2 and  $\Delta$ VA2. The values of changes in fatigue after smelling the aroma (or no aroma for control group) in sweet orange group was significantly lower than the other two groups, indicating that the aroma of sweet orange might have the function of relieving fatigue. As all participants were controlled by limited time not able to finish building the toy blocks, it was possible for them to feel nervous tension even after the process of building blocks. There was no significant difference between changes in tension in control group and sweet orange group; however, the value of changes in tension in peppermint group was found to be significantly lower than sweet orange group. In addition, for the changes in vigor after building blocks, peppermint group was found to be significantly higher than the control group; hence the aroma of peppermint might not only have some functions against nervous tension, but also maintain participants' vigor level.

### 3.4 Willingness to get more interaction

Participants' degrees of willingness to try the blocks after being presented with the blocks, and willingness to continue building blocks were measured by visual analog scale (VAS), which ranged from 0 to 100. Separate ANOVAs and post hoc test (Tukey's HSD) were conducted, finding no main effect of aroma treatment on the two scales and no significant difference of the scale values among different groups (see Table 2-4). This result indicated that aromas of sweet orange or peppermint alone did not have a significant effect on users' willingness to get more interaction with the blocks.

**Table 2-4: Means and Standard Errors for values of the willingness to get more interaction with the blocks**

	No Aroma (n=24)		Peppermint (n=24)		Sweet Orange (n=24)	
	M	SE	M	SE	M	SE
VAS_1	69.28	4.25	60.06	5.47	63.11	3.87
VAS_2	74.12	5.10	72.75	5.49	82.90	3.43

Note: no significant difference was found among groups.

Notwithstanding, it was also tested whether we could predict people's willingness to get more interaction with the product on the basis of their likings for aromas and the blocks, by conducting a stepwise regression selection. The appropriateness rating was excluded, but both the degrees of liking for aromas and the blocks were retained. The regression equation was:

$$\text{Willingness to continue} = 15.26 \times \text{AromaLiking} + 27.44 \times \text{BlocksLiking} \quad (R^2=0.70).$$

It indicated that likings for aromas might also contribute to participants' willingness to get more interaction with the product, though to a lesser extent than likings for the blocks.

In addition, in the result, among the 24 participants in each group, respectively 20, 16 and 21 participants in control, peppermint and sweet orange group showed an increase or remained the same in the values of their willingness to get more interaction. That is to say, after the product experience by hand, most participants' willingness to get more interaction with the product would grow or remain at the same high level.

### 3.5 Perception of the appropriateness of the aroma-blocks combinations

The participants were also asked to give the reasons for their judgments on whether the aroma and toy blocks match, after they did the appropriateness ratings in the last questionnaire. The control group was excluded from the semantic analysis for the lack

of valid responses. The explanations for the appropriateness ratings in the two treatments groups were summarized in Table 2-5.

**Table 2-5: Main explanations given by participants for their appropriateness ratings for the aroma-blocks combinations, including the number of people that mentioned the items.**

	<b>Reasons for inappropriate or neutral ratings</b>	<b>Reasons for appropriate ratings</b>
<b>Sweet Orange</b>	<p><b>Color of blocks</b> 2: Color saturation of the blocks is too high, when the aroma evoked a soft expectation for the color.</p> <p><b>Texture and tactile impression</b> 1: The aroma evoked a smooth impression, but the blocks felt like mosaic. 1: The texture of the blocks felt inferior to aroma.</p> <p><b>Functions of aroma versus blocks experience</b> 1: The aroma let one feel sleepy. 1: The aroma is relaxing, but the blocks are not.</p>	<p><b>Color of blocks</b> 3: The color matches the orange impression evoked by the aroma. 1: The color and the aroma both feel fresh and enthusiastic.</p> <p><b>Shape of the blocks</b> 10: The orange smell is very close to the shape of the blocks</p> <p><b>Functions of aroma versus blocks experience</b> 3: Aroma's functions of relaxing and focusing one's attention are suitable for the slightly complicated and repetitive blocks building task. 1: The aroma's comfortable atmosphere is good for building blocks. 1: The aroma can contribute to the novelty and joy of the game.</p>
<b>Peppermint</b>	<p><b>Color or shape of the blocks</b> 1: The blocks' color does not match the cool aroma. 1: The aroma of orange may suit better.</p> <p><b>Atmosphere</b> 1: The blocks match better with a more smooth and conservative aroma. 1: The blocks feel happier than the aroma. 1: The blocks feel energetic, while the aroma is refreshing and cool.</p> <p><b>Functions of aroma versus blocks experience</b> 2: The aroma is distracting. 1: The aroma makes one energetic, while the blocks make one sleepy.</p>	<p><b>Shape of the blocks</b> 1: Both are relevant to plant.</p> <p><b>Atmosphere</b> 2: Feels as if playing with candy in mouth. 1: The comfortable environment keeps one in a good mood.</p> <p><b>Dislikes for both</b> 1: Both are unpleasant. 1: The smell and the guide of the blocks are abnormal.</p> <p><b>Functions of aroma versus blocks experience</b> 4: Both are refreshing and focusing one's attention. 2: Both are relaxing.</p>

As indicated, besides the relationship between the expectation stimulated by the aroma and the observed appearance of the blocks, the functions of the aroma versus the blocks building experience were also taken into consideration. And in both groups, the similar perceived features of the aroma and the blocks could serve as both the sources of the appropriate or inappropriate ratings for the combinations, depending on how participants perceived the overall experience. For example, some participants in sweet orange group reported that the shape and appearance of the blocks match well with the aroma, while the others thought that the texture and the tactile impressions of the blocks were inferior to the expectation of high quality evoked by the aroma, and that the texture corresponding to the aroma should be smoother. As for the color of the blocks, some participants thought it was in line with their expectations, while the others thought the color saturation of it was too high, when the aroma triggered an expectation of a softer and milder orange color. In addition to the result in 3.1, the fact that some participants reported the dislikes for both of the aroma and the toy blocks as one of the reasons for appropriate ratings, also indicated that the contradiction or consistency between

people’s likings for the aroma and the toy blocks would influence the appropriateness ratings as well. In short, participants would consider the appropriateness from broader dimensions than merely from the aspect of olfactory-visual (in)congruity.

### 3.6 User experience evaluations

Each participant would fill the User Experience Questionnaire (UEQ) twice respectively after being presented with the toy blocks under the treatment of aroma and after the experience of building blocks. To test the effect of aroma on some dimensions of participants’ evaluations of the product experience, separate ANOVAs were performed on each of the scales with Treatment as independent variable. However, for both before and after blocks building questionnaires, no significant difference was found for each of the scales among the three groups. These results indicated that the aroma of sweet orange or peppermint itself would not influence people’s evaluations of the toy blocks noticeably. The results of all the scales in UEQ about first impression and real product experience can be seen in Table 2-6.

**Table 2-6: Means and Standard Errors for scales in User Experience Questionnaire (UEQ) about first impression and real product experience**

		No Aroma (n=24)		Peppermint (n=24)		Sweet Orange (n=24)	
		M	SE	M	SE	M	SE
UEQ_1	Attractiveness	1.11	0.15	0.76	0.27	0.92	0.20
	Perspicuity	0.38	0.19	0.59	0.30	0.40	0.28
	Efficiency	0.49	0.14	0.20	0.23	0.29	0.19
	Dependability	0.81	0.11	0.78	0.22	0.67	0.18
	Stimulation	0.86	0.13	0.52	0.28	0.79	0.20
	Novelty	0.63	0.15	0.07	0.30	0.36	0.20
UEQ_2	Attractiveness	1.24	0.19	1.05	0.21	1.20	0.15
	Perspicuity	0.06	0.22	0.31	0.28	-0.01	0.22
	Efficiency	0.42	0.15	-0.01	0.19	0.11	0.18
	Dependability	1.02	0.17	0.99	0.21	0.74	0.14
	Stimulation	1.09	0.19	0.96	0.25	1.29	0.19
	Novelty	0.86	0.20	0.61	0.31	0.72	0.19

Note: neither significant difference was found between the same scales in each group, nor among different groups.

Because for each group, considerable variances existed in each of the scales of the UEQ, comparisons among different groups were quit, but within each group, two sets of UEQ data were compared and found that the same trend showed up in all groups, though no significant difference was found for these changes. Overall, after exploring and building the toy blocks, evaluations of Perspicuity and Efficiency would become worse, which might be accounted for by the illegible instruction paper and the blocks’ characteristics of not easy-to-learn, which was even worse than their expectation. In

contrast, the evaluations of the scales of Attractiveness, Dependability, Stimulation and Novelty increased, which showed that at least for the toy blocks used in this experiment, as the interaction progress, participants' general evaluations would improve.

## **4. Discussions**

### **4.1 Possible effects of aroma on the product experience**

In this research, we applied two aromas as the starting point for people's interaction with the toy blocks. With the introduction of new sensory property, it would inevitably influence the product expression more or less. Possible effects of aromas on the product experience have been found in the experiment from several aspects.

First of all, the aromas led to significantly different degrees of liking for the aroma. Superior to the control group, the aroma of sweet orange caused a higher degree of liking than peppermint, indicating that aromas could evoke participants' positive affective responses. Secondly, the different aromas evoked different perceptions of the aroma, where the aroma of sweet orange evoked images or expectations closer to the reality of the toy blocks from the visual aspect. This was basically in line with the result that the sweet orange group showed the highest score in appropriateness ratings. Furthermore, in the analysis of POMS, the effect of aroma treatment alone was found on the changes in values of the moods of fatigue, tension and vigor. Put it concretely, the aroma of sweet orange was found to relieve the fatigue of the participants directly after they smelled it, though this effect did not seem to last throughout the whole process. And the aroma of peppermint was found to have the function of moderating the tension and anxiety caused by the task of building the blocks within limited time, and also contribute to maintaining participants' vigor. In addition, likings for aromas might contribute to participants' willingness to get more interaction with the product, as well as likings for the blocks.

Therefore, despite the insignificant effects of aroma treatment alone on participants' degree of liking and evaluations for the toy blocks, we need to admit that aromas would influence how the product was experienced. After all, to some extent, the perception of the aromas, affective attitudes towards the aromas, moods moderated by the aromas are also part of the user experience.

### **4.2 Appropriateness ratings beyond olfactory-visual (in)congruity**

This research started with the expectation that participants would do the appropriateness ratings mainly from the aspect of olfactory-visual (in)congruity, after they perceived the olfactory input, namely, the aromas and saw the toy blocks. However,

it turned out that participants did the appropriateness ratings for the aroma-blocks combinations beyond the olfactory-visual (in)congruity. Therefore, it is necessary to probe into the questions of how aromas were perceived and how the appropriateness ratings were affected.

First, regarding the perception of the aromas, we found that the expectations elicited by aromas were more than visual aspects like concrete images. It could also evoke participants' imagination of concrete scenes or vivid memories relevant to the aroma. This property has been referred to as the "Proust phenomenon", for the French author, Proust made the connection between smell and autobiographical memories in his book, long before neuroscientists did so [10]. Besides, the aromas might simply make participants feel relaxed without thinking of special images.

Next, when doing the appropriateness ratings, though some participants reported expectations concerned the visual perception of the toy blocks, they would not only consider the color, shape and form of the toy blocks, but also take the color saturation, the smoothness of the edge and the overall impression of the texture into account. Attention should be paid to the fact that such features were mainly mentioned by the participants in sweet orange group. This implied that even though some participants in sweet orange group gave a minus rating for appropriateness by reason that the real experience of the blocks failed their expectation, they might have roughly accepted the olfactory-visual congruity between the aroma and the toy blocks.

For peppermint group, the descriptions of the aroma or feelings of it given by the participants did not show semantic relationships with the color, form or shape of the toy blocks. However, as a group that was supposed to represent olfactory-visual incongruity, it showed a neutral result in appropriateness ratings. How was the incongruity perceived and interpreted? When experiencing products, people face the task of integrating meanings connoted by product elements into an overall impression [6]. Some researchers suggest usually the information from different sense would be integrated into a consistent experience, but when the information is conflicting, the brain might ignore the information that does not fit the picture of the world or combine it in some compromise object to solve the perceptual problem [5]. In this way, the associations could be made through other aspects like the product theme, usage environment and atmosphere instead of the visual aspect. And it was possible that the aromas might be perceived purely as ambient scents. That should account for why some participants considered the aroma of peppermint to be appropriate for the toy blocks.

In addition, we also found that the consistency or contradiction between people's likings for the aroma and the toy blocks might also affect the appropriateness ratings, especially when participants expressed a strong affective attitude towards the toy blocks.

This finding to some extent corresponded to Schifferstein and Tanudjaja(2004)'s findings that when stimulus ratings on the pleasure dimension became more similar, the degree-of-fit between odors and colors would increase [11].

### **4.3 Product evaluation and sensory dominance**

Despite the possible effects of aroma we have discussed above, in this research, the aroma treatments did not significantly affect participants' degrees of liking for the toy blocks and the product evaluations reflected by UEQ. This might be explained by the theory of sensory dominance. In multisensory product experience, the contribution of each sense to the overall product experience is not necessarily equivalent [1]. Sensory dominance is the degree of the prevalence of one modality over the others especially in conflicting situations [5]. Though in the experiment, aromas were presented before the further interaction, participants had already observed the toy blocks by their eyes when they evaluated the product in UEQ\_1. Here, rather than the smell, the information from the visual modality might play a more important role in determining participants' first impressions of the product. As the user-product interaction progressed, the effect of aromas on the user experience's evaluations might be further diluted with more sensory modalities coming into play. The same as the evaluations given by the participants in UEQ\_2, the degree of liking for the blocks was also a reflection of participants' comprehensive experience of the product.

Furthermore, based on the results of UEQ, the evaluations of the scales of Attractiveness, Dependability, Stimulation and Novelty showed an increase after the blocks building experience. Similarly, the results of VAS revealed that most participants' willingness to get more interaction with the product would grow or remain at the same high level. And several participants who showed fairly negative attitudes towards the toy blocks at first sight, said it was much more fun than expected, after they really tried it. Therefore, at least for the orange-shaped lego-like toy blocks in the experiment, a trigger to motivate the users to touch and try the product would be beneficial for the overall impression of the product. Aromas might be potential to play such kind of roles because it could evoke positive affective responses and moderate the moods.

To sum up, the aroma did not cause enough effects to overcome the influences of other factors in product evaluations, but it might be potential to be a trigger for the product experience.

## **5. Conclusion**

The present outcomes revealed that the aromas of sweet orange and peppermint

would lead to different degrees of liking for the aroma, evoke different images or expectations in people's minds relevant to the aroma and have functions of moderating moods such as relieving fatigue, easing the tension and maintaining vigor. Notwithstanding, the aromas did not have noticeable effects on people's degree of liking for the toy blocks as well as their evaluations for the product.

In the experimental context, we think the aroma of sweet orange might be the best choice, because it evoked the highest degree of liking for the aroma, namely, the most positive affective attitude toward the aroma itself. Besides, the images or expectations evoked by it were closer to the reality of the toy blocks, which might contribute to a more meaningful perception of the product. In addition, its function of relieving fatigue might make it easier for people to start to try the toy blocks.

Though it is still difficult to demonstrate how adding aromas could lead to better product experience and evaluations, this research might offer some insight into the potential roles of aromas in product experience.

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# Chapter 3

## **Investigating the Roles of Scent in Smell-Related Consumer Products and Experiences from the Perspective of Don Norman's 3 Levels of Emotional Design**

### **1. Introduction**

The smell is thought to have design potentials, as it has unique relationships with human emotions and memories. However, compared with the visual or audio stimuli, only a few researches have focused on the effects of scent on product experience, and researches on scents' effects on product evaluation have sometimes led to contradictory results [1]. Indeed, there is still a lack of knowledge on whether, when, and how adding scents can lead to a better evaluation of a product, which is also reflected in last chapter.

In the experimental exploration we conducted with the orange-shaped lego-like toy blocks, we attempted to investigate how different scents would affect the product experience. We did not find noticeable effects of scents on people's degrees of liking for the product and their product evaluations. Notwithstanding, the scents did evoke people's different affective responses (degrees of liking for the scents) and the scents' effects on mood moderation have also been detected. Therefore, we suggested the potentials of scents should be not ignored simply due to its insignificant effects on product evaluation in the experiment. After all, in the experimental context, the results that reflected how scents influenced the overall product experience would be unavoidably affected by the laboratory and the experimental settings. To put it more concrete, when we asked the participants to start building the lego-like blocks, we told them the time for the task was 12 minutes. Together with the fact that the block-building experience was quite attention-demanding and not easy, such settings might have made participants feel nervous, which could have biased the results of the study. It suggests that we should try to explore the effects of scents under real-life conditions, to get closer to the actual potential impacts of scents.

Moreover, in last chapter, we chose to use the orange-shaped lego-like blocks, which people normally would not expect to have scents. Suppose it was a real orange put in front of the participants, what will the participants' responses be when they peel the orange and smell the scents of sweet orange or peppermint? It is highly possible to find clearer differences brought by the different scents than the experiment we

conducted with the toy blocks. Obviously, the scent and the sense of smell show different importance and play different roles in different product experiences.

As claimed by some researchers, all products would affect the emotions of users, and there are no such things as emotionally neutral products [2]. Considering the smell can prompt immediate and emotional responses [3], in relevant products and experience, such characteristics of scents should have played certain roles related to user emotions. Then, the questions arise: what are the emotional roles and effects of scents in different smell-related consumer products and experiences? How the scents might have emotional effects on product experience in real-life conditions?

Exploring how scents have emotional effects on smell-related products and experiences and how it can contribute to a more positive user experience, we may derive from it the possibilities of applying scents to designing products or experiences that do not carry elaborated smells yet. Such applications might lead to product experiences eliciting more positive emotions, and users may feel better accordingly. Many evidences have shown that people who experience positive emotions regularly would function better and obtain better life outcomes [4]. Besides, products with emotional values might be more engaging and stand out from its competitors. Also, users are more likely to form attachments to such products, which may extend the lifecycle of the product and reduce the environmental impact. Therefore, it is worthwhile to explore the emotional effects of scents and the possibilities to apply it to bring more positive emotions in the product experience.

Based on this, this study has investigated the roles of scents in different smell-related consumer products and experiences, to explore the emotional effects of scents and the potential ways to apply it in product design. We will probe into this from the perspective of Don Norman's 3 Levels of Emotional Design. For this research, the focus lies on the general valence of people's emotions (positive v.s. negative) instead of on particular emotions. Don Norman's 3 Levels of Emotional Design interweave both emotions and cognition, and we think it may imply the mechanisms how scents contribute to a more positive product experience in people's seeing, feeling, using, owning, and thinking about a product or an experience. Therefore, we have adopted it as the approach.

## **2. Method**

This study aims to investigate the emotional effects of scents on smell-related consumer products and experiences and explore the possibilities and potential ways to apply scents in product design. Based on this purpose, we firstly identified 25 samples,

representing 25 different smell-related consumer products or experiences. Then we utilized the Quantification Theory Type III to figure out the similarities and relationships among these samples regarding the features of scents within. To further clarify the relationships among the samples, we conducted a hierarchical cluster analysis of the samples, using the scores from the results of Quantification Theory Type III. And we had a preliminary grouping of these samples. After that, we explored the ways scents play emotional roles in different samples, from the perspective of Don Norman's 3 Levels of Emotional Design. Here, according to what was reflected by the 3 Levels' analysis, we further combined or separated the groups by the semantic similarities. Based on the grouping in this step, we analyzed and summarized how scents, in each group, have emotional effects on user experiences from the 3 Levels of Vertical, Behavioral and Reflective. Interpreting the results, we have found 3 patterns of how scents deliver the emotional effects. And we will discuss the 3 patterns and their implications for applying scents to (product) design in the part of Discussion.

In this part, we will explain how this research was conducted, including the collection of samples, the methods we used, and a brief introduction of the samples.

## **2.1 Collection of samples (smell-related products and experiences)**

To explore how the scents play emotional roles in different smell-related consumer products and experiences, we firstly gathered relevant samples by web search engines. Then we preliminarily examined them and narrowed down the samples. The standard was that the presence of the scents in the products or experiences is with an intention, or we say, with a design intention. Or, in a more direct manner, the scents or the functions brought by the scents are the main parts of the products or experiences.

To cover an as comprehensive range of smell-related products and experiences as possible, we determined 25 samples. Though referred to as samples, some of them represent one particular category of product (or experience), which means that for such so-called samples, there can be many products under them with different features concretely. In later analysis, for such samples, we would follow the commonest styles of them, which fit in with people's perception generally. These samples include: Food; Fragrance in retail stores and hotels; Mosquito repellent incense; Air freshener; Deodorant; Fabric softener; Cosmetic and skincare products (Scented shampoo, hand cream, etc.); Perfume; Essential oil; Reed diffuser; Incense stick; Electric aroma diffuser; Incense burner; Portable fan with aroma tray; Point-of-sale scent; Scented attraction in amusement parks.

As for the rest of the samples, we selected a specific product or experience to exemplify one certain way that scents can be applied in products or experiences. For

most of these samples, although there are few similar products on the market and they are not as popular as the samples mentioned above, they do represent certain possibilities and potentials of scents. Therefore, we think it is necessary to include these samples to make the research comprehensive. These samples include: The aroma of coffee at Starbucks stores; Gas; Scentee Machina (IoT room diffuser); The Barisieur (a bedside coffee and tea brewing alarm clock); Skipping (portable refreshing aroma stick); AROMASTIC (personal portable aroma diffuser); iSmell (a concept of a computer-controlled scent synthesizer device); Scentee Hana Yakiniku (aroma-dispensing smartphone gadget); VAQSQ VR (Scent device for Virtual Reality HMDs).

There are other smell-related products and experiences on the market. For example, the aroma stones and the essential oil containers. They are both products, which hold essential oils and let the scents disperse naturally in a physical way. They can be viewed as media to afford aroma oils. And for such products as flowers, they do carry scents, but here the scents show the wonderfulness of nature instead of the wisdom of design. Therefore, in this study, we did not select them as individual samples. To clearly show what each sample stands for, we would have a brief introduction of the 25 smell-related consumer products and experiences in the last part of Method.

## **2.2 Classification of the samples by Quantification Theory Type III, Cluster analysis, and Analysis of semantic similarity**

To explore the emotional effects of scents in different samples more systematically, we employed the Quantification Theory Type III, hierarchical cluster analysis, and analysis of the semantic similarity of scents' effects in 3 Levels to group the samples. As expected, we would gain more insight into the relationships of different samples on scents' features and how scents deliver emotional effects in the experience of the samples.

Quantification Theory Type III, or referred to as Hayashi's quantification method III, was a multidimensional data analysis method, developed by a Japanese statistician, Chikio Hayashi. This method was published in 1956 in Japan and was termed "quantification of response pattern" then. This method can be used to explore the data structure where the data belongs to qualitative data. In Quantification Theory Type III, a response (dummy) matrix is analyzed, and numerical values will be assigned to the qualitative data so that the correlation coefficients between samples and response categories (columns and rows in the matrix) become maximal. In this way, it will create two-dimensional spaces, where the similarity between samples or response categories can be indicated by the distance between the points. This method can be viewed as a method of taxonomy of samples and categories based on response patterns. It has been

applied in various fields, including natural and human-social sciences and design fields. For more details about the mathematical aspect of the method, it is recommended to refer to [5].

In this study, we would like to employ the Quantification Theory Type III to group the samples based on their smell-related features and other relevant important characteristics. Accordingly, before that, we extracted 17 categories to check the samples, by comparing different samples and identifying the distinguishing features. The 17 categories would cover some features relevant to scents, including the scents' function length of time, the target of the scents, and other features of the products. They are: the scent lasts for a long time; the scent is transient after being triggered; the scent affects the surroundings (not targeted at a particular person); targeted at a single user; the scent acts on a particular object/person, but people around can feel it; people enter the scent (passively surrounded by the scent); the scent spread naturally or with heat; electricity-involved; the scent is an added element to products with other main functions; the scent is essential to the product; the product contains other functional chemical composition except for the scent; the scent in use is portable or wearable; connected to computer or smartphone; the release time and intensity is relatively controllable; natural; involving additional purchase of the scent; the scent is relevant to the presented contents or semantic features of the product.

We examined each of the 25 samples to find whether it meets the categories, from which we would get a response matrix. Then we utilized the Quantification Theory Type III to explore the relationships hidden in the qualitative data. Further, we conducted a hierarchical cluster analysis, based on the first five sample scores of the 25 samples from the results of the last step. The cluster analysis would present a dendrogram, based on which we would have a preliminary grouping. Next, from the perspective of Don Norman's 3 Levels of Emotional Design, we examined how the scents in different samples deliver the emotional effects in 3 Levels of Visceral, Behavioral, and Reflective. Based on the semantic similarities, we further combined or separated the groups. In the part of Results, the procedures are supposed to be clearer together with the outcomes of each step.

### **2.3 Don Norman's 3 Levels of Emotional Design**

There are different languages to discuss emotions in the field of design [6]. Jordan has discussed the four-pleasure framework for considering pleasure with products, in his book "designing pleasurable products: an introduction to the new human factors", which models four types of pleasure—physical, social, psychological, and ideological [7]. Desmet has proposed a framework of nine sources of product emotions, as an

approach to emotion-driven design, with the combination of three appraisals (usefulness, pleasantness, and rightfulness appraisals) and three levels of person-product relationships (product-focus, activity-focus, and self-focus) [8]. Further, Destmet has introduced a set of 25 positive emotion types, elaborated from an analysis of 150 positive emotion words, and six sources of positive emotion in human-product interactions. Here, emotions can be evoked by the object, the meaning of the object, the interaction with the object, the activity facilitated by this interaction, people themselves, and others involved in the interaction [9]. Norman has suggested the three levels of processing – the Reactive, the Routine, and the Reflective [10], and when the theoretical work is applied to design, the three levels translate to Visceral level design and Visceral responses, Behavioral level design and responses, and Reflective level design and responses [11].

In this research, the focus is not to measure what particular emotions scents can evoke, but to explore the effects of scents on the general valence of people's emotion (positive v.s. negative). That is how scents can lead to more positive emotions. Though the 3 Levels of Processing raised by Don Norman may seem to be an oversimplification of the actual processing, as he indicated in the book "The Design of Everyday Things" [12], it can be viewed as a useful approximate model of human cognition and emotion. And we think the 3 Level of Emotional Design raised by Norman interweave both emotions and cognition and can imply the mechanisms how scents can influence the product experience in people's seeing, feeling, using, owning, and thinking about a product or an experience. Therefore, we adopted it as the approach.

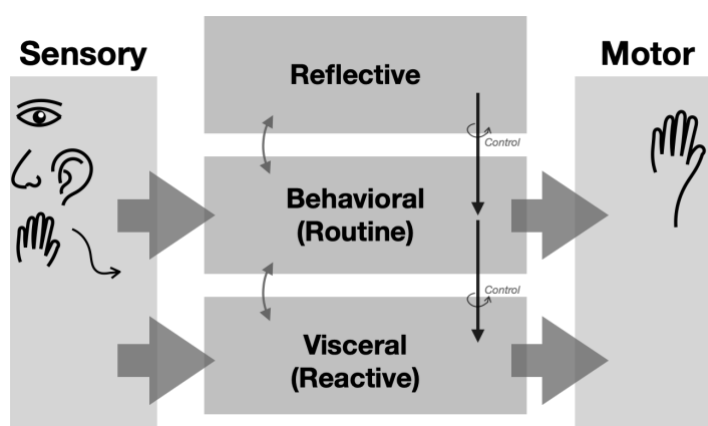


Figure 3-1: Three levels of processing in Norman's theory: Visceral, Behavioral, and Reflective (Adapted from the figure in the book [11])

As indicated in Figure 3-1, the three levels involve different depth of processing and have different implications for emotional design. These levels are [11]:

- **Visceral** (also called as "reactive" in Norman's scientific publications): related to the

automatic, prewired layer of the brain; biologically determined; can be inhibited or enhanced by signals from other two levels; about “now”; about immediate perception; about immediate emotional impact; about attraction or repulsion; where the style matters (appearances: sound, sight, touch or smell); about the first impression and initial impact, etc.

- **Behavioral** (or “routine”): related to the part of the brain that contains the brain process controlling behavior; can be inhibited or enhanced by the reflective layer; about “now”; about use and experience with a product; sensitive to experiences, training, education; function, performance, usability, understandability and physical feel matter; every action is associated with an expectation, etc.

- **Reflective**: related to the contemplative part of the brain; about long-term relations; sensitive to experiences, training, education and individual differences; about interpretation, understanding, and reasoning; about the pride, satisfaction, or shame of owning, displaying, and using a product; about message, culture, the meaning; about the self-image or the image people present to others; about the overall impression of a product, etc.

We would analyze the grouped samples in each of the 3 Levels and discussed the results in later sections.

## **2.4 Introduction of the samples representing 25 smell-related consumer products and experiences**

As we introduced in 2.1, there are mainly two forms of samples we selected for further research. Some samples represent particular categories of product (or experience). Inevitably, products belong to such samples may be different in details. The other samples are specific products or experiences, representing certain possibilities and potentials of applying scents. To make readers have a better understanding of them, especially the latter ones, we would have a brief introduction of the 25 samples of smell-related consumer products and experiences in this part, the overview of the common appearances of the 25 samples can be found in Figure 3-2 in the end of this part.

- Food, without doubt, is one of the everyday objects that people cannot live without. As revealed, for food products, smell (second to taste) plays an important role [13]. Food products can take various forms. In this study, as a sample of smell-related products, the food is referred to as things that people eat with detectable inherent smells, not packaged.

- Fragrance in retail stores and hotels, represents the application of ambient scent in some retail settings and some spaces that provide certain services.

- Mosquito repellent incense is used to mainly repel mosquitos. The line-up of it now includes some products with elaborated aromas.
- Air freshener typically makes the air in an interior space, such as homes or commercial spaces, smell more fresh and pleasant.
- Deodorant represents product released into the air or applied to the skin to mask or suppress unwanted smells.
- Fabric softener is typically a conditioner that people put in water when washing clothes to make the clothes feel softer and smell more pleasant. The line-up is now full of products with various fragrances.
- Cosmetic and skincare products (Scented shampoo, hand cream, etc.), refer to scented cosmetic and skincare products, such as scented shampoo, and hand cream.
- Perfume is typically a fragrant liquid that people put on their skin or clothing to give pleasant scents to their bodies.
- Essential oil is an aromatic, volatile oil typically extracted from a plant with a strong smell.
- Reed diffuser is a product to disperse essential oils into the air around. The reeds or sticks will absorb the oils and diffuse the scent, without the use of heat or flame.
- Incense stick is made from fragrant woods or grasses. When burned, it will produce a scent.
- Electric aroma diffuser typically uses ultrasonic waves to vaporize the water and essential oils and diffuses mist to spread the aroma. In many cases, it can be used as a humidifier.
- Incense burner is a container for holding burning incense.
- Portable fan with aroma tray, refers to a portable electric fan, in which the users can install an aroma tray so that they can also feel a pleasant scent when they switch on the fan. It exemplifies one way to apply scent as an additional optional function.
- Point-of-sale scent refers to the scent samples that can deliver the scents of certain products, which people can smell at the shelf before they make purchase decisions.
- Scented attraction in amusement parks, refers to some attractions in amusement parks that add sensory elements including the scents to augment the experience.
- The aroma of coffee at Starbucks stores, is exactly what the name indicates. It exemplifies the signature scents in some spaces.
- Gas is a clear substance used as fuel for heating or cooking. Natural gas in its native state is odorless. Mercaptan, which stinks, is added to natural gas to make it easier to detect the leak of gas.
- Scentee Machina (IoT room diffuser) is the room diffuser equipped with IoT technology. All the controls are done with the smartphone app. Users can manipulate

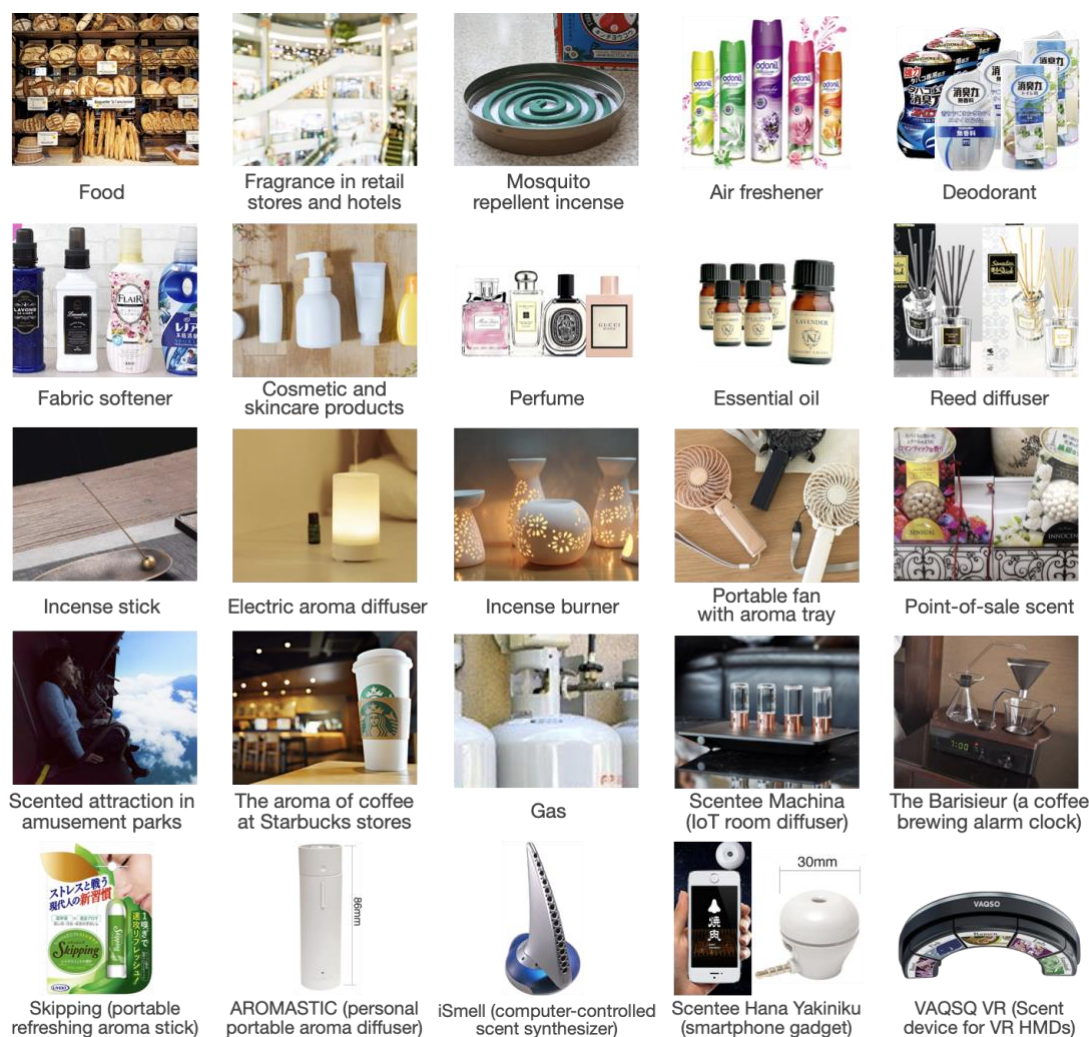


Figure 3-2: Overview of the common appearances of the 25 samples

the scent, check the condition of the device, and set a timer by their smartphones.

- The Barisieur (a bedside coffee and tea brewing alarm clock) is a coffee maker alarm clock that wakes the user up with a freshly brewed tea or coffee. It exemplifies the application of scent to accompany certain experience, which in this case is the experience of waking up together with the sound of the alarm clock.
- Skipping (portable refreshing aroma stick) is a portable refreshing aroma stick with the scent of citrus mint. The size of it is no bigger than a lipstick. It exemplifies a portable scent product with an affordable price, which people can carry around and use the scent of mint to refresh themselves easily.
- AROMASTIC (personal portable aroma diffuser) is a personal portable aroma diffuser, which is charged by micro-USB. Each device should be equipped with a scent cartridge, which typically contains five different aromas. It will release the aroma when the user is pressing the button, and the aroma will not spread and impact other people except the user.

- iSmell (a concept of a computer-controlled scent synthesizer device), is a prototype raised by Digiscents in 1999 aiming to enhance the Internet experience. In the concept, it was a scent synthesizer device connected to a computer, and with 50-128 so-called primary odors, it could replicate different scents by certain mixtures of the primary odors. Though the company failed to make it a reality, it did bring the ideas of computer-controlled scent systems to the foreground.
- Scentee Hana Yakiniku (aroma-dispensing smartphone gadget) refers to using Scentee Balloon with the theme scent kit Hana Yakiniku (“tasting the grilled meat with nose” in Japanese). The device of Scentee Balloon is attached to the smartphones. It should be equipped with one of the three scent cartridges of the Hana Yakiniku kit beforehand to release certain scent. And the Hana Yakiniku app can control the release of the scent and show the grilled ingredient on the screen.
- VAQSQ VR (Scent device for Virtual Reality HMDs) is a device adding scents to the VR experience. It can be attached to HMDs (Head Mounted Displays). Users can feel the scent simultaneously with the scenes and actions on the VR experience. Since VR is a technology that has gained broad attention in recent years, it is necessary to have a sample exemplifying the combination of scent and such technologies.

In the next part, we would present the outcomes of each step and the results.

### 3. Results

#### 3.1 Quantification Theory Type III: Similarity and Spatial Structure of Samples

In this study, we have chosen 25 samples representing 25 different smell-related consumer products and experiences and extracted 17 categories that refer to the smell-related features and relevant important characteristics of the products. We examined each sample with the 17 categories, and get a response (dummy) matrix, as shown in Table 3-1. The qualitative data was analyzed by Quantification Theory Type III.

**Table 3-1: Response (dummy) matrix of smell-related samples and response categories**

	the scent lasts for a long time	the scent is transient after being triggered	the scent affects the surroundings (not targeted at a particular person)	targeted at a single user	the scent acts on a particular object/person, but people around can feel it	people enter the scent (passively surrounded by the scent)	the scent spread naturally or with heat	electricity-involved	the scent is an added element to products with other main functions	the scent is essential to the product	the product contains other functional chemical composition except for the scent	the scent in use is portable or wearable	connected to computer or smartphone	the release time and intensity is relatively controllable	natural	involving additional purchase of the scent	the scent is relevant to the presented contents or semantic features of the product
Fragrance in retail stores and hotels	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Scented attraction in amusement parks	0	1	0	0	0	1	0	1	1	0	0	0	1	1	0	0	1
The aroma of coffee at Starbucks stores	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0
Fabric softener	1	0	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0
Air freshener	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0
Deodorant	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0
Reed diffuser	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Incense stick	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Essential oil	1	0	0	0	1	0	1	0	0	1	1	1	0	0	0	0	0
Incense burner	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0
Electric aroma diffuser	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0
Perfume	1	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0
Portable fan with aroma tray	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0
Point-of-sale scent	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1
VAQSQ VR (Scent device for Virtual Reality HMDs)	0	1	0	1	0	0	0	1	0	1	0	1	1	1	0	1	1
(Smell (concept of a computer-controlled scent synthesizer device))	0	1	0	1	0	0	0	1	0	1	0	0	1	1	0	1	1
Skipping (portable refreshing aroma stick)	0	1	0	1	0	0	1	0	0	1	1	1	0	0	0	0	0
Gas	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Mosquito repellent incense	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0
Cosmetic and skincare products (Scented shampoo, hand cream, etc.)	1	0	0	0	1	0	1	0	1	0	1	1	0	0	0	0	0
Food	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1
The Barisieur (bedside coffee and tea brewing alarm clock)	0	1	0	0	1	0	0	1	0	1	1	0	1	1	0	0	1
AROMASTIC (personal portable aroma diffuser)	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	1	0
Scentee Hana Yakiniku (aroma-dispensing smartphone gadget)	0	1	0	0	1	0	0	1	0	1	0	1	1	1	0	1	1
Scentee Machina (IoT room diffuser)	1	0	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0

The Quantification Theory Type III results showed that the eigenvalues of the first, second, and third dimensions were respectively 0.5579, 0.3258, and 0.2816. We would use only up to the second dimension because of the little difference between the second and third dimensions. Based on the category scores up to the second dimension, we plotted the 17 categories into a two-dimensional space, which created the scatter plot of category scores. As shown in Figure 3-3, in the first dimension (horizontal axis), the category “the scent is transient after being triggered” is on the positive side (right side),

while the category “the scent lasts for a long time” is on the negative side (left side). It indicates the horizontal axis is the axis relevant to “time”. On the other hand, in the second dimension (vertical axis), the categories of “people enter the scent (passively surrounded by the scent)” and “the scent affects the surroundings (not targeted at a particular person)” are on the positive side (upper side). Meanwhile, the categories of “targeted at a single user”, “the scent acts on a particular object/person, but people around can feel it” and “the scent in use is portable or wearable” are on the negative side (lower side). Therefore, the vertical axis can be viewed as the axis related to “space”. To put it more concretely, for the horizontal axis (the axis of time), the left end indicates “the scent is long-lasting” and the right end indicates “the scent is transient after being triggered”. For the vertical axis (the axis of space), the upper end and the lower end respectively indicate “the scent acts on a large space” and “the scent acts on a small space”.

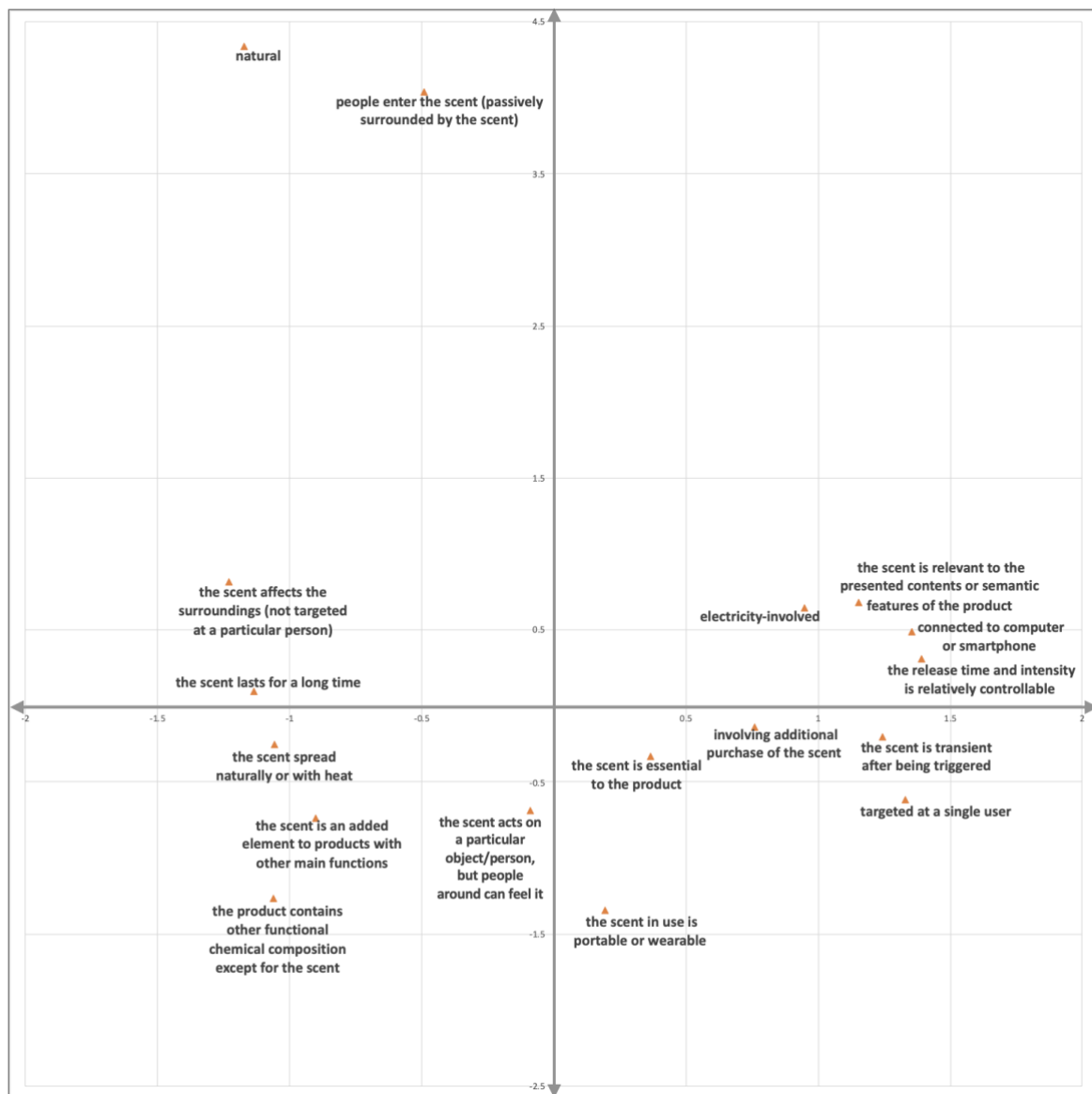


Figure 3-3: Scatter plot of category scores

When we plotted the 25 samples into the scatter plot based on the sample scores up to the second dimension, we combined the interpretation of the two axes into the plot. The Figure 3-4 shows the similarity and spatial structure of the samples, from which we can generally know the distribution of the samples and the relationships of these smell-related products and experiences.

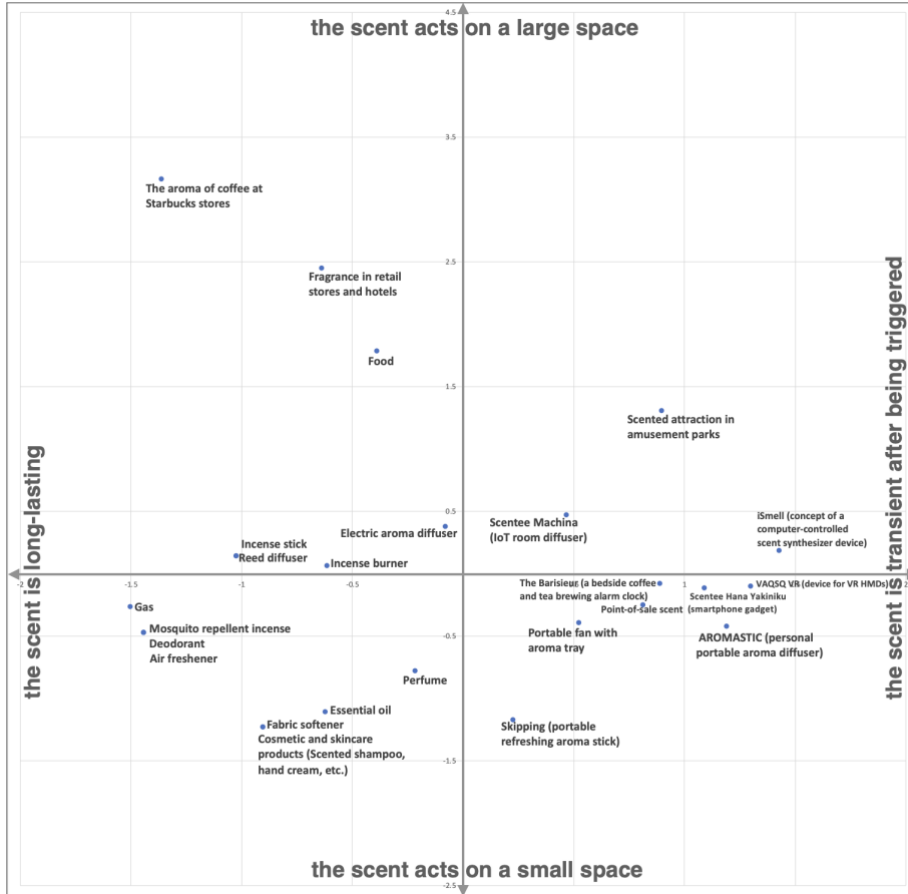


Figure 3-4: Similarity and Spatial Structure of Samples

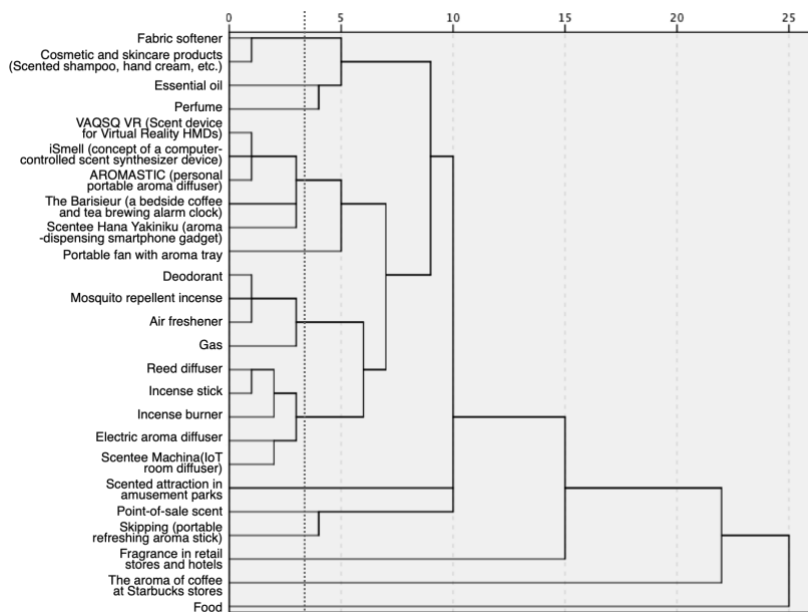


Figure 3-5: dendrogram from the hierarchical cluster analysis. The grey dotted line represents the pruning level to generate clusters.

### 3.2 Classification by hierarchical cluster analysis

As indicated in Figure 3-4, some samples show a tendency to congregate, while some other samples are separate from the others. To further clarify the similarities and relationships of these samples, we conducted a hierarchical cluster analysis using the first five sample scores of the 25 samples. Here, the analysis was done by the nearest neighbor-clustering method, and the sample scores were from the results of Quantification Theory Type III. From the hierarchical cluster analysis, we got a dendrogram as shown in Figure 3-5. As indicated in the Figure, the grey dotted line is what we used to get a reasonable grouping. The 13 clusters from this step represent the preliminary grouping of the samples. The 13 groups were as follows.

The Gas, Mosquito repellent incense, Air freshener, and Deodorant were in one group. As for their main similarities, they all have functional chemical compositions except for the scent; the scent is an added element in these products; the scent is relatively lasting.

The Fabric softener, and Cosmetic and skincare products (Scented shampoo, hand cream, etc.) were in one group. Similar to the above group, the scent is an added element to these products that have other main functions. Here, the scent acts on a particular object/person, but people around can feel it.

The Incense stick, Reed diffuser, Electric aroma diffuser, Incense burner, and Scentee Machina (IoT room diffuser) were in one group. For them, the scent, which affects the surroundings instead of targets a particular person, is essential to the product experience.

The Barisieur (a bedside coffee and tea brewing alarm clock), Scentee Hana Yakiniku (aroma-dispensing smartphone gadget), AROMASTIC (personal portable aroma diffuser), iSmell (a concept of a computer-controlled scent synthesizer device), and VAQSQ VR (Scent device for Virtual Reality HMDs) were divided into one group. They all are electricity-involved and targeted at a particular single user. In these samples, the release time and intensity of the scent are relatively controllable, and the scent after being triggered is transient.

In addition, there were 9 samples that form independent groups by themselves. They were: the aroma of coffee at Starbucks stores; Fragrance in retail stores and hotels; Food; Essential oil; Perfume; Skipping (portable refreshing aroma stick); Portable fan with aroma tray; Point-of-sale scent; Scented attraction in amusement parks. By the hierarchical cluster analysis, we attempted to reveal the similarities among different samples. In this study, the 25 samples represent 25 different smell-related consumer products and experiences, which hold different features distinguishing them from other samples. Therefore, it was reasonable that some of these samples were not grouped

together with other samples in this step. However, their distribution in the scatter plot indicated that further examination of the grouping was necessary to some extent.

### 3.3 Further grouping based on the 3 Levels of Emotional Design

Because the grouping by the hierarchical cluster analysis was conducted based on the results of Quantification Theory Type III, the groups we got in last step might fail to reflect the similarities or differences of the samples on how the scents deliver the emotional effects in the product experience. Therefore, we examined the scents' effects on the product experience from the perspective of Don Norman's 3 Levels of Emotional Design and further combined or separated the groups based on the semantic similarities of scents' effects in 3 Levels of Visceral, Behavioral, and Reflective.

By doing so, "the aroma of coffee at Starbucks stores" and "Fragrance in retail

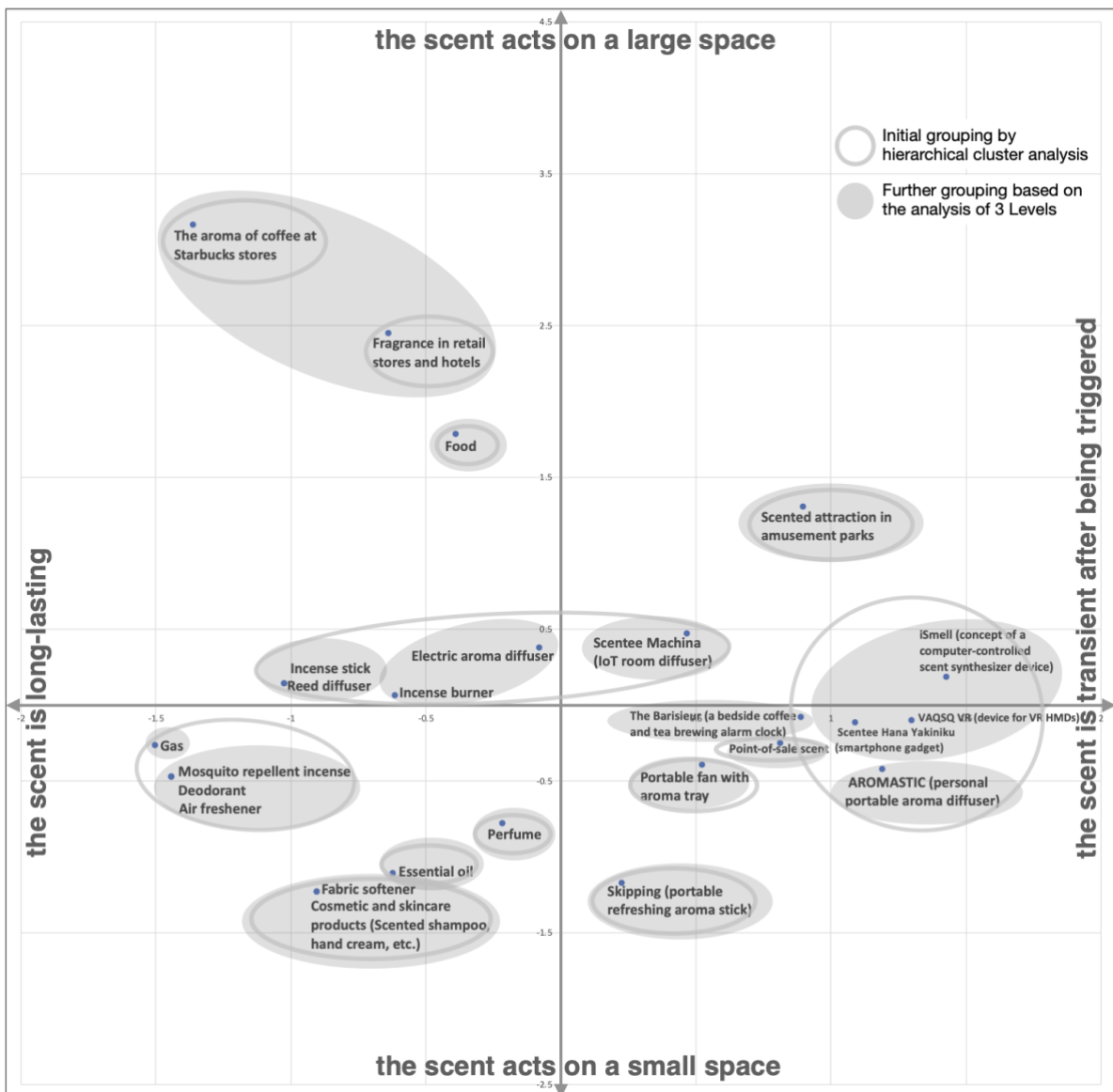


Figure 3-6: The grouping by hierarchical cluster analysis and the analysis based on 3 Levels

stores and hotels” were combined into one group. “Gas” was separated from the original group and formed a group individually. The group in the middle of the scatter plot was divided into 3 groups: “Incense stick” and “Reed diffuser”; “Electric aroma diffuser” and “Incense burner”; and “Scentee Machina (IoT room diffuser)” individually. The group in the right side of the scatter plot was also divided into 3 groups: “Scentee Hana Yakiniku (aroma-dispensing smartphone gadget)”; “iSmell (a concept of a computer-controlled scent synthesizer device)” and “VAQSQ VR (Scent device for Virtual Reality HMDs)” in one group; “The Barisieur (a bedside coffee and tea brewing alarm clock)” individually in one group; and “AROMASTIC (personal portable aroma diffuser)” individually. The grouping was showed in Figure 3-6.

### 3.4 Emotional Effects of Scents on Smell-Related Consumer Products and Experiences

As we mentioned, we had examined the scents’ emotional effects in the samples from the 3 Levels – visceral level, behavioral level, and reflective level, before we conducted the further grouping. The results revealing the emotional effects of scents on the product experience of samples in different groups were summarized below in Table 3-2.

**Table 3-2: The roles of scents in the samples from the 3 Levels of Emotional Design**

Samples	Norman’s 3 Levels of Emotional Design		
	Visceral Level	Behavioral Level	Reflective Level
<b>The aroma of coffee at Starbucks stores</b>	When people enter the space, they will perceive the ambient scent. The scent may lighten their mood, evoke their desire for a certain thing, influence their first impression of the space, and build an emotion base for the subsequent behaviors, even when people are sometimes unconscious of it.	The scent would not necessarily lead to certain actions and behaviors of the users, but as proved by some researchers, the ambient scent would possibly influence people’s action or behavior tendency. (The potential manipulation of people may sometimes raise ethical concerns.)	The scent may help to enhance people’s memory and familiarity with certain brands and spaces or locations and increase people’s overall impression of the product or experience.
<b>Fragrance in retail stores and hotels</b>			
<b>Food</b>	When the scent floats into people’s noses, it would cause people’s immediate instinctive responses, appetite (a desire for food), expectation, or in contrast, repulsion.	When people eat food, the scent is often an important factor influencing the food flavor and eating experience. Good smell may contribute to the pleasure of the eating experience at the moment. Meanwhile, the smell preceding the action of eating would form people’s expectation towards the taste.	The scent would influence people’s satisfaction and overall impression of the eating experience and food. In addition, about some food with bitter and sour tastes and smells that people initially dislike, people can learn affection towards such food by rationalization.
<b>Gas</b>	The smelly unpleasant featured scent can trigger people’s instinctive alert response, and inform people of the potential danger of a gas leak	After detecting the abnormal smell, people can take actions such as checking the gas, ventilating the space, or getting away from the spot.	When there is no abnormal scent, the space where people are can be interpreted as safe without a gas leak.

<b>Mosquito repellent incense</b>	When the product fulfills its main function, the added scent can meanwhile make the particular space smell more pleasant. Thus, people in the space would feel better.	People should act to set up the product. The scent for these products is an additional element, which can serve as a feedback or sign of the product's functioning.	The scent may improve people's satisfaction and overall impression of the product.
<b>Air freshener</b>			
<b>Deodorant</b>			
<b>Fabric softener</b>	After the use of these products, the scent remaining on the object (or people's skin or hair) would evoke a pleasant feeling.	With people's action to use the product, the scent would diffuse. These products can still function without the additional scent. However, with the added scent, the scent can serve as a feedback, making users feel clearer that "the products are used and functioning". Besides, the scent can increase the enjoyment of using the product at the moment.	In the line-up of these products, there is often no lack of scent options. Except for the scent, these products have their own main functions. The scent, as an additional element, can provide another angle for people to make their purchase decisions based on personal preferences. Now, many products use the scent to do the storytelling of the brand, from which people can get the message and meaning of choosing the product. Also, the scent can improve the satisfaction and overall impression of the product experience and help to justify the value of the product. Compared with perfume, using these products to make people smell nice is a milder way to show people's taste, lifestyle, and attitude.
<b>Cosmetic and skincare products (Scented shampoo, hand cream, etc.)</b>			
<b>Perfume</b>	The scent of perfume can arouse users' instinctive affective responses. On the other hand, it may impact other people's first impressions of the user.	When using the perfume, people may form an expectation of the scent based on the design of the perfume bottles. If the real perception did not fail the expectation, this may lead to a good feeling. For people who have the habit of using perfume, the routine of using perfume followed by a pleasant scent may be a source of enjoyment.	There is a wide choice for the perfume product. The story of the product (the story of the scent, production-related story, etc.), the message it conveys, and the scarcity of the product would influence how people value the perfume. The process of users choosing a product involves their thinking about their preference and self-image. The choice and use of the perfume, can reflect the taste, sense, and self-image of the user, and also convey some messages to the outside world.
<b>Essential oil</b>	The scent of essential oils can arouse users' instinctive responses. The aromatic compounds are thought to help to induce relaxation, relieve pain, and so on, depending on the essential oils people use.	There are various ways to use essential oils. Except for the direct sniff, it can be used in different types of aroma diffusers or added to other products. For different oils, people would have different expectations towards the function it may fulfill.	There is a wide choice for the essential oil product. In choosing and using the product, people would have a consideration about themselves, their lifestyles, and well-being. It also reflects people's pursuit of healing and inner peace.
<b>Reed Diffuser</b>	The scent created by the product in use can make a particular space smell more pleasant. Thus, people in the space would feel better.	People should set up the product before the scent diffuses. When doing this, they may have an expectation of the scent. If the real scent satisfies the expectation, it may lead to a positive emotion.	There are many products available for selection in the line-up of these products. In selecting the scent, people may consider their preferences, and the ambience they would like to create. People may have a sense of satisfaction when the scent they chose turned out to make the space smell good.
<b>Incense stick</b>			

<p><b>Electric aroma diffuser</b></p>	<p>The scent diffused by the product in use with the source of the scent can make a particular space smell more pleasant. Thus, people in the space would feel better.</p>	<p>The use of these products entails the selection of the scent source, set up the scent source in the product, and actions to start the scent diffusion. The scent will spread in the space until people switch it off or the scent source runs out. If the scent meets people's expectations, it may lead to positive emotions.</p>	<p>There are various scent sources that people can choose to use in these products. In selecting the scent, people may consider their preferences, and the ambience they would like to create. People may have a sense of satisfaction when the scent they chose turned out to make the space smell good.</p>
<p><b>Incense burner</b></p>	<p>The scent diffused by the product in use with the source of the scent can make a particular space smell more pleasant. Thus, people in the space would feel better.</p>	<p>The use of these products entails the selection of the scent source, set up the scent source in the product, and actions to start the scent diffusion. The scent will spread in the space until people switch it off or the scent source runs out. If the scent meets people's expectations, it may lead to positive emotions.</p>	<p>There are various scent sources that people can choose to use in these products. In selecting the scent, people may consider their preferences, and the ambience they would like to create. People may have a sense of satisfaction when the scent they chose turned out to make the space smell good.</p>
<p><b>Scentee Machina (IoT room diffuser)</b></p>	<p>The scent diffused by the product in use can make a particular space smell more pleasant. Thus, people in the space would feel better.</p>	<p>The diffusion of the scent is controlled by the smartphone app. Users can also check the amount of the scent leftover, set a timer for the scent diffusion by the app. If the scent delivered by the device meets the expectation, it may lead to a positive emotion, otherwise, it may cause negative emotions.</p>	<p>The process of considering in what time and context to switch on the scent diffusion would allow users to think about their own lifestyles. The product turns the aroma diffuser into an IoT (Internet of Things) device, which may bring the user the pride of ownership or use. Meanwhile, using the product reflects people's pursuit of life quality.</p>
<p><b>Portable fan with aroma tray</b></p>	<p>With a pleasant scent, the wind from the fan can make people feel better.</p>	<p>Users may have to set up the optional added scent when they use it for the first time. After the set-up, they can switch on the device and feel the coolness caused by the wind, together with the additional scent. The scent may increase the enjoyment of using the product.</p>	<p>The additional scent may improve people's satisfaction and overall impression of the product.</p>
<p><b>Point-of-sale scent</b></p>	<p>The scent can evoke users' instinctive responses. The scent may help people form their first impressions of certain products.</p>	<p>People see certain products on the shelf, and then know the scent by the act of sniffing the point-of-sale scent. If the scent meets the expectation, it may lead to a positive emotion.</p>	<p>People's judgement on whether the scent meets their own preferences would influence their impression of the product and the following purchase decision.</p>
<p><b>The Barisieur (a bedside coffee and tea brewing alarm clock)</b></p>	<p>In this product, the sounds of the alarm and the coffee bubbling way, together with the smell of coffee, which would evoke people's instinctive response, wake people up in the morning.</p>	<p>Users have to prepare the water and coffee powder in advance and set up the alarm clock. The next day, the device will brew the coffee on time. And people can wake up and start a new day with the aroma of freshly brewed coffee. It may make people feel better in waking up.</p>	<p>The aroma of coffee contains a message related to habits, lifestyles, and self-fulfillment (such as self-discipline). The scent may remind the users of the self-image they want to present to themselves.</p>
<p><b>Skipping (portable refreshing aroma stick)</b></p>	<p>The scent is supposed to make people feel refreshed, help to relieve the stress, or raise concentration.</p>	<p>By the simple action and conscious sniffing, the user can immediately perceive the functional scent. If the user feels that the scent has fulfilled the expected function, it may further evoke the user's positive emotions.</p>	<p>The scent is perceived in particular time and scenes, and thus may be related to the time and use scenes. When people recollect the experience, the existence of scent may moderate the emotions of the related memory.</p>
<p><b>AROMASTIC (personal portable aroma diffuser)</b></p>	<p>The scent generated from the product can evoke the user's immediate positive reactions.</p>	<p>To make the product diffuse a certain scent, the actions are simple. If the scent following the simple action meets the user's expectation, it may make the product experience evoke more positive emotions. If it fails the expectation, negative emotions would possibly occur.</p>	<p>The scent is perceived in particular time and scenes, and thus may be related to the time and use scenes. When people recollect the experience, the existence of scent may moderate the emotions of the related memory.</p>

<p><b>Scented attraction in amusement parks</b></p>	<p>People enter a space (experience) where the scent and other components (contents or information) are programmed in advance. The scent is relevant to the presented contents. The contents may feel more vivid. And the experience may be more immersive with the added scent, the input from the sense of smell. If the quality of the scent is not good, the presence of scent may induce negative responses, such as repulsion.</p>	<p>When people enter the setting of the experience, they do not have to trigger the scent by themselves. The scents come as programmed. During the experience, if the scent does not fit in well with people's real-time expectation of it based on the experience contents, it may lead to negative emotions.</p>	<p>The scent is perceived together with other contents. The scent may make the contents and the experience more memorable. When they recollect the related memory, they may also recall the scent there. Or when they smell the scent in other places, the memory of the contents and the experience may be recalled.</p>
<p><b>iSmell (concept of a computer-controlled scent synthesizer device)</b> <b>Scentee Hana Yakiniku (aroma-dispensing smartphone gadget)</b> <b>VAQSQ VR (Scent device for Virtual Reality HMDs)</b></p>	<p>The scent is relevant to the presented contents. With the triggered scent, the contents may feel more vivid. And the experience may be more immersive with the added scent, the input from the sense of smell. If the quality of the scent is not good, the presence of scent may induce negative responses, such as repulsion.</p>	<p>People need to set up the device before the diffusion of the scent is triggered. If the scent does not fit in with people's expectations of the scent that they form based on the contents, it may lead to negative emotions.</p>	<p>The scent is perceived together with other contents. The scent may make the contents or the experience more memorable. When they recollect the related memory, they may also recall the scent there. Or when they smell the scent in other places, the memory of the contents and the experience may be recalled.</p>

On the whole, from the three columns, we could respectively extract such keywords (key sentences) representing the scents' roles in each of the Levels of Visceral, Behavioral, and Reflective, as follows.

In Visceral Level, the scent could impact people's first impressions of the products and experiences (or people who are using the product), trigger instinctive responses (such as pleasure, and a desire for something), bring about good feelings (relaxation, refreshment, for example), and make certain contents feel more vivid. On the other hand, the smelly, unpleasant scent can also induce people's instinctive reactions, which can alert people or attract their attention.

In Behavioral Level, the scent could affect people's action or behavior tendency possibly, constitute the experience of product consumption/use as a component, serve as feedback of the product use, and enrich the pleasure in the process of using the product. It also has something to do with the expectation, either the expectation of the scent formed based on other elements of the product (such as the product's appearance, brand, the marketing storytelling, or the stereotype about the product), or the expectation of the product experience formed on the perception of the scent. Both types of expectations will be checked in the product consumption/use. Besides, in some products, the scent is the main functional component. Therefore, the performance of the scent in use reflects whether it functions well and how the usability is, and accordingly cause emotions in the Behavioral Level.

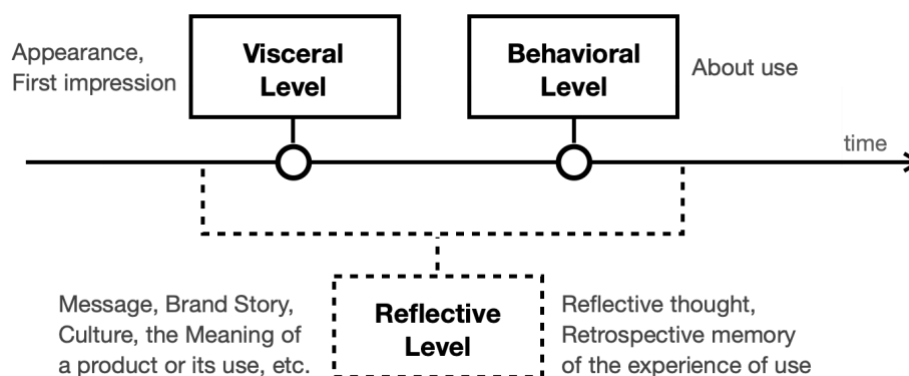
In Reflective Level, the scent may influence people's overall impression and

satisfaction with the product/experience, help to convey the messages about the story of the brand, product and experience, the concept, and the meaning (even serve as a signature). It may also involve people's thinking about the self-images, personal preferences, and the lifestyles they want to have or show to the outside world, and increase people's pride of their ownership or use of the product. Besides, the scent may be related to certain times, scenes, and contexts, making them more memorable or moderating the emotions of the related memory.

The above was the general summary of the scents' potential emotional effects on the product experience in the 3 Levels, based on the interpretation of the samples. Reviewing the Table again, we would find that in different groups of smell-related products and experiences, the ways the scents play the emotional roles from the 3 Levels were quite different. However, at the same time, despite the difference, in some groups, there are similarities in when and where (even how) the scents deliver the effects. Based on this finding, in the next part, we would further discuss the patterns reflected by the results of how scents have emotional effects on smell-related products or experiences, and the patterns' implications for applying scents in product design.

## 4. Discussions

### 4.1 Three patterns: how scents have emotional effects on smell-related products or experiences



**Figure 3-7: The 3 Levels' relationship with time**  
(Adapted from the book by Noriko HASHIDA [14])

As mentioned in 2.3, the 3 Levels of Emotional Design are differently related to time. While the Visceral and Behavioral Levels are about “now”, about the real-time feelings and experiences when people actually seeing, feeling or using the product, the Reflective Level is about longer-term relations. Some researchers have used Figure 3-7 above to show the relationships of the 3 Levels of processing with time in Norman's theory [14]. It represents under Norman's 3 Levels of Emotional Design, normally how people have emotional responses in different phases when using a product or having a

certain experience.

In addition to the scents' emotional effects on product experience in 3 Levels as reflected by Table 3-2, the plot in Figure 3-4 or 3-6 indicated the features of the scent related to its function time and space in the product experience. Combining these, we have found 3 Patterns of how scents have emotional effects on smell-related products or experiences. The model revealed in Figure 3-7, has served as the basic model for the patterns. Admittedly, there must be individual differences in people's interaction with the product. To tackle this issue, we chose to focus on the commonest ways, which may ideally represent how most people would have the product experience. Besides, to classify different samples into a generalized pattern would inevitably lead to distortions of the details of the product or experience. For those samples located near the boundary between different patterns, we would briefly explain how we made the judgement. Also, it is worth noting that this study focused on the effects of the scent, so the analysis was mainly conducted around the scent. Obviously, there are many elements involved in a product experience. Although in this study, the roles of other elements would not be emphasized, attention should also be paid to their importance to the product experience.

The details of the three patterns are introduced as follows.

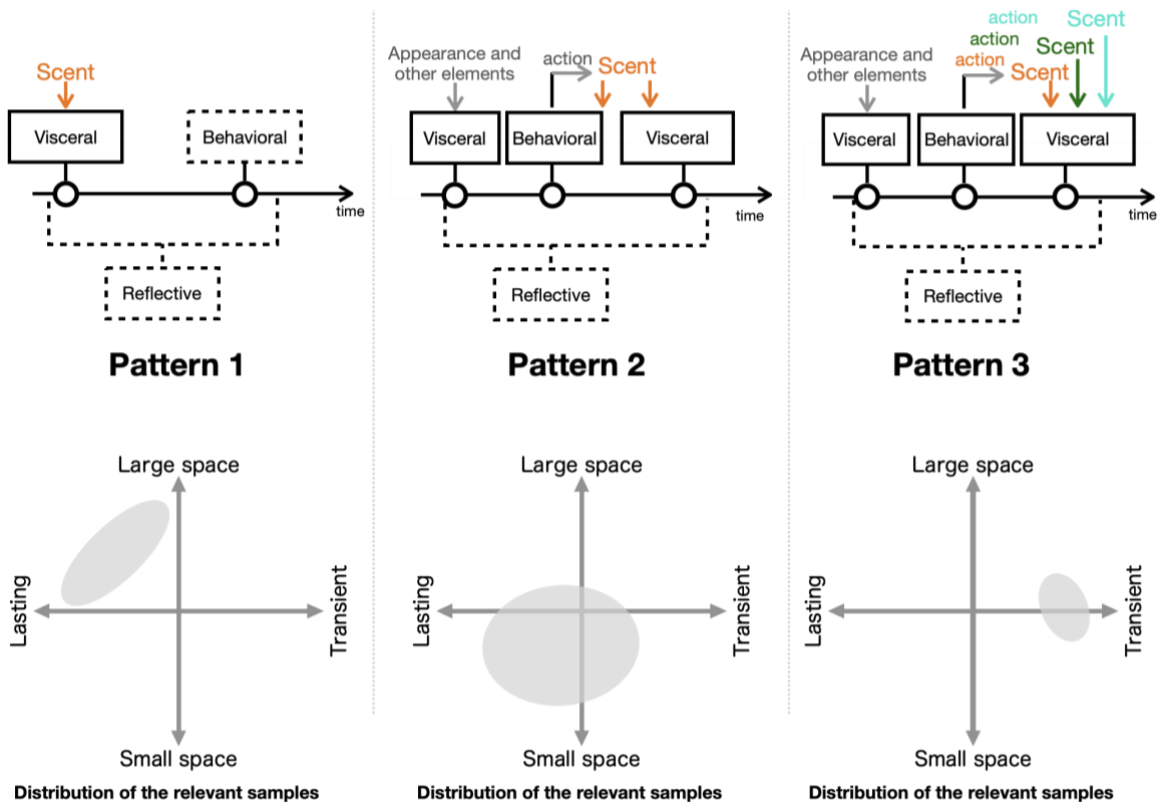


Figure 3-8: Overview of the patterns and the distribution of the corresponding sample

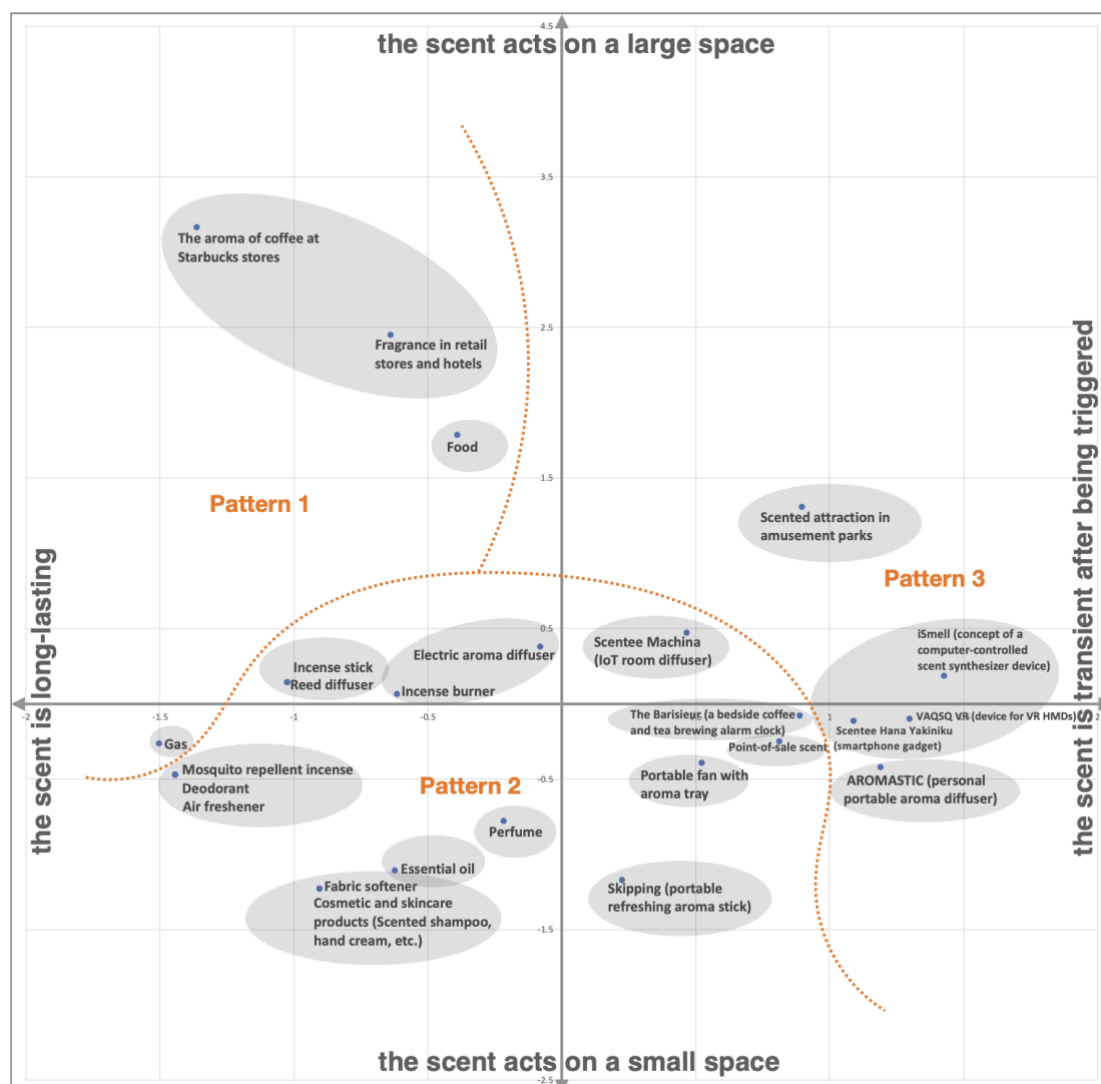


Figure 3-9: Concrete distributions of the relevant samples in each pattern

### Pattern 1

As indicated by Figure 3-8, in Pattern 1, the scent can act on people's visceral level (together with other elements) without the intended trigger from people. The effects on the visceral level may influence the following behavior or experience, or form people's expectation of the following experience. The subsequent actions would not affect the presence of scent, that is, people's behaviors would mostly not bring about changes in the scent itself. From the aspect of the Reflective Level, the scent may impact people's overall impression of the experience.

Among the 25 samples, the samples of the aroma of coffee at Starbucks stores, fragrance in retail stores and hotels, food, and gas belong to Pattern 1. The scent in some of them is the exemplification of the application of pleasant ambient scents. The scent in this pattern can also be the inherent attribute of the product, which can attract people and act as an important factor for evaluation. And the sample of gas exemplifies making use of people's instinctive repulsion to bad smells to alert people.

## **Pattern 2**

In Pattern 2, usually, people first perceive the product from other elements, such as the appearance, brand, advertising, and storytelling of the product, in Visceral and Reflective Levels. With a simple action or a series of steps to trigger the scent, the scent will come into play in a relatively stable state, and often it is relatively lasting (sometimes depending on users). Besides, the scent here acts on a relatively particular target space. After the appearance of the scent, it may act on the Behavioral Level, which is related to people's expectation of the scent, and the scent may serve as a feedback of the product being used. Meanwhile, the presence of the scent would also act on the Visceral Level at the moment, and the Reflective Level.

The samples belonging to Pattern 2 are: Mosquito repellent incense; Air freshener; Deodorant; Fabric softener; Cosmetic and skincare products (Scented shampoo, hand cream, etc.); Perfume; Essential oil; Reed diffuser; Incense stick; Electric aroma diffuser; Incense burner; Scentee Machina (IoT room diffuser); Portable fan with aroma tray; Point-of-sale scent; The Barisieur (a bedside coffee and tea brewing alarm clock); Skipping (portable refreshing aroma stick).

Some of them are products where the scent is the main functional component, while the others have their own functions where the scent is the additional element. There are two samples located next to the boundary between Pattern 2 and Pattern 3. They are the Point-of-sale scent, and the Barisieur (a bedside coffee and tea brewing alarm clock). Since the scent from one unit of them or the use of them for one time is relatively stable and not varying, they were considered to belong to Pattern 2.

In this study, considering how the scents deliver the emotional effects from Norman's 3 Levels of Emotional Design, over half of the samples follow Pattern 2. It is worth noting that for these products, it is people who determine when and where to use the product. And it would often raise people's thinking about the "self" of them in Reflective Level, including their self-image, personal preferences, lifestyles, and messages they want to convey to themselves or to the outside world.

## **Pattern 3**

In Pattern 3, similar to Pattern 2, the scents come into play after being triggered, either by people or by the system. In Pattern 3, the scent is related to certain scenes or contents, and it is relatively dynamic and changeable. In the experience, the change is either caused by the user's active action, or by the system as programmed.

The samples belonging to Pattern 3 are: Scented attraction in amusement parks; iSmell (a concept of a computer-controlled scent synthesizer device); VAQSQ VR (Scent device for Virtual Reality HMDs); Scentee Hana Yakiniku (aroma-dispensing smartphone gadget); AROMASTIC (personal portable aroma diffuser). The scents in

some of them are related to certain contents, aiming to enhance people's experience of the contents. Or, the scents mainly focus on different use scenes, to fully fulfill the scents' effects to moderate the emotions. In Pattern 3, the changeable scents serve particular contents or scenes.

In this part, we have outlined the 3 Patterns of how scents have emotional effects on smell-related products or experiences. In the next part, we would explore the implications of these Patterns and the relevant samples for the possibilities of applying scent in (product) design.

## **4.2 Implications of the three patterns for applying scents in (product) design**

As indicated by our analysis of the samples, in smell-related product experience, the scents can contribute to evoking more positive emotions more or less in different phases, or utilize people's instinctive emotional response to certain scents to achieve other goals instead of positive emotions, such as alerting people to danger. It was revealed that there are different patterns of how scents have emotional effects on product experience from the perspective of 3 Levels of Emotional Design. Based on the three patterns we identified, we would discuss their implications for applying scents in (product) design. It is worth noting that different from the common problem-driven approaches to design, which aim to reduce or solve negative situations, behavior, or factors [15], this study has focused on exploring the possibilities of creating new scent-related products (or experiences) and applying scents in (product) design. That is, the main focus is on utilizing the scent to evoke more positive emotions rather than solving certain existing negative problems.

### **Implications from Pattern 1**

In Pattern 1, immediately people enter the space or are faced with the product, the scents together with other elements start to act on the Visceral Level. The scents may influence people's first impressions of the space, product, and experience, build a positive emotional tone for people, affect people's action and behavior tendency, and also impact their satisfaction and overall impression of the product experience. The samples in Pattern 1 have reflected the merits of applying the ambient scent and its application in sensory marketing. Also, it indicates the potential ways of using scent to improve the product experience of some other traditional products that usually do not carry an odor.

The scent has the potential to make people feel more pleasant. As Norman has said in the book, when people feel good, they would be more likely to find solutions for the

problems they encounter [11]. Therefore, for some puzzle products that require brains, the addition of a pleasant scent to it may contribute to a better experience, since people may be able to enjoy the process more fully. However, it should be noted that the scents in Pattern 1 do not have a direct relationship with people's actions in the experience. As the experience continues, people's actions may be more complex and they may receive more and more sensory information; thus, the effects of scent may be diluted and gradually become insignificant during the experience. This was also partly revealed in the experiment we conducted with the orange-shaped lego-like toy blocks in Chapter 2. The scents could affect participants' moods, but their effects on the product evaluation were not detected.

Furthermore, since the scent can influence people's first and overall impressions of a product, adding scents to products that are originally odorless may contribute to better first and overall impressions of these products. However, we should pay attention to the fact that not all products are like food. For food, it is natural and common to have a scent as an inherent attribute. For other products, people may already have a fixed idea about what these products should be like, based on the products' normal styles that people have got used to in daily lives. It is still unclear how to manipulate the scents of the originally odorless products and meanwhile make people think it is natural. Besides, there is a lack of a clear standard for the choice of an appropriate scent.

Although today the use of scent to mask the original bad smells of some products is common, the gas indicates the potential of utilizing bad smells appropriately. A moderate scent can be used when the space or product wants to remind people of danger or keep people away. Such effects are playing on the negative emotions. Some researchers have demonstrated that negative emotions can contribute to rich and meaningful experiences in some cases [16]. As revealed, bad smells can serve as a source of negative emotions, which might be potential in some cases. Notwithstanding, if we put the unpleasant smells into use, it is a must to carefully consider about the type of the smell, the intensity, and the space where it functions. The degree has to be carefully controlled, otherwise, the inappropriate use of the unpleasant smells may evoke people's strong negative emotions, such as disgust.

What's more, in Pattern 1, the scent acts on people in Visceral Level before people take further actions, implying that it might be possible to prime through smell. According to the Nudge theory, one of the behavior-focused approaches, altering the environment can "nudge" a person's automatic decisions [17]. The features of scents make it available as an "unconscious intervention". And some other researches have demonstrated that the scents do affect some of the human behaviors. Therefore, we think that when appropriately applied, the scent can be a vehicle to nudge for the good.

## **Implications from Pattern 2**

Among the 25 samples, 16 of them belong to Pattern 2, indicating the relative popularity of such smell-related products and experiences. In Pattern 2, before the scent is triggered, people first perceive the product from the appearance in Visceral Level, as well as brand, product advertising, and storytelling in Reflective Level. Based on this, for such smell-related products, we think there is plenty of room for design and innovation in the product appearance, form, the way/mechanism to trigger the scent, and the storytelling of the product. Designing these elements in a smart way can make the product more attractive, which may also gain a synergy with the scent that comes after being triggered and lead to a better experience as a whole. Taking perfume for example, the perfume industry has shown their efforts in designing the perfume bottles, colors of the fluid, packages, and advertisements to communicate the properties of the scent experiences. Further, there are two other examples for a better understanding of what we mentioned above. One of them is HA KO [18], a leaf-shaped incense made from Japanese washi paper. Another one is On&Off sansui [19], a crafted personal humidifier and aromatherapy diffuser, which combines traditional design elements of Chinese landscape painting with a modern expression.

Besides, extending the possibilities implied by the fabric softener, we may have such products that can add pleasant scents to other personal belongings like books or stationery products. As the scent in Pattern 2 often reflects personal preferences and works as a way of self-expression, it may also be desirable to have a customization service, by which people can have a unique version of the product created according to their preferences and requirements.

On the other hand, to apply scents to products that do not intentionally carry an odor, we could focus on the point that certain actions/behavior trigger the scent, which then acts on the Behavioral Level and Visceral Level. For those products that people can keep using for a particular length of time with the initial actions, or that are possibly used accompanied by negative emotions, it may lead to more positive experiences by adding scents to them. The scents are supposed to make the following experience more pleasant or help to reduce the negative responses. For example, if the masks were with pleasant scents, people may feel more positive and show better conditions when wearing masks, compared with the ordinary masks. For some exercise aid products, the addition of appropriate scents may help to elevate the users' performance, as breathing is important in exercise [20]. As for those products, the use of which may induce negative feelings, we may introduce a trick that the scent will be released to moderate the negative emotions when people are about to do the following actions. For example, we may design the mechanisms of the medicine package or container, or the envelopes

that are used to inform people of good or bad news.

Furthermore, the scents' effect in Reflective Level, which is often related to introspection and self-expression, indicates that the scents may enrich the experience of introspection or creation-related process or product experience. For instance, applying scents in meditation experience or relevant products may increase people's mindfulness during the experience [21]. Besides, for creativity-related products, for example, paints used for painting pictures, the addition of scents may bring people more sensory stimuli during the painting, make the experience more pleasant and lead to a richer expression [22].

### **Implications from Pattern 3**

Among the five samples belonging to Pattern 3, four samples were specific products to exemplify certain ways that scents can be applied. These samples did not have many parallel products in the market. And since they did not represent a typical, common, and prevalent application of scents, the discussion we would have as follows is more about the possible and potential application of scents reflected by these samples, rather than applying scents to other products' design.

The samples in Pattern 3 mainly indicated two directions. One is to pack several scents into a portable device so that people can carry it around, and the other one is to utilize scent as a media component presented together with other certain contents. The former one allows people to make use of the scents' effects on emotions in different contexts as they want, and the latter one assumes that adding scent, the olfactory sensory input, to the experience on the basis of audiovisual information can make the contents more vividly perceived. In fact, although such applications are still not prevalent, it has been applied or once applied in the cinema, Virtual Reality and even in front of a small screen to enhance the sense of realism/immersion/presence [23], which was also revealed by the samples in this study. Despite the fact that many commercial technologies aiming to engage olfaction never reached the market or have not lasted long [24], research laboratories have explored the potential of the olfactory display continuously. Even though about two decades after the bankruptcy of Digiscents (the company of the sample "iSmell"), the concepts of iSmell are still not realized, some promising olfactory display devices have begun to emerge in the consumer market. Perhaps, one day, iSmell's dream of making the Internet smell will come true.

In addition, the relations between scents and certain contents or contexts may indicate the possibility of applying scents to assist visually impaired and hearing-impaired people. The scent may be an option to communicate some messages. As a

media component, it may also be applied in Universal Design.

In this part, we have generally discussed the possible and potential ways to apply scents in product design. It is worth noting that at the current stage (general proposal), it is still difficult to predict the actual effects of adding scents on product expression and people's evaluations of it. It is possible that such efforts may appear to be meaningless when measured by experiments with certain questionnaires and assessment tools. However, the potential effect of scents to evoke positive emotions should not be ignored, and we should evaluate its effects on the overall product experience from a broader dimension, such as taking the pleasure into consideration.

### **4.3 Issues worth noting and limitations**

There were several issues and limitations worth noting, regarding the methods, results, and interpretation of the results in this study. We would discuss them respectively in this part. Hopefully, with an awareness of these issues and limitations, the outcomes of this study would be understood more properly.

#### **4.3.1 About the method, materials, and the perspective**

Attention should firstly be paid to the limitation of the samples we selected to represent different smell-related products and experiences. The scales of these samples were not necessarily parallel. As we mentioned in 2.1, some samples are particular categories of product (or experience), while the other samples are specific products or experiences representing certain ways that scents can be applied. Besides, although we attempted to cover the range of smell-related products and experiences as comprehensive as possible, it did not cover all of the related product and experiences, due to the limitations of the knowledge and the searching ability. We might have inevitably missed some products that would contribute to the outcomes of the study, but some of the products were intentionally excluded because they overlap other chosen samples.

Next is about the 17 categories, and how we examined the samples with these categories to create qualitative data for Quantification Theory Type III. As mentioned in 2.2, we obtained these categories by comparing different samples and identifying the features that distinguish one sample from another. Most of the categories were smell-related features or other relevant characteristics of the product/experience. There might be other meaningful categories that could cover certain features of the smell-related product/experience but we failed to identify in this study. As regards using the categories to check the samples, for those samples that represent certain product types,

we had to base the evaluation on their commonest styles, which fit in with people's perception mostly. However, it is worth noting that products belong to such samples may be different in several aspects, including the appearance and other details. Therefore, it is possible that some readers may find some descriptions in this study different from the personal experiences they have had.

To reveal the emotional effects of scents, we have chosen Don Norman's 3 Levels of Emotional Design as the approach, and we have analyzed respectively from the 3 Levels. However, this perspective did not help us to identify which specific emotions the scent could evoke. Although the "emotional effects" we focused on in this study were about the general valence of human emotions, namely positive or negative emotions, we have to notice that the positive emotions alone are already highly diverse. Some researchers have demonstrated consumers can experience at least twenty-five different positive emotions when using products [16]. The lack of further probing into the concrete emotions is one of the deficiencies of this study.

#### **4.3.2 About the results, the patterns, and the implications for applying scents**

In Table 3-2 and the three patterns we identified, for some of the samples, the results were based on the analysis of the commonest ways that most people would have product experiences with these samples. However, the products belonging to these samples can be different. The most explicit example might be food. As a sample in this study, we assumed that the food was exposed to the people in a directly edible condition, and we put it under Pattern 1. However, in our daily lives, processed food with an elaborate package is also very common. For such food products, it requires the action of taking the food out of the package, and then the scent is perceived by people. In this case, it should belong to Pattern 2. Such conflicts might occur in other samples as well.

Besides, as people get familiar with the products with repeated use, they may form their own habits of using, and the changes in people's emotional responses during the use will take place accordingly. Inevitably, the patterns of how scents play emotional roles may also be different. The results of this study might fail to cover such dynamic changes.

As mentioned before, when we discussed the emotional effects of scents and the patterns of how scents deliver such effects, we focused on in which ways the scent can make the product evoke more positive emotions, instead of what particular emotions the scents will elicit. Also, we did not probe into and explain the physiological and psychological mechanisms behind the effects. It should be noted that different particular emotions would lead to different behavioral impacts, which may influence the human-product interaction [9]. Furthermore, this study focused on the effects of "scents" on

product experience, so we did not emphasize the impacts of other elements when we conducted the analysis from the 3 Levels. Despite this, we should keep in mind that in some products, other elements such as appearance, color, and texture are much more important than scent and even are the determining factors of the product experience. The significance of these elements should never be ignored in product design. Moreover, the cross-modal correspondences between the scent and other sensory stimuli, such as color, shape, texture may exist, which might also influence how the scents deliver the emotional effects.

When discussing the possible and potential ways to apply scents, this study raised several general proposals but did not offer concrete recipes. In terms of the practical implementation, including how to choose the scent and add it to the product (experience), we did not provide reference guidance. Besides, due to the lack of a manual about the application of scent in product design, it is still hard for us to estimate the efficacy of adding scents at the proposal phase. Further, as revealed by this study, the role of scent is closer to vitamin instead of painkiller, indicating that the effects of scent may not be easy to verify. Therefore, designers and design researchers should iteratively explore and test the actual effectiveness of scents during the product or experience design process, if they would like to make use of the emotional effects of scents in product experience.

Moreover, we should consider whether the actual outcome of adding scent deserves the efforts we pay to realize it. After all, in smell-related products and experiences, people can more or less notice the presence of the scents in the product experience. However, in other originally odorless products, if the scents were mild and not strong, people might not even notice the scents unless there were some explicit cues. We should also consider whether the effects of scent deserve the extra costs to realize it and whether adding scents to the product would increase the environmental burdens of the production. Last but not least, we should pay attention to some potential side effects of adding scents, including the negative experience brought to some people who have allergies to certain scents, and the so-called fragrance pollution. It may also raise some ethical concerns regarding the manipulation.

#### **4.3.3 To interpret the reflection of the status quo**

In this study, we have pointed out that some potentials of scents in design have not been widely applied and fulfilled, including the scents' potentials to augment people's perceptions of certain contents, as a media component. In the current Information Age (New Media Age), while our lives are filled with various information, the scent, which is an olfactory stimulus thought to have unique relationships with human emotions and

memories, is far behind the visual and audio information in terms of informatization. In this chapter, we did not discuss the potential reasons behind this phenomenon. However, we believe that by exploring the reasons behind the phenomenon, we may uncover some valuable findings and gain more insight into the potentials and problems of the olfaction and the application of scents. In the next chapter, we will conduct a research relevant to this topic.

In summary, we have discussed several issues and limitations of this study in this part. Hopefully, it would make the logic and the results more understandable.

## 5. Conclusion

Product experiences eliciting more positive emotions can benefit the users. To demonstrate the potential positive effects of scents on product experience, this chapter has explored the roles of scent in smell-related consumer products and experiences, on the basis of analyzing 25 samples from the perspective of Don Norman's 3 Levels of Emotional Design. It has been revealed that in the product experience of the related products, the scents could have emotional effects in all the 3 Levels of Visceral, Behavioral, and Reflective. The effects include impacting people's first and overall impressions of the products and experiences, triggering instinctive responses, affecting people's action or behavior tendency, serving as the feedback of the product use, conveying certain messages, and making certain time, scents, and contexts more memorable, to name a few. We have also identified 3 patterns of how scents deliver the emotional effects in smell-related products (experiences), in which the scents come into play in different phases and act on the 3 Levels differently. In addition, the scents' features in the 3 patterns have implied several possible and potential ways to apply scents in product design. These include applying scent as an unconscious intervention to nudge for the good, introducing a trick to release scents to moderate the negative emotions that the use of some products may induce, using scents to enrich the introspection or creation-related experience, and utilizing scent as a media component together with other contents or for Universal Design, to name a few. Although this study has revealed some of the potential emotional effects of scents, it requires further joint efforts of scientists, design researchers, and designers to uncover the possibilities of the scent and fulfill its potentials in more areas.

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# Chapter 4

## **Rethinking the Roles of Smell in Different Types of Products from a Habit-Forming Perspective: A Comparative Analysis among Four Olfactory Display Devices**

### **1. Introduction**

The smell has unique relationships with human emotions and memories. Though remaining as one of the least explored senses by design researchers, it is thought to have potentials. It can trigger specific emotions and memories, improve people's efficiency, convey information with the advantage of a lower cognitive load [1], and allow a subliminal communication between people and the environment [2]. However, different from the sense of sound and sight, there are no known standard classification schemes for smells so far [3], posing challenges in applying smell in some fields.

When we speak of smell, we will find that there is no lack of smell-related products in our daily life. Besides perfume, aroma diffusers, and deodorant, even the store with pleasant smell might be one case of smell applied in sensory marketing. And smell also conveys information from warnings of the gas leak, burning things to more positive scents in such fields as cooking, and wine [3]. Notwithstanding, in the field of Human-Computer Interaction (HCI), the olfactory displays are not as readily and inexpensively available as visual and auditory displays [4]. As defined by some researchers, an olfactory display is a device that generated scents with the intended component and concentration of odor material and provides it to the human olfactory organ [5]. In fact, many commercial technologies had aimed to engage olfaction, but most computer-controlled olfactory devices never reached the market or have not lasted long [6]. Despite this, research laboratories have explored the potential of the olfactory display continuously. And today, some promising olfactory display devices have begun to emerge in the consumer market.

Since it is a relatively new product form for consumers, to reach the market and last long, the olfactory display has to make certain consumers willing to use it and form the habit of using it. Except for commercial value, the repeated use of such a new

product has several benefits. According to life cycle thinking, the use is an essential stage in the life cycle of a product. If the product is fully used throughout its lifetime, it can reduce its environmental impact. Next, if the olfactory display devices become prevalent, it will raise more people's awareness of the emotional effect of smell, contributing to a less stressful society where people pay more attention to their spiritual and mental health against negative feelings. Based on this, this chapter aims to investigate the olfactory display devices from a habit-forming perspective, explore the roles of smell in such products and provide insight into how such new products can make consumers use it repeatedly.

## **2. Method**

After investigating some olfactory display devices, we chose to study and discuss four products that were selected, as stated below. We explored the specification of these products and examined them by using the Hook Model, revealing their habit-forming potentials. We analyzed them separately and compared them in pairs to explore the roles of smell in such products and the important factors for them to be more habit-forming.

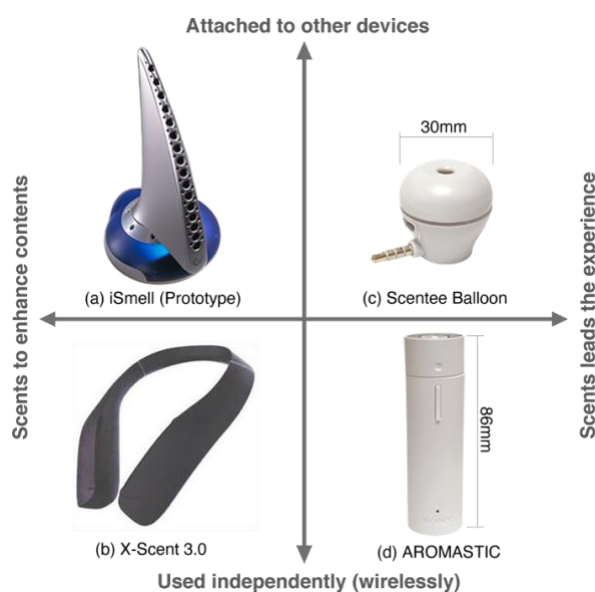
### **2.1 Determination of the objects**

Through literature study and web search, we identified twenty-one candidates, and had a preliminary appraisal of them. Two of the twenty-one were blanked out because they were the predecessors of another two candidates and had almost the same features as their successors. The overview of nineteen of them was summarized in Table 1. As revealed, among the nineteen candidates, fifteen of them require users to connect or attach them to other devices, such as computers, smartphones, and HMDs. Ten devices generate scents to enhance concrete contents, including videos, games, and Internet experience. After that, we narrowed down the research objects, following the standards below.

- 1) The device can generate and deliver scents to users and is mainly for personal use, which means that the scent from the device is delivered to a particular person.
- 2) It does not involve communication between users via the devices. Alternatively, communication is not the primary purpose. As it is hard for a product not prevalent yet to have both sender and receiver, this study prefers devices that focus on the scents' effect on a single user.
- 3) The device is or was once on the market. Alternatively, the device has once tried to reach the market and left a certain impact, so that its expected concept and function are deducible based on the available literature.

**Table 4-1: Overview of the nineteen candidates, including the release year and relevant features**

Device	Year	Features (e.g. scene, scent number, delivery)
<b>Smell-O-Vision</b>	1960	·Cinema ·A network of tubes to emit scents to seats
<b>Sensorama</b>	1962	·A simulator stimulating multiple senses ·Scent as part of an immersive 3D bike ride experience
<b>iSmell by Digiscents</b>	1999	·One scent cartridge with 50-128 so-called primary odors (concept) ·Vaporization by heating ·Connected to computer by USB ·Enhancing the Internet experience
<b>Aromajet Pinoke</b>	2000	·Worn (wearable) or placed in front of a monitor ·Controlled by digital signals ·Associated with computer games
<b>TriSenx Smell Dome</b>	2003	·Twenty liquid scents in one cartridge ·Connected to computer ·Enhancing the Internet experience
<b>Aroma Geur by NTT Com</b>	2005	·Maximum of six liquid scents ·Connected to computer
<b>Dale Air's Vortex Activ USB</b>	2006	·Four scents in four cartridges with four fans ·Cartridges: cotton pads soaked in oils ·Connected to computer
<b>Kaori Tsushin Mobile by NTT Com</b>	2008	·Sixteen scents by airflow vaporization ·Connected to mobile phone by infrared ·Scent communication between people
<b>i-Aroma by NTT Com</b>	2009	·Six liquid scents (aroma oils), emitted either individually or in combination ·Connected to computer ·Enhancing the Internet contents
<b>Scent Sciences Scentscape</b>	2011	·Maximum of twenty scents in a cartridge ·Connected to computer, controlled by a USB interface ·For games and videos
<b>Aroma Shooter by Aromajoin</b>	2012	·Six solid-state scent cartridges ·Connected to platforms such as computer and smartphone, by USB, Bluetooth, or Wi-Fi ·Available desktop and smartphone apps for users ·Available software development kits for developers
<b>Scantee Balloon</b>	2013	·One liquid scent in one cartridge ·Ultrasonic vaporization ·Attached to smartphone ·Controlled by smartphone app
<b>oPhone DUO</b>	2014	·Maximum of thirty-two scents ·Connected to smartphone by Bluetooth ·Controlled by smartphone app ·To send and receive electronic aroma messages
<b>FEELREAL Multisensory VR Mask</b>	2015	·Nine scent capsules ·Connected to VR headsets via Bluetooth or Wi-Fi ·Enhancing the movie or game experience
<b>Cyrano Scent Speaker</b>	2016	·Twelve scent cartridges ·Connected to smartphone by Bluetooth ·Portable and battery-operated ·Controlled by smartphone app
<b>AROMASTIC</b>	2016	·Five or two scents in one cartridge ·Scents emitted by dry air ·Portable and battery-operated
<b>VAQSO VR</b>	2017	·Maximum of five scents in a device ·Attached to HMDs (Head Mounted Display) ·Connected by USB ·Augmenting Virtual Reality experience
<b>X-Scent 3.0 by ScentRealm</b>	2017	·Cinema ·Maximum of twelve scents ·Wearable and controlled wirelessly



**Figure 4-1: Overview of the four products [Note: the origin of (a) should be [www.digiscents.com](http://www.digiscents.com), inaccessible now; (b) is reproduced from Patent CN305210331S; (c) and (d) are taken by the author]**

Among the candidates, iSmell, X-Scent 3.0, Scentee Balloon, and AROMASTIC meet the above standards and represent four different types of olfactory display devices. That is, they can cover the main distinctive features revealed by Table 4-1. As indicated by Figure 4-1, iSmell and Scentee Balloon need to be connected or attached to other devices; the usage of iSmell and X-Scent 3.0 is relevant to concrete contents; in AROMASTIC and Scentee Balloon, the scents lead the product experience. Such implies that the comparison of them in pairs might reveal meaningful findings. Thus, we determined to focus on these four products.

## 2.2 The Hook Model

### 2.2.1 Determination of the Model

In determining the model, we assumed that the model should reflect the process of users using the product and reveal how the repeated use would occur, because this study aims to explore how to make consumers use an olfactory display device repeatedly. Except for the Hook Model, we examined four models regarding consumer behavior, including AIDMA, AISAS, AIPL, SIPS, and three models relevant to human behavior and habit, including the Fogg Behavior Model, the COM-B model, and the Cue-Routine-Reward model.

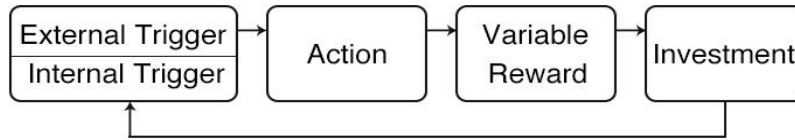
The AIDMA (Attention, Interest, Desire, Memory, Action) model represents a step-by-step process. It suggests that a consumer, who notices a product, will take an interest in the product. The interest should evoke a desire to purchase it. Next, the consumer should remember the product, which, together with other stages, should lead to the action of buying the product. The AISAS (Attention, Interest, Search, Action, Share)

model is a non-linear model, where a phase may be skipped or repeated. In this model, after the product has caught the consumer's attention and interest, the consumer will search to gather and evaluate information, and then make a purchase. After the action of buying, the consumer will share with others about the product on the Internet. The shared information may be found by others who are in the phase of search. The AIPL (Awareness, Interest, Purchase, Loyalty) model supports the process of consumer asset management. It focuses on converting consumers from the current phases to the next phases. Consumers who are aware of the brand, are converted to consumers who are interested. Then, they turn to buy the products. After the purchase, some consumers are further converted to loyal consumers, who will repurchase and share with others about the product. The SIPS (Sympathize, Identify, Participate, Share & Spread) model explains the consumption behavior of the social media age. In this model, the initiator of consumer behavior is consumer's sympathizing with the information and idea disseminated by a company or a person. After that, the consumer will identify whether empathy with the information is right by searching. This is followed by participation, which does not necessarily mean the action of purchase. Then the consumer will share with others, and the information will spread. The Fogg Behavior Model (Behavior = Motivation, Ability, Prompt) indicates that a behavior will only occur when motivation, ability, and a prompt are present at the same time and in enough degrees. It can be used to identify what stops people from performing a particular behavior. The COM-B (Capability, Opportunity, Motivation - Behavior) model suggests that capability, opportunity, and motivation need to be present for any behavior to occur. These three factors interact over time, and they are bi-directional with the behavior. The Cue-Routine-Reward model shows how a habit loop occurs. First, a cue triggers the person to the routine, where the actions take place. Then the actions link the cue to the reward, which determines if the person will continue the loop.

As revealed by the examination of the models, the AIDMA, AISAS, AIPL, and SIPS models indicate the importance of catching consumer's attention and interest. However, in these models, the usage of a product is not straightforwardly reflected, although some of them have the so-called phase of action, which refers to purchase action. Meanwhile, the Fogg Behavior Model, COM-B model, and Cue-Routine-Reward model mainly focus on a particular behavior or a habit. However, they all lack the attention to the changes that may occur in using a product. This study chose to use the Hook Model, because it not only covers such factors as attention, interest, awareness mentioned in the consumer behavior models above, but also focuses on the usage of the product and the changes that may occur with the repeated use of the product. Besides, we think it is diagnostic to discover what is wrong with those products that are not

habit-forming. The details of the Hook Model are introduced below.

### 2.2.2 About the Hook Model



**Figure 4-2: The Hook Model (Adapted from the illustration in the book [7])**

The Hook Model was raised by Nir Eyal in his book *Hooked: How to Build Habit Forming Products*, trying to answer such questions as why some products capture widespread attention while others flop, what makes people engage with certain products out of habit, and what makes some products so habit-forming [7].

As a framework based on human psychology and a close examination of many successful habit-forming products, the Hook Model has four phases: trigger, action, variable reward, and investment, as indicated in Figure 4-2.

The first phase in engaging a user is the trigger, namely, the actuator of behavior. Triggers can be external or internal. External triggers place information within the user's environment, which tells the user the next action the user should take. External triggers aim to propel users into and through the Hook Model so that, after successive cycles, they form habits and do not need further cues from external triggers. Here, internal triggers come into plays by telling the users what to do next through associations stored in the users' memory. It works when users tightly couple a product with a thought, an emotion, or a routine. Emotions, especially negative ones, are powerful internal triggers.

The next phase is action. The trigger, driven by external or internal cues, is only useful when the user does take action. Based on the Fogg Behavior Model, all behaviors are initiated when motivation, ability, and a prompt are present at the same time and in sufficient degrees. Among the three necessary ingredients, the ability is influenced by the six factors of time, money, physical effort, brain cycles, social deviance, and non-routineness. These factors will differ by person and context, and the easier an action, the more likely the user is to do it. In the Hook Model, the action also refers to the simplest behavior in anticipation of reward.

Variable reward is the third phase of the Hook Model. Research indicates that the anticipation of a reward leads to the emission of the neurotransmitter dopamine in the human brain. However, if the reward becomes increasingly predictable with use, users might probably lose their interest after some time. Adding variability can help the experiences maintain user interest. Variable rewards have three types. Rewards of the

tribe mean the search for social rewards from connectedness with other people; rewards of the hunt is the desire to acquire material resources and information; rewards of the self is connected with intrinsic rewards of self-achievement such as mastery, competence, and completion. In the Hook Model, the variable reward must satisfy users' needs, and meanwhile, make them want to re-engage with the experiences.

The investment phase is the fourth step in the Hook Model. At this point, users are prompted to do a bit of work. However, unlike the Action phase, investments are more about the anticipation of longer-term rewards, instead of immediate gratification. People have the tendency to overvalue our work, be consistent with past behaviors, and avoid cognitive dissonance. Due to this, when the user puts something of value into the product such as time, effort, data, social capital, or money, these investments increase the likelihood of users' returning and passing the Hook cycle again.

## **2.3 Research objects**

Details of the research objects are as follows.

### **2.3.1 iSmell**

Founded in 1999, Digiscents, a company whose main product was the iSmell Personal Synthesizer, had once been the subject of a cover story in *Wired* magazine [8]. Though it failed to make iSmell a reality and crashed by 2001, it deserves the credit for bringing the ideas of computer-controlled scent systems to the foreground [9].

#### **Specification**

The iSmell (prototype) was a scent synthesizer device connected to a computer via USB or serial port. It contained a scent cartridge with 50-128 so-called primary odors, certain mixtures of which were expected to replicate different odors. In this concept, a sort of smell database would be created, and scents could be indexed, coded, and digitized into "scent objects". The scent object could be attached to different kinds of web contents. When users clicked it, it would be sent to the software of the iSmell, and the device would emit the corresponding mixtures of the odors to make the requested smell. The primary odors in oil form were heated and dispersed to the user's nose. To maintain the accuracy, the scent cartridge would have to be replaced, just like the toner cartridge of a printer [10].

#### **How to use**

Available literature indicated the way to use this unreleased prototype. Assuming it is available, the user generally needs to go through the following process. Firstly, the user powers the iSmell using an electrical outlet and connects it to a computer. Next, the user opens the software that supports the function of the device. Then the user starts

to surf the Internet. For the user, it is hard to prejudge whether the web that he is going to browse is possible to smell or not, but when he browses a website with available scent objects, he can click on the scent object to trigger the device. It takes some time for the device to generate the smell, and also time is needed for the generated smell to disappear.

### **2.3.2 X-Scent 3.0**

X-Scent 3.0 is developed by ScentRealm. Founded in 2015, ScentRealm is a company based in China engaging in Digital Scent Technology, which has started to be commercially available since 2017. Regarding the Digital Scent Movie enabled by the device X-Scent, ScentRealm focuses on the R&D of the technology, while it collaborates with another company on the marketing and distribution of the device to movie theaters. The professionals from the team take charge of the scent digitization of the hit movies to be released, and they provide the necessary digital scent data and the supplementation of the scent cartridges to the cooperative theaters. In China, hit movies such as *Midnight Diner* and *Frozen 2* have once had their scent movies in some cinemas.

Besides the X-Scent and its application in Digital Scent Movie, ScentRealm has also developed other product forms like VR headset, and digital scent module, and kept further spreading the digital scent technology in various fields.

#### **Specification**

X-Scent 3.0 is a smart scent display in the shape of neckband. Used in cinemas, it can release a scent to reproduce the smell of the scene on the screen synchronously. The device can contain and release twelve pre-set scents. The release of them is controlled by 433Mhz industrial wireless transmission, which is at a millisecond level so that it can create a fine and smooth scent experience for the user. The X-Scent has a valid delivery range of about 25 centimeters. It can switch among scents seamlessly, without one influencing another. Such is possible with its advanced digital scent technology, including a nanoporous material with sealed construction to store the scent, scent delivery mechanism with a special design to adapt to different scenarios, and Digital Signal Processor chip and system to control the scent release in a fixed time and amount [11].

#### **How to use**

Based on the current reality, people can only experience the Digital Scent Movie with the X-Scent in ScentRealm's cooperative theaters when there is a scent-digitized movie. For a person who uses the X-Scent device for the first time, he may happen to know the option of the scent movie when he wants to buy the movie ticket online or at the ticket counter. Since the price is normal without a noticeable increase, he can buy

the ticket, not considering too much about the extra cost. After the ticket is checked, the person gets an X-Scent device before entering the projection hall. He puts on the neckband-type device and starts to watch the movie. When the movie ends, he only needs to return the device to finish the experience.

### **2.3.3 Scentee Balloon with Hana Yakiniku cartridge**

Founded in August 2011, Scentee is a technology design company based in Japan, aiming to present new styles of communication and culture with a focus on smell experience [12]. In 2013, the team launched a campaign at a Japanese crowdfunding site with the proposal of ChatPerf, a smartphone plug-in cartridge that would emit a scent when the user receives a message. The idea eventually turned into their first commercial product Scentee Balloon, which is said to have successfully sold over 20,000 units, though it has been discontinued later. Hana Yakiniku, with its meaning in Japanese as “tasting the grilled meat with nose”, is a theme scent kit used with the Scentee Balloon [13].

#### **Specification**

The device of Scentee Balloon is charged by micro-USB [14]. It is attached to the earphone jack of the smartphone, and the Scentee app can control the connected device and manipulate the duration and the strength of the sprayed scent [6]. It uses ultrasonic transducers to provide the controlled release of the liquid scent contained in the scent cartridge [15]. One device can only hold one scent cartridge, so it only supports the delivery of a single scent at a time. Hana Yakiniku is a theme scent kit for Scentee Balloon. It has three replaceable scent cartridges, including the scents of short ribs, beef tongue, and buttered potato. It has an exclusive app showing the grilled ingredient on the screen [13].

#### **How to use**

For a user who uses Scentee Balloon with the Hana Yakiniku scent cartridge, he generally goes through the following steps. To start using, firstly, the user needs to charge the device, download and install the exclusive app Hana Yakiniku on the smartphone. If the user wants to smell the scent of short ribs, he should put the scent cartridge of short ribs in the device. Then in an environment where the scent will not influence other people, the user starts the app and presses the button of short ribs on the screen. Then he plugs the device into the headphone jack of the smartphone, after which the device releases the scent of short ribs. The user can then enjoy the scent while seeing the short ribs getting grilled on the screen. To finish the experience, the user pulls the device out and exits from the app.

### **2.3.4 AROMASTIC**

AROMASTIC, a personal portable aroma diffuser dubbed the “aromatic Walkman”, was released in October 2016 by Sony, a famous corporation. The product was developed under Sony’s Seed Acceleration Program (SAP), which aims to fast-track new promising business ideas. The AROMASTIC project was started in the summer of 2015, and after being crowd-funded during November 2015 to January 2016 on First Flight, a platform for both crowdfunding and e-commerce launched by Sony, the product was developed valuing potential consumers’ advice and finally became commercially available.

#### **Specification**

The AROMASTIC device is charged by micro-USB. With average use, the device needs to be charged every two months. The device itself weighs about 33g. Each exclusive scent cartridge contains five aromas. The monthly cartridge under the regular delivery service, and the custom cartridge, have two aromas. The cartridges can pack and store aroma oils. To bring the personal scent experience into reality, it employed Sony’s exclusive Sentents™. Different from using heat or vapor to generate scents in some other diffusers, it uses a dry-air system to deliver the scent inside the cartridge to the user’s nose; thus, the scent will not spread and influence other people. As for the scent cartridge, it employs the micro-channel technology so that multiple aromas can be packed into one cartridge without influencing each other [16].

#### **How to use**

To start using, first of all, the user charges the device by micro-USB. After that, he takes the aroma cartridge out from the package and inserts it into the device. With the fixed-up device, the user can start to enjoy aromas. He selects his choice of aroma by rotating the dial. Then he holds the device toward his nose, presses and holds the button. The aroma will be released while the button is pressed, and stop when the user releases the button. To smell another aroma, he only needs to rotate the dial to choose that aroma and repeat the above action. To finish the use, the user rotates the dial to the off-position mark. When the cartridge has run out of aromas, the user can simply take it out and replace it with a new one [16].

## **3. Results**

### **3.1 The four objects in the Hook Model**

We analyzed the four objects separately in the Hook Model. To mainly focus on analyzing the usage of the products, we have assumed that ideally, the external triggers

of all products serve to lead users to the action phase. The results are as follows.

### **3.1.1 iSmell in the Hook Model**

Assuming that the iSmell device is available, the external trigger that prompted the user to buy it should be the good promotions done by its company. When the user has already owned one, the conspicuous appearance of the device itself might serve as a reminder.

The action itself is simple. After the user has powered the iSmell, connected it to a computer, and opened the software, the user only needs to browse the website in which the iSmell scent objects are embedded, and click on the scent objects to activate the device.

However, the simple action may not lead to fulfilling rewards. Leaving the essential problem that there are no such things as primary odors yet out of consideration; even if it is possible to replicate certain scents by mixing different odors, still many problems exist. On the one hand, it is not clear how to determine the scent of specific web content and how a scent can be viewed as an appropriate smell. Moreover, if it is the provider of the web contents who decide on the expected smell, it remains a question whether it is possible for the device to generate the scents as accurate as expected. On the other hand, Internet surfing behavior varies individually. The device is supposed to deliver the scent to enhance the user's experience of surfing the Internet. However, it takes time for the user to sense the smell after he clicks on the button, and the residue of odors may influence the experience. As the user keeps using it, he may feel negative emotions instead of variable rewards.

Without fulfilling rewards, it is difficult to make users invest more time and money in using the product repeatedly, and thus impossible to form an internal trigger in the user's mind. That is to say, iSmell performs poorly in the phase of variable reward in the Hook Model. Thus, the product is not habit-forming.

### **3.1.2 X-Scent 3.0 in the Hook Model**

The X-Scent device only functions when it accompanies a certain Digital Scent Movie. Therefore, to analyze the X-Scent is to analyze how consumers repeatedly use it by watching digital scent movies.

The external trigger that prompts a consumer to watch a scent movie can be the promotional events, other people's comments on SNS platforms, or the symbol that shows the option of the digital scent movie on online ticket platforms or at the cinema's ticket counter. Internal curiosity about a hit movie can make people go to the cinema, and the scent movie can be an attractive option.

Compared with the traditional way of watching a movie, the extra action that a consumer needs to take is only getting the X-Scent device, wearing it when the movie is shown, and returning the device in the end. Because the price is normal without a noticeable increase, the consumer will not consider much about the extra cost when buying the ticket.

The variable reward comes from both the story presented by the movie and the enhancement of people's olfactory experience of the movie contents. People cannot expect when they will smell the scents, as they cannot fully predict how the movie will tell the story. Carefully prescribed by the professors, the scent reproduces the smell of the scenes on the screen, leading to a more immersive movie experience.

If the consumer is satisfied with the movie, he may write comments online or even share the experience with his friends orally or by SNS platforms. Such efforts involved can be viewed as the consumer's a bit of investment of time. ScentRealm produces the digital scent version of hit movies periodically; hence, the digital scent movie is accessible. With the repeated use of it, the consumer may turn to pursue not only the sense of gratification and relaxation from a good movie but also a more immersive experience enabled by scent. As indicated above, the X-Scent device generally fits the Hook Model, so it has the habit-forming potential.

### **3.1.3 Scentee Balloon in the Hook Model**

We chose to analyze Scentee Balloon with the Hana Yakiniku scent cartridge, despite other available scent cartridges, such as the scents of rose and coffee.

The external trigger that propels the user to try the product can be the online and offline activities held by the company, comments on SNS platforms, and the attractive website design of Hana Yakiniku.

The action is not simple. Firstly, the user needs to charge the device, download and install the exclusive app on the smartphone. After that, there are still several steps. The user has to put the particular scent cartridge into the device, start the app, press the button, and plug the device into the phone. When the device sprays the scent, the user may have to hold the device close to the nose when there is no suitable place to put it.

The product cannot provide variable rewards, either. Admittedly, the high quality of the meaty scent can fulfill the user's desire for a good smell. However, as the appetizing scent evokes the user's appetite, such kind of desire for food cannot be fulfilled simply by smell. Also, the device can only spray one kind of scent at a time, which in the form of mist, tends to spread in the air and thus limits the contexts where users can use it.

The purchase of new scent cartridges can be viewed as an investment. However,

without simple action and satisfying rewards, it is difficult for users to re-engage with the experience, let alone buy new cartridges. In a word, it is revealed that the product is not habit-forming.

### **3.1.4 AROMASTIC in the Hook Model**

AROMASTIC is launched by Sony, whose influence is so huge that the brand itself works as a strong external trigger. On this basis, the promotional events conducted by the company, as well as the display and sale of the products in stores, also prompt people to try it. For those who have owned one, the product's portability increases the chance that the user sees it and wants to use it.

To start using, the user should charge the device by micro-USB and insert the aroma cartridge into it. For a user to use a fixed-up device, the action is simple. He only needs to rotate the dial and press the button to smell an aroma. When the user releases the button, it will stop. No extra effort is required for cleaning and maintenance.

Besides, the product can provide variable rewards due to its feature of portability and multiple optional aromas in one cartridge. Also, the aroma it releases will not impact other people except the user. Therefore, users can use it whenever and wherever they like. Depending on the actual situations, the aroma affects users in different ways, such as refresh them in the morning, increase the concentration before important activities.

Users can buy not only different cartridges but also other accessories like silicone jacket for their devices. In addition to such investment of money, they may also share the new aroma experience with other people orally or by SNS platforms. The portable size, ease-of-use, and little limitation on usage situations all contribute to the reality that users can easily use the product frequently and feel the aroma's effects. Such repeated use further builds an internal trigger in users' minds so that they will naturally want to use the product in certain time and situations, especially when some negative emotions are associated. As revealed above, AROMASTIC fits the Hook Model well. Based on this, we think the habit-forming potential of it is relatively high.

## **3.2 Comparison of the objects in the Hook Model**

The analysis of the four objects in the Hook Model has revealed that X-Scent 3.0 and AROMASTIC have the habit-forming potential. This result is supported by the fact that both of them have been available on the market for about three years by the end of 2019. In contrast, iSmell and Scentee Ballon are thought not to be habit-forming. To clarify what factors influenced their habit-forming potential, we compared them in pairs.

First, we compared iSmell and X-Scent 3.0. The iSmell and X-Scent devices

provide scents to augment users' perception of certain contents; that is to say, the smell plays a supporting role, which has to rely on the contents to play the role. Without the contents, the smell cannot work, and the devices would be useless. Exploring the reasons behind why the X-Scent device can bring users variable rewards while iSmell would fail to do so, we assume that it is determined by the nature of the contents that the scents from the devices try to accompany. The iSmell device attempts to allow users to smell the web content, which is variable and changeable, unpredictable, and related to individuals' Internet surfing behavior. In contrast, the contents that X-Scent attempts to augment are fixed and prepared, so that the scents from the device can be configured and programmed in advance. Besides, the scents here try to reproduce the movie scenes' smell, so it is relatively objective. Such distinction leads to the different levels of difficulty in making the scents augment the particular contents. Thus, it distinguishes X-Scent from iSmell in whether the scents can serve its role to support the contents and bring the variable reward. Consequently, it caused the different habit-forming potential of the two devices.

Then, we compared the Scentee Balloon and AROMASTIC devices. As for them, the experience is created by the devices' delivering scents, where the smell itself playing the leading role. It turned out that the difference of their habit-forming potential can be mainly accounted for by the phases of action and variable reward in the Hook Model. From the aspect of action, although both of them are relatively small and easy to carry, Scentee Balloon has to be used with a smartphone and an exclusive app. To use it, users must go through several steps. In contrast, AROMASTIC can be used independently and effortlessly. From the aspect of variable reward, Scentee Balloon only has one scent in one cartridge. In addition to the limited choice of the available scent, the diffusion of its sprayed scent will restrict the feasible usage situations. In contrast, each aroma cartridge of AROMASTIC contains multiple aromas, and its mechanism can prevent the emitted aroma from impacting other people. Such difference distinguishes AROMASTIC from Scentee Balloon in whether users can use it anytime, anywhere, and then form emotional associations with the product through repeated use in different contexts.

In a word, we analyzed and compared the four devices through the phases of the Hook Model. It turned out that the variable reward was the main factor influencing the habit-forming potential of these products. Furthermore, how the scents serve the roles determined whether the device can bring variable reward. Although the other three phases, which were more relevant to the other factors of the device, such as its form, ease-of-use, available refills, accessories, would also influence the habit-forming potential of the device, the effect was not as apparent as the variable reward in this study.

## 4. Discussions

In this section, we would further discuss other findings and their implications on how to increase the habit-forming potential of the olfactory display devices.

### 4.1 Possibility of the scents from the olfactory displays to cause a negative experience

Among the four olfactory display devices we analyzed and compared, the smell's roles are most relevant to the variable reward phase. Whether the scents can lead to variable rewards has mostly determined the devices' habit-forming potential. Therefore, in this part, we explore the issues that make it hard for the scents from such devices to bring variable rewards.

We have noticed that some issues unique to olfaction are posing challenges, although the main reason for the less prevalence of such devices is often thought to be the lack of a rigorous, systematic, and reproducible classification scheme for smell [17]. Firstly, scents, as composed of chemicals, when diffused into the air, face the issues of slow movement and lingering in the air. As a result of these, the associated phenomenon, olfactory adaptation, is likely to arise when the sensory nerve activity decreased due to the user's continued olfactory stimulation [18]. Another problem is the unintentional scent mixture when the previous scent remains in the air and mixes with the subsequent ones [19]. These issues are often used to account for the previous failures of the scented movies. The X-Scent became commercially available in 2017, but the first documented use of smell with movies dates back to 1906 [20]. And the early attempts to enter the mass market came in 1959 and 1960, in the form of AromaRama with the film *Behind the Great Wall*, and Smell-O-Vision with *Scent of Mystery*. They both emitted the scents into the ambient environment, but neither tried to solve the problem of clearing the lingering scent out before the next arrives. It then made the viewers unpleasant and left the impression that the mixture of motion pictures and synthetic odors was not acceptable [21]. Even in Japan, back in 2006, NTT Com attempted to employ olfactory displays in theaters to emit scents according to the movie's image as programmed [22], but the same problems also occurred.

Secondly, unlike the more instantaneous nature of its visual and auditory counterparts, the slow-moving nature of scent also causes the time lag between the scent being launched and being recognized. To accompany specific contents, its ejection timing is crucial to achieving the temporal harmonization [19]. If the scent does not arrive at the right time, users may feel confused. Besides the temporal disharmony, the semantic one is likely to cause users' confusion and discomfort too, since associations with scents vary by socio-cultural background and personal past experiences. Moreover,

there is high individual variability in scent perception, liking, and preferences [23]. A scent may be pleasant for some people, but annoying for the other [17]. Even a healthy person may encounter the hyposmia or anosmia, the olfactory phenomena of reduction or loss of the ability to detect odors. In addition, unlike the vision and audition, the scents end up entering the body. Therefore, what concerns some people is the natural or synthetic nature of the scents' origins. Consequently, the use of cheap synthetic scents may prompt people's negative responses [24]. Further, some people are concerned that they might be manipulated, get sick, catch an allergy, or be addicted if they are exposed to chemical stimulations from the technology [25]. Meanwhile, there is a concern for the risk that the scents for one individual will spread and be detected by others, which might annoy other people or lead to the problem of privacy.

In a word, the issues raised above indicate that for the scents from the olfactory displays, it is easy for an inappropriate scent to occur, no matter temporally, semantically, or related to individual variability. Such inappropriate scents are apt to cause negative responses instead of variable rewards. Therefore, attention should be paid to preventing the inappropriate expression of the scents if the olfactory display aims to be habit-forming.

#### **4.2 Fundamental attribution error and the perceived utility**

Another tricky issue is that even if the carefully assigned scents do not cause unfavorable effects and do serve its role, the users would not necessarily attribute the experience enhanced by the scent, like pleasure, to the sense of smell. This phenomenon is relevant to sensory dominance that the contribution of each sense to the overall experience of a product is not necessarily equivalent [26]. When people concentrate on something attention-demanding, they may often fail to detect scents; even when they notice the scents, they will typically tend to attribute the enjoyment from the smell to one of the other more dominant senses, which is often vision and to a lesser extent, audition. Some researchers call this as the fundamental attribution error [24]. Due to this, in the case of the scents from the olfactory displays, it is difficult that the users will be willing to pay for it or invest more if they cannot even notice or value the effect of the smell. So the issue here is to convince users to assign the source of their enhanced enjoyment to the stimulation of the sense of smell [24], or in other words, increase the perceived utility of the scents.

#### **4.3 Possible ways to increase the habit-forming potential of the olfactory display devices**

Although the issues we discussed in 4.1 and 4.2 tend to make it difficult for the olfactory display device to be habit-forming, in this study, there are still two objects

that we thought are successful from the habit-forming perspective. In this part, we would discuss how X-Scent 3.0 and AROMASTIC overcome the above issues and explore the possible ways to increase the habit-forming potential of such products, as implied by the findings.

Of the two habit-forming objects, the X-Scent device is a case where the smell plays a supporting role in augmenting certain contents. It has a habit-forming potential because it is not only accessible and affordable for users and easy to use, but also it can convey variable rewards to users. Concretely speaking, here, the contents are fixed and prepared, and the scents are objective (to reproduce the scenes of the movie) so that the scents can be prescribed, configured, and programmed in advance. Combined with the advanced scent delivery mechanism, the issues mentioned in 4.1, such as scent lingering in the air and scent mixture, can be avoided. Hence, the scents here do serve its role. Besides, compared with the alternative of 4D cinema (where scent together with motion-enabled chairs, smoke, fans, and water accompany the movie), the appearance of the X-Scent device emphasizes the presence of the smell. Hopefully, it could reduce the impact of the fundamental attribution error mentioned in 4.2, and people will thus perceive that the enhanced enjoyment is derived from the smell.

Unlike the X-Scent device, AROMASTIC can be used independently, where the smell plays the leading role in the product experience. It is thought to be habit-forming, as it is portable, easy to use, and has many available aroma cartridges and accessories. More importantly, it can bring variable rewards. Each cartridge of the device contains multiple optional aromas, and the scent from it will not spread and influence other people. Thus, users can use it in various contexts. Besides, the custom cartridge is available for people to customize the scents up to their preferences. All these factors contribute to the variable rewards. Speaking of the perceived utility issue, we have to mention there is no lack of low-tech alternative solutions to it. For example, people can satisfy their needs for aromas by simply carrying a bottle of essential oils around. Considering that people have a strong tendency to go along with the status quo or default option [27], for those who have already had their own aroma habits, it is necessary to convince them why delivering the scents from an olfactory display device is better than the low-tech alternatives. Therefore, the product's company might need to provide enough external triggers, such as convincing storytelling of the product's advantages, to prompt people to try the product. In this way, the Hook cycle starts. With all the habit-forming factors mentioned above, people may find it useful and rewarding over low-tech alternatives.

Overall, to increase the olfactory display devices' habit-forming potential, attention should first be paid to enabling the scents from such devices to communicate the

variable rewards to the users. And then, the perceived utility should be guaranteed. To put it more concretely, if the smell's role is to augment particular contents, we suggest that the rules of the correspondence between the scent and the content should be determined in advance. Besides, the scents should be pre-set according to the particular contents. And then, the required scents in the device should be configured in advance. Most importantly, the scent delivery mechanism should avoid the happening of the scent lingering in the air, scent mixture to ensure a positive effect. When the smell is the leading role of the product experience, we suggest that it should hold multiple optional scents in one device, be portable and make sure the experience is personal (not influencing other people). It is also recommended to make the customization of the scents to users' preferences available. Meanwhile, the company or the creator of the product should provide powerful external triggers, such as introducing the products in a convincing storytelling manner, to make more people willing to try the product at least. Only in this way will users start and repeat the cycles of the Hook Model.

Last but not least, it should be noted that this study has some limitations. Firstly, the four selected products were not developed at one time and have different backgrounds where the level of technology and the trend of the consumer lifestyles are different. Besides, they only cover a limited range of product types. Although we think they are relatively representative in this study, they do not represent the latest technology of olfactory display. Furthermore, this study is from the perspective of habit-forming and thus may fail to cover some factors that are important from other perspectives.

## **5. Conclusion**

To investigate the roles of smell in olfactory display devices from a habit-forming perspective, this chapter has selected four different personal olfactory display devices, analyzed and compared them in the Hook Model. The outcome has revealed that whether the scents can bring the variable rewards is the main factor influencing the habit-forming potential of such products. On the one hand, the olfactory display device should avoid the scents' inappropriate expressions because some issues unique to olfaction make the scents from such devices liable to result in negative responses. On the other hand, it should guarantee the perceived utility of the scents.

To fulfill the potential of scents to convey the variable rewards, the scent delivery mechanism should firstly avoid issues such as scent lingering and mixture. If the smell serves to augment particular contents, it is suggested we should determine the rules of the correspondence between the scent and the content in advance, preset, and configure

the required scents in the device. If the smell itself leads the product experience, in that case, we suggest it should hold multiple optional scents in one device, be portable and keep the scent experience personal. Besides, available customization of the scents to users' preferences is also recommended. Although it is still challenging to predict the future of the personal olfactory display device, this chapter might offer some insight into this field from a habit-forming perspective.

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# Chapter 5

## **New Challenges and Opportunities in Fulfilling the Potential Effects of Scent in the Post-Covid-19 World**

Most parts of the previous chapters in the thesis were conducted before February 2020. At present (October 2020), some things have been different, since the past several months has witnessed the tremendous changes that the outbreak of COVID-19 has brought to the world. People have been experiencing mixed feelings and emotions that many of them may have never experienced before. Facing an uncertain future, some people have thus behaved in a relatively irrational way, which was reflected in the unprecedented panic for toilet paper for a time, for example. With the spread of the pandemic, something we have taken for granted now should be questioned. For example, in the past few months especially when the self-restrict and stay-home were requested in Japan, it was hard to recruit participants and conduct smell-related experiments due to safety and ethical concerns. Even if we could manage to conduct some experiments, it is highly possible that the results reflecting participants' emotions may be biased by the emotions caused by the pandemic. In addition, in the past few months, some cases we have mentioned in Chapter 4 have gone through some changes, which might have been influenced by the pandemic.

Although many things are still inconclusive about the pandemic, at present we know that we have to be prepared to live with the pandemic for some time to come. The fact has led to more challenges to the outside world, but meanwhile, it may also serve as an impetus to fulfill the potential effects of scent, as well as other things that may produce positive outcomes to the world.

### **1. Scent in the Post-Covid-19 World**

In Chapter 4, when we used the Hook Model to compare different representative olfactory display devices, there were two objects that we thought are successful from the habit-forming perspective. They are AROMASTIC and X-Scent 3.0. However, AROMASTIC (a personal portable aroma diffuser dubbed “aromatic Walkman”, released by Sony in October 2016), has announced to discontinue the shipment of “AROMASTIC” and related products in June 2020. This inevitably makes people think

about whether it had something to do with the pandemic. After all, the advantages of the product lie in its portability, capability to provide multiple scents in one device, and applicability in different contexts. However, due to the spread of the COVID-19, people have fewer chances to go outside, and they pay more attention to their behaviors in public spaces. Thus, the advantages of AROMSTIC over other low-tech alternative solutions became less useful than it used to be. Instead, when people spend more time staying home, some low-tech alternative solutions may show better efficacy.

As for X-Scent 3.0 (a scent display used in cinemas, releasing scents to enhance the experience of the movie on the screen), the company ScentRelam is based in China. After the outbreak of the COVID-19, all of the cinemas in China had been closed for about half a year. Subsequently, the use of this device was also suspended. Today, cinemas in most areas of China have restarted the business as usual, and the device has been put into use again. Besides, we have found that it has released an upgraded version, X-Scent 4.0, which is supposed to create a better movie experience for the users [1].

As exemplified by the above two cases, the changes in the external world, the increase in external constraints, and the difference in people's lifestyles will inevitably trigger a shift in design. Likewise, we have to pay attention to such changes when designing smell-related products (experiences) and applying scents in other fields. Because some practices are likely to stay even after the pandemic ends, while some may return to the previous conditions, we have to carefully think about it depending on the concrete cases.

## **2. New Challenges and Opportunities in Fulfilling the Potential Effects of Scent**

Apart from the potential effects of scents that we have discussed in previous Chapters of the thesis, there are other fields where the scents' potential may be fulfilled. Here, the "new" does not necessarily mean something born due to the pandemic. It means that the trend may have existed, and the outbreak of the pandemic may foster the development of it. We think the following directions, which have not been covered by the previous chapters, are worth looking forward to.

### **Digitization, or to a lesser extent, integration into an IoT system**

As we have mentioned in Chapter 4, different from the sense of sound and sight, there are no known standard classification schemes for smells so far [2]. Besides, the concept of iSmell, a computer-controlled scent synthesizer device to enhance the Internet experience, which has appeared in both Chapter 3 and 4, has not yet been

realized after over 2 decades since Digiscents came up with the concept. Yet, it is undeniable that we are living through a digital revolution, where the development of ICT (Information and Communications Technology) and the Internet is producing changes rapidly. As the outbreak of COVID-19 has led us to the age of self-isolation and social distancing, we have spent even more time in the cyberspace, which, for some people, is becoming the new window to the outside world. The cyberspace is filled with an enormous amount of information in various types. However, the sense of smell has not been an available resource yet. Regarding this fact, the development of AI (Artificial Intelligence) may facilitate the uncovering of the mystery of olfaction and accelerate the exploration of scent's digitization. Although it is still challenging to digitize the scent as visual and audio information do, for the present time, it is possible to integrate the related product into an IoT system, so that it can meet certain new needs that have emerged with the tide of technology.

### **Kansei education, to sharpen the sense of smell and the overall sensibility**

Kansei, is a Japanese word originally, the meaning of which cannot be exactly translated by any English word. Following the explanations in the *Shin meikai* Japanese dictionary, Kansei refers to the “intuitive mental action of people who feel some sort of impression from external stimuli” and “the sensibility to perceive external stimuli”. Also, it is said that psychologically, Kansei can be defined as the state of mind where the knowledge, emotion, and passion are harmonized. Thus, those who are rich in Kansei are filled with emotion and passion and have the ability to adaptively and sensitively react to anything [3]. Accordingly, Kansei education, here, refers to what can nurture such Kansei as defined.

The sense of smell has unique relationships with human emotions and memories and has several functions essential for survival, yet it is sometimes thought to be less important than other senses. The possible reasons include the lack of words to describe a scent and the fact that different from signals of other senses, olfactory signals directly go to the olfactory cortex, and are not filtered by the thalamus, which is a part of the brain that chooses which sensory signals to proceed to the cortex, where they will be noticed consciously [4]. In addition, as mentioned above, we have spent more time in the cyberspace, where the sense of smell is still inaccessible. Despite this, we should never let go of our ability to sniff out nuances of information [5]. Instead, we should raise more people's awareness of the significance of smell, and do something to sharpen our sense of smell. In fact, SCENTMATIC, a company in Japan has emerged in 2019, focusing on building the relationships between scents and word expressions. It has raised a concept model named KAORIUM, which is a system equipped with AI and a

database that can translate the scents into Kansei words, and vice versa. Although it is still challenging to actualize the concept to a broader extent, it is believed to bring about a new scent experience and enrich the Kansei towards scents. Besides, the company has also conducted scent-related online activities, such as inviting elementary school students to create stories based on a concrete scent, which can exemplify one way of Kansei education [6].

### **Health, and emotional well-being**

The pandemic has brought about more uncertainties. People may become aware of their own emotional well-being and want to pursue emotional healing more than ever before. Therefore, there is an opportunity for scent and scent-related products, services, and experiences to gain more attention.

In summary, because most parts of the previous chapters were conducted before February 2020, this chapter has provided some supplementary information about the new challenges and opportunities in fulfilling the potential effects of scent, especially in the post-COVID-19 world where the unprecedented situation has made people feel mixed emotions. Apart from what we have discussed in previous chapters, we think the digitization of scents (or integration into IoT systems), Kansei education via scents, and application of scents in the field of emotional well-being are also promising in fulfilling the scents' potentials in the future whether soon or late.

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# Chapter 6

## Discussions and Conclusions

The studies reported in this thesis were conducted generally seeking to explore the potential effects of scents on product experience. Through the studies conducted with different materials and methods, both potentials and limitations of the application of scents have been revealed. In this chapter, we will discuss the general findings and conclude the thesis.

The experimental study with the orange-shape lego-like blocks in Chapter 2 is the starting of the research, with the expectation to find the effects of scents and olfactory-visual (in)congruity on product experience. However, this study did not find significant effects of scents on product evaluation and product liking. We think that this might be explained by the theory of sensory dominance, that the contribution of each sense to the overall product experience is not equivalent in multisensory product experience. In the experiment, the contribution of aromas to the product experience might be inferior to other sensory stimuli, and as the user-product interaction progressed, the effects of scents might be further diluted with more sensory stimuli coming into play. Although here the scents did not cause enough effects to overcome the influences of other factors, the different aromas did lead to semantically different perceptions, different degrees of likings for the aroma (where a higher degree of liking can be viewed as more positive affective responses), and the aromas were found to moderate the moods, such as relieve fatigue, moderate tension and anxiety, and maintain vigor in different phases. These effects are also important. Therefore, we think the scent is potential, but we need to keep the phenomenon of sensory dominance in mind and keep exploring the possible ways to apply scent. Also, in 4.2 of Chapter 4, the sensory dominance was mentioned again, when we discussed about the perceived utility of the carefully assigned scents in some products, which refer to olfactory display devices in Chapter 4. Here, we have used the term – fundamental attribution error. It means that when people concentrate on something attention-demanding, they may often fail to detect scents; even when the scents do serve its role and the users notice the scents, they would not necessarily attribute the experience enhanced by the scent, like pleasure, to the sense of smell, and they would typically tend to attribute it to one of the other more dominant senses, which is often vision and to a lesser extent, audition. Although sometimes the scent is preferred as an “unconscious intervention”, in some cases it is important to let users value, or at

least, notice the effect of the scent if we want the users to invest more time or money in using the smell-related products. Therefore, according to the type of product and the performed tasks, in some cases, it is necessary to consider how to convince users to assign the source of their enhanced enjoyment to the stimulation of the sense of smell when applying scent in design.

In Chapter 3, by conducting the investigation of 25 samples, we aimed to learn from the existed application of scents to know the emotional effects of scents and to further extend such potentials to other products' design. It is clear that in a real orange, the role of the scent must be different from the orange-shaped lego-like toy blocks. That is, the scents are supposed to play different roles and deliver different emotional effects according to the product. By employing several approaches, we have described the emotional effects of scents on different smell-related products and experiences, identified 3 patterns of how scents deliver the emotional effects, and further explored the possibilities of applying scents based on the 3 patterns. The potential ways to apply scents include utilizing scent as an unconscious intervention to nudge for the good, introducing a trick to release scents to moderate the negative emotions that the use of some products may induce, and applying scent as a media component together with other contents or for universal design, to name a few. This study has several limitations and issues worth noting as reported in 4.3 of Chapter 3. We have expected that the study in Chapter 3 would demonstrate the emotional effects under real-life conditions better than the experimental setting in Chapter 2. However, the results were a little bit general than expected, and some effects of scents were based on ideal assumptions, which requires further validation. Despite this, Chapter 3 did reveal the emotional effects of scents and the possibilities of applying it in other fields, to some extent.

As also revealed in Chapter 3, the olfactory display is a potential medium to utilize the effects of scent. However, it is still not prevalent, especially compared with its audiovisual counterparts. Therefore, in Chapter 4, we further examined the roles of scent in product experience from a habit-forming perspective, by comparing four different representative olfactory display devices. We employed the Hook Model for the analysis. And it turned out that whether the scents can bring the variable rewards to users is the main factor influencing the habit-forming potential of such products. On the one hand, the olfactory display device should avoid the scents' inappropriate expressions because some issues unique to olfaction make the scents from such devices liable to result in negative responses. On the other hand, it should guarantee the perceived utility of the scents. The end of Chapter 4 has raised brief suggestions for olfactory display devices to be more habit-forming. But the general directions as mentioned before may also work for the application of scents in other product forms,

because the phenomena mentioned in 4.1 and 4.2 of Chapter 4 may also tend to happen for other smell-related products and experiences. In addition, to estimate the potentials of new smell-related proposals, we may use the Hook Model together with other tools.

There is much room for improvement in the implementation of the studies reported in Chapter 2, 3, and 4. The data in the experimental study in Chapter 2 were mainly obtained by self-report questionnaires which were completed by the participants. In fact, in preliminary experiments (which is not recorded in the thesis), we had once used devices to record participants' pulse rates, but the accuracy of the data did not meet the expectation, so we had to give up using that device. If the condition allowed, we could use other tools, such as electroencephalograph (EEG) to measure the physiological effects. As revealed by some electrophysiological studies, a variety of scents could affect spontaneous brain activities and cognitive functions, which are measured by EEG [1]. If we had used such tools, combining the results of physiological measurements and self-report questionnaires may enrich the insight we could gain from the experiment. As for the two studies reported in Chapter 3 and 4, they did not involve participants' participation. The problem is that some results were obtained based on relatively ideal assumptions, and there is a lack of a clear definition of users. It would be better if we could corroborate it with actual users' voices and feedbacks. After all, it is thought that there are individual differences in people's responses to a scent. Therefore, in future research, we should consider more carefully in the choice of the methods.

Comprehending the outcomes of the main studies reported in this thesis, it is fair to say that we should never stop promoting the application of scent in existing related products and experiences in appropriate manners. Further, in some areas that have not had relevance to scent yet, if designers aimed to achieve emotional appeals, they could consider utilizing the scents accordingly. As we have raised several possible directions to apply scents in 4.2 of Chapter 4, it has shown some possibilities of applying scents but definitely did not cover all of the potential ways to make use of scents. Still, some issues and limitations related to the olfaction and scent are worth noting when applying scents. Apart from the limitations brought by some tricky olfactory phenomena, to further employ scents as what people have done with audiovisual information, there are still plenty of technical limitations. For example, different from the sense of sound and sight, there are no known standard classification schemes for smells yet [2], and hence replicating a large number of certain scents with several limited "primary odors" is still impossible, let alone the digitization of scents at present. Despite these unsolved issues, we think it is still worthwhile to further explore the potential emotional effects of scents on the product or user experience from broader aspects, including new potential ways to utilize scents and tackle the issues unique to smell, in the future. After

all, we could expect that someday in the future, the development of AI may accelerate the uncovering of the mystery of olfaction, and increase the possibility of digitizing scents, just as we have mentioned in Chapter 5 when discussing the opportunities and challenges of fulfilling the potential effects of scent. In addition, even when such limitations will remain for some time to come, we can still probe into the potential emotional effects from some other angles. For instance, we can move our focus to the relationships between scents and descriptive words. Or we can utilize scents to implement Kansei education, to raise more people's awareness of the significance of smell, sharpen people's sense of smell and their overall Kansei, and make people take more care of their emotional well-being. In future research, we could also lay our focus on such directions. And to investigate and verify the effects of scents in future research, as mentioned in the previous paragraph, we should conduct experiment design in a smarter way to reduce the influence of experimental settings on the reflection of scents' real effects, employ appropriate methods, such as the combination of physiological measurements like EEG and self-report questionnaires, and listen to actual people and users' voices and feedbacks more, to truly validate the efficacy of emotional effects of scents.

In conclusion, the thesis has shown that the scent has many potential effects, including making people feel good, improving the first or overall impression of the product or experience and making it more memorable, and even conveying information. When applied appropriately, it should make the product experience elicit more positive emotions and increase its emotional values, so it is necessary to avoid some phenomena that may be negative, such as olfactory adaption due to the scent lingering, and the unintentional scent mixture. Also, the issue of sensory dominance should be overcome so that user experience enhanced by the scent can be fairly attributed to the sense of smell. In today's world that has been more stressful especially due to the outbreak of COVID-19, the potential effects of scents should be valued and fulfilled more.

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# Acknowledgments

The completion of the PhD research and this thesis has been greatly supported by so many people, to whom I would like to express my gratitude.

First and foremost, my deepest gratitude goes to my principal advisor, Professor Makoto WATANABE, for not only offering me the opportunity to further study design science in Japan in the past several years but also giving me great encouragement to continue the academic pursuits. He also helped me grasp the valuable chance to have a part-time job in the Japan Institute of Design Promotion, the over two-year experience in which has shown me various perspectives to view design and broadened my horizons.

Warm and respectful thanks to Professor Kenta ONO, for all of the time and efforts in helping me finish and improve the thesis. He kindly pointed out the inadequacy of the previous thesis, which pushed me to rethink about the whole structure of the thesis.

A gratitude to Professor Shinichi KOYAMA, Professor Ayako NAGASE, and Professor Jinghua HUANG, the guidance and advice from whom greatly deepened my insights into the study results and enriched this thesis. I would like also to thank all the editors and anonymous reviewers who spent their valuable time in reviewing the manuscripts I submitted to the Journals and providing insightful comments, which contributed a lot to improving the quality of the manuscripts. I am also grateful to Professor Fumio TERAUCHI, and Professor Michiko TAKAGAKI for accepting the role of examiner for the thesis review, the valuable comments from whom further improved the overall quality of the thesis.

I would like to express my gratitude to all of the members in the System Planning Laboratory. Ms. Keiko SUGITA, Ms. Emi TAKAMORI, and Ms. Yuko TAKAHASHI helped me a lot in tackling different kinds of documents. Suggestions from Mr. Algirdas PASKEVICIUS helped me adjust myself to life in Japan as an international student. The kindness of both the Japanese and international students made my life in Japan colorful, fun, and memorable.

Last but not least, I am deeply grateful to my family members and friends who have supported me along the way. The year 2020 has been a hard year. Objectively I was alone when I wrote the thesis, but I did not feel I was alone thanks to them. Thanks for all the love and supports, especially emotional supports, which have made it possible for me to finish the thesis.