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Master's Thesis
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Scent-Based Play Design Prompting Olfactory Stimulation for Elderlies in Japan

Keio University
Graduate School of Media Design

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A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Annika Kondo

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Abstract of Master's Thesis of Academic Year 2023

Scent-Based Play Design Prompting Olfactory Stimulation for Elderlies in Japan

Category: Design

Summary

This research aims to investigate the design principles for olfactory stimulation games tailored specifically toward elderlies in Japan. While all our senses deteriorate with age, in contrast to visual and auditory impairment, olfactory impairment is frequently seen as a poor subjective symptom. Yet the consequences that olfactory impairment can have on our lives are significant. However, olfactory ability can be trained and improved through active olfactory stimulation. In activities for elderly people, scent is almost completely overlooked, despite being a powerful medium to stimulate cognitive activity, connect to memories and emotions, and spark social interactions. It is a creative medium that is yet to be explored, especially in the context of scent-based play for elderlies. To accommodate for the lack of investigation in this context, this research proposes a scent-based game kit designed to be played among elderlies in facilities such as daycare centers and community spaces. The game kit contains a selection of game components and instructions that can be used to play a variety of scent-based games. The game kit is designed to stimulate the sense of smell and to increase awareness and interest in scents. Furthermore, it is an attempt to create a novel and enjoyable recreational activity that can facilitate social interaction and activate olfactory memory recall. Based on user feedback from observations, interviews, and questionnaires, the key design principles for scent-based games for elderlies were identified to be simple game rules, relatively short play duration time, proper scent control, variation in ways to play, and social activity. The evaluation results of the game kit have proved a high level of motivation, enjoyment, and an increased interest in scents among the participants, validating the design objectives of the game kit. The

findings from this study suggest scent can be used as a playful medium in the development of engaging recreational games for elderly people to stimulate the sense of smell.

Keywords:

scent, olfactory stimulation, hyposmia, aging society, scent-based play, recreation

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Chapter 1
Introduction

For impaired vision, a pair of glasses can be used, and for impaired hearing, a hearing aid can be used, so what can be used to help with impaired smelling? In the current state, while all our senses undergo changes with age, there is no existing corrective technology for olfactory deterioration [1]. Among sighted and hearing individuals, input from our surroundings is received in the proportions of 60% visual, 20% auditory, and a combined 20% of touch, taste, and smell [2]. Unlike vision and hearing, the deterioration of the sense of smell happens unconsciously, and olfactory deterioration is frequently seen as a poor subjective symptom, meaning that we rarely notice it until it is very impaired [3]. This is due to the unconscious processing nature of the sense, and we rarely pay active attention to the sense in our daily lives. Nonetheless, a decreased ability of the sense of smell can have significant consequences on the overall quality of life, food-related behavior, decrease in cognition, and be indications for neurological diseases like Alzheimer's disease [4]. However, uniquely for olfactory cells, their functions can be regenerated [5]. Hence, through active olfactory stimulation, the olfactory ability can be trained and improved. Olfactory training and stimulation are proven methods to mitigate age-related olfactory deterioration [6].

Several researchers claim that there is a lack of public awareness regarding this problem and limited existing research [7]. However, in recent years, olfactory loss has attracted more attention due to its frequent occurrence as a symptom of COVID-19. Despite being less investigated, the loss of smell and scent distortions brought on by COVID-19 has raised awareness among people regarding its significance for nutrition, health, and well-being and is certainly receiving more attention than before [3]. At the same time, according to epidemiological studies, olfactory deterioration is increasingly prevalent in people aged 60 and older [4].

Accordingly, the Ministry of Health, Labor and Welfare has estimated that people aged 65 years and above will take up 35% of the population in Japan in 2040 [8]. In a rapidly aging society where more than a third of the population in a few years will be represented by people aged 65 and over, age-related olfactory deterioration becomes a problem that should not be ignored.

In our daily lives, olfactory exposure is relatively passive compared to olfactory training paradigms [1]. When designing concepts for olfactory stimulation, there is a necessity for distinguishing between the unconscious and non-focused ways individuals encounter scents in their daily lives versus the conscious and focused way they smell when doing olfactory training. Active and focused smelling can improve olfactory sensibility and cognitive functions [9]. Thus, raising awareness and piquing people's interest in using their sense of smell more consciously is believed to have a positive impact on olfactory and cognitive function and well-being.

Current olfactory training is a simple strategy that involves repeatedly smelling selected scents. Thus, it is argued that there is potential and a need for more sophisticated and playful training methods. Game-like approaches can increase motivation and facilitate user engagement and can be a valuable form of training, particularly for elderlies who still have some olfactory sensitivity but want to employ olfactory training to enhance further cognitive and emotional benefits [1]. However, the concept of training can for many be associated with a rather serious and involuntary concept. But by turning it into a playful activity, a tedious training task can be transformed into an enjoyable and motivating experience [10].

Having introduced the background and problem scope, this research explores the possibilities for designing scent-based play for elderlies in Japan. The meaning of "elderlies" in this research is defined as individuals above age 65, as evidence shows that age-related olfactory deterioration gradually begins from the 60s [11]. As a final concept, a game kit containing various olfactory games is designed. The objectives behind the game kit are to stimulate the players' sense of smell, increase awareness of the sense of smell and interest in scents, facilitate social interaction, activate olfactory memory recall and experience sharing, and design a novel and

enjoyable experience.

Using scent as a medium for games is an underexplored but opportunity-rich research topic [12]. However, in Japan, playing with scents is an activity and an art form rooted in history and has already been a tradition for more than 700 years. This traditional art form is called Kōdō. The way that our sense of smell is used in Kōdō is similar to how it is used in olfactory training. It is the highly conscious and concentrated way of smelling the fragranced woods in Kōdō that is closely related to olfactory training. Kōdō allows individuals to concentrate and immerse themselves in the scent, and from this activity, they can improve their olfactory ability [13]. For this reason, this research and the concept design are inspired by this unique Japanese tradition.

Currently, various recreational activities and creative attempts to engage elderlies in social activities exist. However, these activities are mainly engaging physical and cognitive activities through sensory inputs limited to visual, auditory, and tactile stimulation. The challenges that arise from using scent as a medium may be a reason for its exclusion from playful recreational activities. However, designing engaging activities for elderlies to prompt olfactory stimulation is meaningful, and scent as a playful medium has so much potential due to its personal nature and unique power to elicit emotions and distinctly bring memories to the surface. Very little research has been done on how to engage elderlies in scent-based play. Hence, this research is the first of its kind to explore scent-based play for elderlies in the context of recreation and olfactory stimulation. It aims to contribute to increased interest and knowledge in the field of working with scent as a medium in play design.

1.1. Terminology

Since many terms convey the notion of “smell”, most commonly “smell”, “scent”, “odor”, “aroma”, “fragrance”, and “olfaction”, a clarification on what each of these terms means will be provided. These terms all relate to the sense of smell, but they each have slightly different meanings and nuances and are context de-

pendent. “Smell” is in its basic form a neutral and general term for what we can smell through our nose. In the same vein, “scent” is used synonymously to “smell” as it is also perceived as neutral. However, it tends to be used more often in the context of a distinctive and pleasing smell. “Odor” refers to a smell in its neutral form as well but is mostly used in the context of unpleasant smells and is a term that is often used in a rather scientific context. On the other hand, both the terms “aroma” and “fragrance” describe pleasant smells. While “fragrance” is frequently linked with perfume and flowers, so sweet or pleasant smells that are added to products, “aroma” is mostly used to describe plants, food, and spices. And lastly, “olfaction” is a more technical term that refers to the physiological process of sensing smells through the nose and is mainly used in a scientific and technical context[1]. The abovementioned terms will be used in this thesis depending on the context and references. However, for the sake of simplicity and cohesion, mainly “smell”, “scent”, and “olfaction” will be used in this thesis.

1 All the definitions are retrieved from Cambridge Dictionary: https://dictionary.cambridge.org/ja/dictionary/english/olfaction

Chapter 2
Literature Review and Related Works

In order to better understand how scent can be used in play design for elderlies, first, an understanding of how the sense of smell functions, how the sense deteriorates with age, how the sense can be stimulated through scent-based play, and what previous attempts and research exists in this field must be gained. Looking into the unique qualities of scents and how the sense of smell differs from the other four senses gives insight into the opportunities and challenges of using scent as a medium. Further, a fundamental understanding of the context and target group is crucial for the final design of a purposeful concept. Lastly, in order to grasp the opportunities for novel olfactory play design, the long-lasting Japanese tradition of using scent in games, Kōdō, and the cross-modal associations that arise from olfactory stimuli, will be reviewed.

2.1. Olfaction - the Sense of Smell

How do humans perceive smells and what are the unique qualities of the sense of smell? The sense of smell is considered the most instinctive and ancient sense among the five human senses [14]. At the same time, the sense of smell is undoubtedly the most complex sense in the human body as humans are able to detect over 10.000 different scent subtleties [15]. The sense of smell transmits signals from the nose to the olfactory bulb located near the limbic system, which is the part of the brain associated with memory formation. This proximity allows smells to directly influence the hippocampus and amygdala, which are two key brain regions involved in memory encoding and emotional processing [16]. Thus, unlike all other sensory information, olfactory information is not conveyed through the

Thalamus (a main integration destination for sensory information) but is instead sent directly to the amygdala-hippocampal complex [14]. This strong connection between scent and memory is also what is known as the Proust effect (Proust 1960), which describes the human's ability to recall a scent from their childhood upon smelling the same scent again in their adulthood [17].

Unlike memories prompted by any other cue, memories generated by scents are more emotionally and evocatively remembered, which is why they are significant for human health and wellness. These emotionally potent and vivid smell-evoked memories gives people a strong sense of "being brought back" [18]. The neurobiological substrates of emotional processing are activated and can transport people to the original time and location of their memories far more accurately in comparison to when the same events are recalled through other modalities [16]. Due to the direct transmission of smells to the limbic system, research suggests a relationship with unconscious emotions and memories that underlie human conscious information processing. Since human subjective and conscious experiences are formed from such unconscious emotions and memories, stimulating the sense of smell is believed to lead to stimulating cognitive functions [19]. Due to this background, the sense of smell is gaining attention in terms of stress management, prevention of dementia, and general well-being.

2.1.1 Olfactory Language

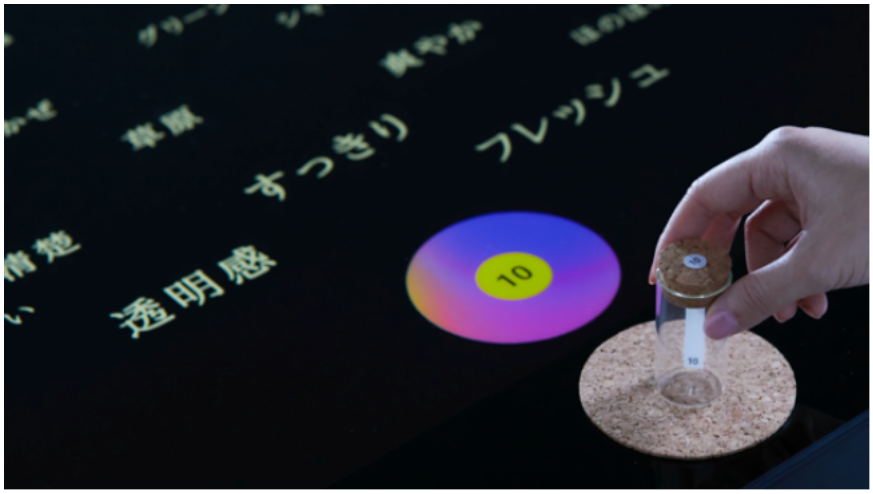
Another intriguing aspect of the sense of smell is our relatively poor ability to identify and label a scent and the source of the olfactory stimuli, especially in the absence of other sensory stimuli and contextual information [20]. This phenomenon is known as the "tip-of-the-nose" effect [21]. Because a substantial portion of the processing of olfactory stimuli takes place in the limbic system, semantic categorization of these stimuli is challenging. Majid [22] uses the phrase "olfactory language" to describe both a specialized, abstract olfactory vocabulary and the ability to consistently and effectively name or classify scents.

How we perceive and understand a scent is impacted by associative learning. Associative learning is the process through which one event or thing is connected

to another according to an individual's prior experiences [23]. Thus, it is related to our past experiences, memories, and gained knowledge. Consequently, scents are often referred to as the scent of an odorous object itself, compared to the appearance or taste of the object, or with adjectives that compares the scent through similarities with another sense [24]. First, when we recognize the scent of a specific thing, we use the name of the object, such as the scent of vanilla. Next, in case it is not possible to specify what the scent is, we compare it to something similar, such as a dessert-like scent or a sweet scent. Scents are also often expressed in terms of qualities of taste, as the sense of smell and taste are closely intertwined [25].

Unlike scents, colors and sounds, for example, can be quantified. Colors are given clear classes like red, blue, and yellow, and sounds are given names such as do, re, and mi [26]. However, since there exists no such thing as a semantic field for scents, there are no distinct scent lexemes [27]. Thus, scents are described by comparison to distinctive scents of particular well-known kinds of objects. Comparative descriptions enable us to provide sufficiently accurate and intersubjectively comprehensible characterizations of the way things smell, which can serve diverse communicating roles. This compensates for the lack of a specialized olfactory vocabulary in our language [26].

As an attempt to bridge this gap between scents and language, the concept of Kaorium was developed by the company Scentmatic. It is an artificial intelligence (AI) system that verbalizes olfactory impressions through word suggestions. Kaorium presents each scent with a variety of terminology, enabled using big data and natural language processing technologies. Kaorium as a concept is aimed to provide customers with descriptive words of a chosen scent allowing them to explore and discover their scent preferences in a purchasing process. However, it is also believed that the act of verbalizing our impressions of scents helps add depth to our olfaction and possibly enhances our sensitivity towards scents in our surroundings [28].



(Source: Scentmatic website [28].)

Figure 2.1 Related work: Kaorium.

2.2. Hyposmia – Olfactory Deterioration

Hyposmia (or olfactory deterioration) refers to a decline in the ability to detect and discriminate smells, which can occur because of a variety of factors. One of the main reasons for the decline in olfaction with age is due to the decreasing number of olfactory receptor cells in the nose. The olfactory receptor cells are responsible for detecting smell molecules and sending signals to the brain, so a reduction in their number can lead to a decreased sense of smell. Additionally, the structure of the olfactory bulb can change with age, leading to a reduced ability to detect and discriminate different smells [29] [30].

Factors that are associated with an increased incidence of olfactory deterioration with age include neurodegenerative diseases, such as Parkinson's disease and Alzheimer's disease. Smoking and heavy alcohol use, for example, has also been shown to be a risk factor for age-related olfactory decline [4]. According to a survey conducted in Japan, the sense of smell among the participants began to decline gradually from the age of 60 [11]. While all sensory systems weaken as we age, the olfactory system's shifts have distinctive causes and effects on our health

and well-being. For example, it can affect a person's ability to detect dangerous odors, such as gas leaks or smoke, which can be life-threatening. It can also impact a person's enjoyment of food, as the sense of smell plays a crucial role in how we perceive flavors [4]. Less enjoyment of food can lead to reduced appetite and malnutrition and a poor gustatory ability accelerates decreased sensitivity to flavors (salt, sugar, etc.) and ultimately leads to various health issues [31]. Additionally, studies have shown that a decline in olfaction with age may be associated with an increased risk of depression, social isolation, and overall cognitive decline [32].

In the United States, a national questionnaire-based survey revealed that just 1.4% of the population overall knew about their olfactory impairment [33]. On the other hand, a large-scale survey conducted in the United States using the San Diego Odor Identification Test revealed increased rates of olfactory impairment occurrence, affecting 3.8% of the general population and 13.9% of people 65 and older [34]. There is a difference in method between these two surveys, where the first one was a subjective survey based on self-assessment questionnaires and the second one was an objective survey in which participants underwent a measurable olfaction test. Thus, when comparing the two surveys, the low prevalence of olfactory impairment on the subjective tests indicates that the elderly are less likely to be aware of their olfaction declining [3]. This can quickly become a problem, as people tend to realize their decreased olfactory ability once it has become very impaired and starts affecting their daily lives. Miwa et al. [7] emphasize that there is a lack of public awareness regarding this problem, thus stressing the importance of raising awareness about the impact of olfactory impairment on quality of life and disability and how this can be alleviated.

2.3. Olfactory Stimulation

While there is no complete cure for age-related olfactory decline, there are some strategies and approaches that are suggested to help mitigate its effects. For example, maintaining good general health and avoiding environmental toxins may help to preserve the sense of smell [35]. Additionally, engaging in activities that stimulate the sense of smell can help to maintain olfactory function [36]. Olfactory

cells are rare cells that can regenerate their functions [5]. Thus, through active olfactory stimulation, the olfactory ability can be trained and improved [6].

According to research by Baker et al. [37], sensory stimulation and activities can improve both emotional and social responses in people. Activities with sensory stimulation engage consciousness or passively immerse people in their surroundings to stimulate their five senses by using direct sensory stimulation [38]. A range of activities can be employed using different types of stimuli, and some of these activities can also target unisensory stimulation (like in the case of this research). Emerging evidence shows that an individual's olfactory performance can be trained, and such interventions are often referred to as olfactory training [36]. Not only does olfactory training have an effect on alleviating age-related olfactory deterioration but also has the ability to improve people's emotional and cognitive health. The majority of current existing olfactory training studies have employed a simple training strategy that involves repeatedly smelling a set of scents [1]. This simple training strategy is also reflected in the existing olfactory training kits, which have become more common and widespread due to the prevalence of olfactory loss caused by Covid-19 infections. However, as Olofsson et al. [1] state, traditional olfactory training is very simple and does not attempt to activate olfactory-cognitive processes. Thus, they argue that more sophisticated and playful training methods should be suggested.

2.4. Recreation

Recreation is an activity for enjoyment that people engage in and acknowledge as having socially beneficial qualities. Although recreational activities can take many different forms, they have the connotation of being ethically acceptable to both the individual and society. This, therefore, implies that the kind of recreational activities that are socially acceptable might alter over time. There are countless examples of recreational activities, such as sports, gaming, music, arts and crafts, and reading. The purpose of carrying out the practice is considered more significant than the activity itself and its content. Most people's main goal is to enjoy their time or heal themselves. People believe that engaging in recre-

ational activities will help them maintain a mentally and physically healthy life. Because of what recreation contributes to society, many also view it as a means of socialization. In other words, professionals have long employed recreation services and programs to create socially desired outcomes including responsible leisure time usage, physical and cognitive activity, and better well-being [39]. Recreational games are characterized as being simple and with a relatively low entry barrier. Research has shown that such qualities of recreational games foster social interactions and companionships. Thus, they have the potential to assist the development of social capital in elderly people by giving opportunities to build social networks and reducing social isolation. It is believed that engaging in playful recreational activities helps to link language, movement, sociability, cognition, and emotion [40].

2.5. Scent in Play

As Niedenthal states, "playfulness is one way in which we reclaim our humanity, and smell is one of our most basic channels for engaging the world" [12]. With this, he claims that there are many possibilities for scent integration in games and play. Due to the lack of exploration and research on scent in games, no one approach can be applied to designing scent-based games. Thus, there is a freedom of approach and exploration [12].

According to several studies, gamification improves motivational and performance factors. With this, it is anticipated to increase both the overall enjoyment of the activity as well as the individual's long-term motivation and engagement [41]. Munson et al. [10] contends that the effectiveness of gamification arises from its power to transform tedious tasks into exciting and motivating experiences. The authors emphasize the potential of gamification for changing behaviors with the example of health care. Munson et al. bases their study on behavioral theories and claim that gamification has a role in activating the right psychological trigger to motivate individuals. Similar to Proust's involuntary memory remembrance, the act of smelling is transformed into a stimulating, embodied adventure in attempting to explain or locate the scent inside a past event when one experiences the

memory but is not (yet) able to find the appropriate terminology or connotations for it. As a result, it is believed that scents will be powerfully motivating game features since they involuntarily stimulate memories that encourage engagement or play [42].

In recent years, tabletop games that require multiple cognitive abilities, such as attention, memory, or communication have been linked to improvements in elderlies' executive function and general cognition. This type of game has characteristics of cognitive training and has further proved enhancement in social participation and interaction among elderlies [43]. Thus, tabletop games have shown great potential for stimulating cognition and interpersonal interactions. Game-like approaches can increase motivation and facilitate user engagement. As Olofsson et al. [1] argue, game-like challenges may show to be a valuable form of training particularly for elderlies who still have some olfactory sensitivity but want to employ olfactory training to enhance further or possibly achieve cognitive or emotional benefits. This indicates a potential for exploring the combination of olfactory training and tabletop games for elderlies.

2.5.1 Scent in Tabletop Games

Despite some of the challenges that derive from designing with scents (scent dispersion etc.), there have still been some previous attempts to use scent in play [12]. However, most of the recent research in implementing scent in play or entertainment are heavily focused on creating immersive multisensory experiences (as in multimedia or therapeutic applications) by adding scent to technologies such as VR/AR experiences [44] [45]. Thus, research and attempts in implementing scents in tabletop games are very limited, and in terms of recreational purposes, it is close to non-existing.

For commercially available scent-based board games (such as "Topscent", "Follow your Nose", etc.), the primary target audience appears to be children, with the core purpose of encouraging their discovery and exploration of the scents. There exist games like these for adults as well, though with the additional purpose of honing the player's sense of smell. For instance, Le Nez du Vin is a board

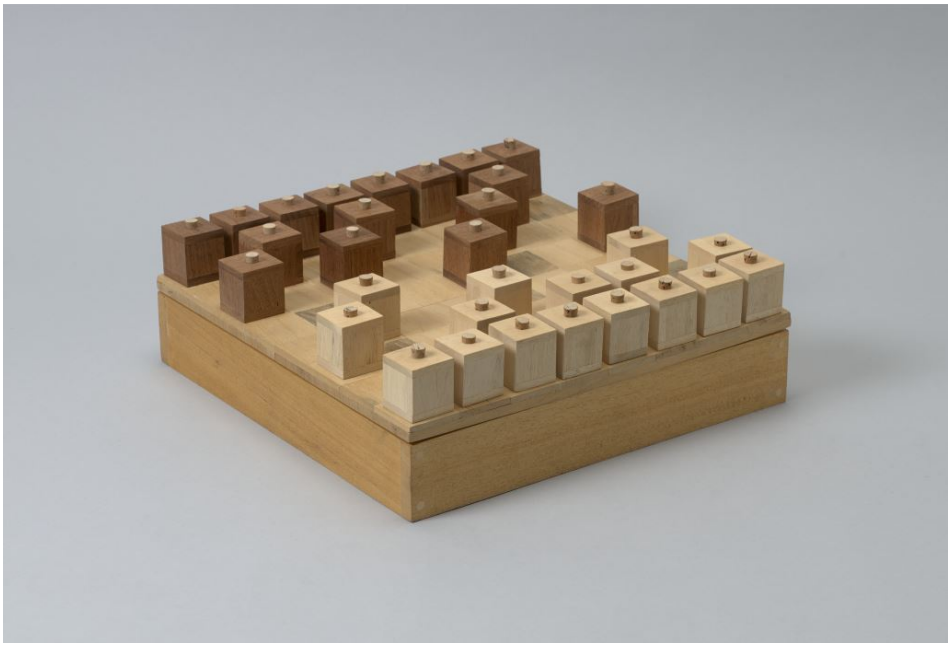
game that aims to increase players' sense of smell and their understanding of wine components. In this case, the player's primary objective is to identify one or more smells from the game elements and build a "personal library" of scents through exploratory learning.

(Source: Editions Jean Lenoir [46].)

Figure 2.2 Related work: Le Nez du Vin.

Another example is to add scent to a familiar game setup. In the mid-1960s, Takako Saito, a Fluxus artist, modified various chess sets including Spice Chess. Saito kept the chessboard but substituted the conventional chess pieces with similar bottles holding twelve different scented spices [47]. This change has led to the result that the only way to tell which piece is which, is by smelling it: the white pawns were cinnamon, the white rooks were nutmeg, the white knights were ginger, the white queen was anise, and so on. Players were required to spend time understanding and remembering the scents before the game. In contrast to a more conventional chess experience, the game creates an intimate nature whilst being played. By analyzing Spice Chess, some significant insights can be gained

about how to create new types of olfactory involvement in games, which may be applicable for elderlies as a target group. First, Spice Chess functions by adding scents to a well-known game format. The players can concentrate on the sensory aspect of the game by applying their understanding of how chess works. Thus, it does not take too much effort to understand the game rules. Second, it might be claimed that scent games are intrinsically educational games since they include a completely novel method of participation [12].



(Source: MoMA Website [48].)

Figure 2.3 Related work: Spice Chess by Takako Saito.

2.6. Kōdō

An example of one of the longest-lasting scent-based plays or art forms, is Kōdō. Kōdō is one of Japan's three major ancient art forms along with the tea ceremony (Sadō) and flower arrangement (Kadō/Ikebana). The culture of incense was brought to Japan with Buddhism, and approximately 1500 years after the introduction of incense, at the end of the Muromachi period (1338–1573), incense-using

rituals began to evolve into an art form known as Kōdō, or incense ceremony. The Edo period (1603–1867) marked the formation of the foundational elements of the art form, which have been carried on to the present day. It is a highly spiritual and unique art form that cannot be found elsewhere [13]. A traditional Kōdō ritual in an incense ceremony tries to identify the incense being burned by detecting the slightly different scents of fragrant woods (called Kōboku). Among the fragrant woods are cedarwood, agarwood (Jinsuikōboku), sandalwood (Byakudan), etc. [49].

(Source: photos taken by the author.)

Figure 2.4 Preparation of fragrant woods (Kōboku).

Very uniquely in Kōdō, the act of "smelling" a scent is expressed as "hearing" a scent. This is because it is believed that the fragrant wood is a living organism, where each wood has a soul, and we hear the voices of nature and earth through the smell of fragrant wood. The term and act of "Monkō" (literally meaning to listen to what scents are telling you) were inspired by the practice of "listening" to the scents. Through the listening of scents, we face ourselves [50]. Kōdō is not only the act of enjoying the scent itself, such as just smelling if it is good or bad, but it is also about connecting the scent to something else. The incense ceremonies frequently contain themes based on traditional Japanese poetry (e.g., the Tale of Genji), historical occasions, or seasonal changes [13]. Thus, the scent is used to create cross-modal expressions and connections to elements that are not

directly related to the scent.

Kōdō embodies two aspects: one being the aspect of enhancing well-being and mental health and the other being the gaming aspect [49]. Listening and fully immersing oneself in the scents provides a deeply mindful and meditative experience and it is believed that improving the art of scent is connected to improving the mentality. The very concentrated and actively focused way of using the sense of smell in Kōdō is said to be unique in the world. In Kōdō, the sense of smell is used to play, and through smelling, we imagine the world and scenery of the subject matter of literature and experience the difference in how we perceive smells with others. It goes beyond just enjoying the scents [13]. At the same time, the way that the sense of smell is used in Kōdō is similar to the way it is used in olfactory training. Thus, it is very different from how we use our sense of smell in our daily lives and serves as an effective and playful way to stimulate the sense of smell.

(Source: photos taken by the author.)

Figure 2.5 The setup for a Kumikō experience.

The gaming aspect is another core part of the incense ceremony. In the traditional Kōdō game Kumikō, participants must describe the scents and the order in which various incenses were burned after being given with a variety of them simultaneously [49]. However, there are several variations of how to enjoy and play Kumikō. In Kumikō, the worldview and atmosphere can be imagined and felt through the scent of incense [51]. A semi-structured interview was conducted with a Kōdō Specialist, Mr. Y. In this interview, Mr. Y explains that the starting point for Kumikō was gambling, arising from how much good fragrant wood the wealthy brought back in the Muromachi period. However, as an art form, Kumikō was created for people to concentrate on the scents. The reason why Kumikō still exists is that, in order to get people (especially beginners) to concentrate on the scents, it was necessary to make it into a game-like format with a goal of, for instance, guessing the correct answer. Otherwise, it is difficult for beginners to fully focus on the scents. Thus, the importance of this activity lies not only in the ability to distinguish the different scents but also in immersing ourselves and concentrating our attention on them. In summary, it is characterized as a sophisticated form of recreation for all participants to enjoy the scent, the setting, and the aesthetic ambiance of the ceremony and to identify relations to other artful expressions, like classical literature [13].

2.7. The Cross Modal Correspondence

Rarely do we experience our surroundings through one sense alone. Our senses are interconnected in the way we experience the stimuli around us and the stimulus in one sensory modality is very often connected to a perception in another sensory modality [52]. This phenomenon is termed cross-modal correspondence, which is defined as “a tendency for a sensory feature, or attribute, in one modality, either physically present or merely imagined, to be matched (or associated) with a sensory feature in another sensory modality” [53].

Until now, studies have documented the existence of cross-modal correspondences among almost every pair of sensory modalities [54]. Though within the investigation of cross-modal correspondences, the sensory correspondences between

audition and vision are the most established, and those between olfaction and vision are yet to be explored [55]. It is here worth stressing that there is a difference between cross-modal correspondences and synesthesia. Synesthesia is an instinctive and involuntary phenomenon in which activation in one sensory or cognitive modality causes activation in a second, usually unrelated modality, leading to the perception of an abnormal subjective experience [56]. Cross-modal connections show substantial correlations between sensory modalities but are not automatic or involuntary like synesthesia [57]. Thus, cross-modal links are widespread including in non-synesthetes. Cross-modal associations have a crucial influence on cognitive processing. It is well established that humans typically are better at detecting, identifying, and recognizing multisensory inputs compared to unisensory inputs [52]. In terms of olfaction, this means that compared to the input of scent alone, we are better at identifying the scent in the presence of e.g., visual, haptic, gustatory, or auditory cues.

2.7.1 Scent and Color

One of the modal elements that humans most naturally correlate scents with, is colors. Studies have shown that individuals often exhibit consistent associations between specific scents and colors and remained consistent over time when tested again up to two years later [58]. For example, the scent of bergamot and lemon is frequently associated with yellow, patchouli with brown, and strawberries with red or pink [59]. Further, darker hues are often associated with stronger scents [55]. As previously mentioned, the dominant explanatory framework for these correspondences is learned associations. Thus, an individual's personal experiences and knowledge are related to what cross-modal connections are made [23].

Not much research has been conducted examining the influence of cultural background on scent-color associations. However, the dominant theory about the associations being learned through experience indicates some degree of cultural influence [20]. A study conducted by Levitan et al. [60] investigated 14 scents linked with common products (flower, vinegar, musty, fruity, woody, etc.) among six different participant groups, including Dutch, Chinese, Malay, German, Malaysian Chinese, and Americans. Participants were asked to choose three

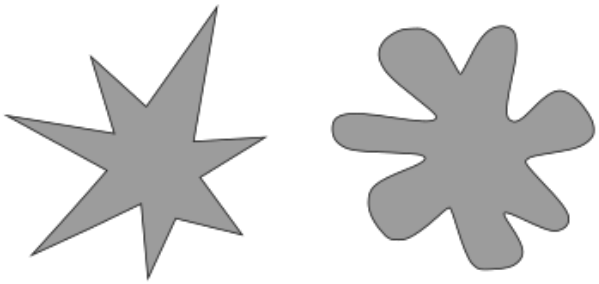
congruent matching colors and three incongruent ones. The findings showed that several of the scents had common color correlations among the different cultures. For instance, the musty scent was frequently matched with browns and oranges whereas the fruity scent was more frequently matched with pink and red hues. However, representational dissimilarity research also showed a number of cultural variances. According to the results, participants from Germany and the US showed the highest degree of scent-color matching similarity. Another crucial observation was that all the scents in all six of the examined cultural groups showed strong non-random color preferences [20] [60].

Furthermore, the reported scent-color correlations seem to vary depending on how familiar the scent is and how easy it is to identify the source, and this affects the association and interpretation that is obtainable [20]. Nehmé et al. [61] conducted a study investigating the cultural influence of scent-color associations among participant groups with three different cultural backgrounds: French, Lebanese, and Taiwanese. From the study, the scent-color correlations appeared to be influenced by both perceptual and semantic elements in each nation. Thus, cultural experiences have an impact on the frequency of perceptual (intensity, irritancy, and hedonics) or semantic (labeling, familiarity) processing of these associations, which affects how familiar a scent is perceived [60] [61]. The studies mentioned in this section indicate that scent-color correspondences could indeed be impacted by the role of certain scents in different cultures. Although, many universally familiar scents also appear to result in a significantly non-random pattern of scent-color matching cross-culture. For scent-based games, this insight emphasizes the necessity of selecting scents that are culturally familiar to the target user.

2.7.2 Scent and Shape

Compared to the scent and color correspondence, less research and previous work has been done on the cross-modal correspondence between scent and shapes. There is a definite scarcity of research on this topic, suggesting more investigation. In previous research by Seo et al. [62] it was demonstrated that abstract symbols can be associated with specific scents and some symbols were consis-

tently associated with particular scents across participants. This odor-symbol congruency altered the scent pleasantness and raised the intensity of olfactory event-related associations. Furthermore, a study led by Hanson-Vaux et al. [63] investigated the match between scents and visual shapes. Associations between twenty different scents and two shapes (angular ("kiki") and rounded ("bouba") shape) were presented, and the scents of lemon and pepper were discovered to be strongly correlated with angular shapes, while raspberry and vanilla scents were strongly correlated with rounder shapes (see Figure 2.6). Additionally, Lee et al. [64] studied this further and analyzed the cross-modal associations between scents, colors, and the shapes "kiki" and "bouba". The study's findings supported the correlation between the angular shape ("kiki") and stimulating scents such as menthol, pine, and orange (matched with blue, green, and orange), and the rounded shape ("bouba") with the calming and sweet scent of chocolate (associated with brown) [2]. These studies are however limited to only two shapes (angular and round) and do therefore not give any clear indications of specific shape associations. Since shapes exist in various appearances, an in-depth study providing multiple shape selections will likely contribute to further valuable insight into this field of study.



(Source: Milan et al. [65].)

Figure 2.6 Related work: Kiki-Bouba Figures.

Although there are tendencies in the olfactory-visual correlations, at the end of the day, it all comes down to subjectivity and individual associative learning. There will never be a complete agreement on the most appropriate color (or shape)

and scent match, and the occurrence of cross-modal mappings is not necessarily limited to familiar source objects [20]. These differences and nuances in the way we interpret scents, create associations, and recall memories are what make for the intriguing and personal quality of the sense of smell. Furthermore, it creates opportunities for sharing and communicating these instinctive scent interpretations, thus acting as a ticket to talk and enhancing social interactions.

2.8. Summary

In sum, previous studies have demonstrated that individuals encounter scent in their daily lives in an unconscious manner, and they smell in a conscious, focused manner when training their olfactory function. As a result, raising awareness and encouraging people to use their sense of smell more consciously can lead to improvement in olfactory and cognitive function.

Furthermore, the literature suggests that these training paradigms can benefit from a more playful and engaging design approach. As identified, scent in play design is largely unexplored, and in the context of tabletop games, it is usually marketed toward children or intended for identifying scents. Historically, Kōdō has used scents for games for hundreds of years, demonstrating the value of scents in play. It is also recognized that intuitive cross-modal correlations can be used in playful activities as they are related to individual-associated learnings and create opportunities for communication. As a result, it is believed that combining some Kōdō principles with cross-modal matches between scent and color or shape could lead to the creation of novel scent-based activities.

Various recreational activities and creative attempts to engage elderlies in social and physical activities already exist. However, these activities are mainly engaging physical and cognitive activation through sensory inputs limited to visual, auditory, and tactile stimulation, thus leaving an opportunity and a need for investigating how olfactory stimulation can be included in such recreational activities. This research aims to contribute to filling this research gap as it investigates methods to incorporate scent into recreational activities for elderlies.

The research is specifically focusing on identifying design principles for developing scent-based games for elderlies in Japan prompting olfactory stimulation through conscious and active smelling.

Chapter 3
Concept Design

Despite being a compelling medium for stimulating cognitive function, linking to memories and emotions, and initiating conversations, scents are almost completely overlooked in the application on activities for elderlies. It is an unexplored creative medium, particularly in the context of scent-based play for elderlies. To address the absence of research in this context, the concept of a scent-based game kit, Kaori Game, has been designed. The game kit includes a selection of game parts and instructions for a range of scent-based games. The game kit is intended to activate the sense of smell while also raising awareness and interest in scents. It is also an attempt to develop a unique and enjoyable recreational activity that can promote social interaction and stimulate olfactory memory recall. The scent-based games are meant to be played among elders in institutions such as daycare centers, nursing homes, and community spaces.

This chapter also presents the initial part of the design process, introducing the two preliminary studies which lead to the ideation and prototyping of the games. It is important to clarify, that the two preliminary studies described in this chapter were conducted before deciding on the final research scope and design concept of this research. Thus, it does not display a direct correlation to the final concept but acted as foundational work of the design process.

3.1. Preliminary Study 1

A preliminary study was carried out to investigate potential correspondences between scent and colors. The purpose of this preliminary study is to collect data on the instinctive color associations that people have on certain scents and how

potential factors such as age, gender, and nationality can have an impact on this relation. Additionally, the participant's ability to detect the olfactory properties of each scent together with the reasons for their choices were observed. The study was carried out as a part of the annual public event, KMD Forum, which took place at Tokyo Port City Takeshiba on October 29th and 30th 2022.

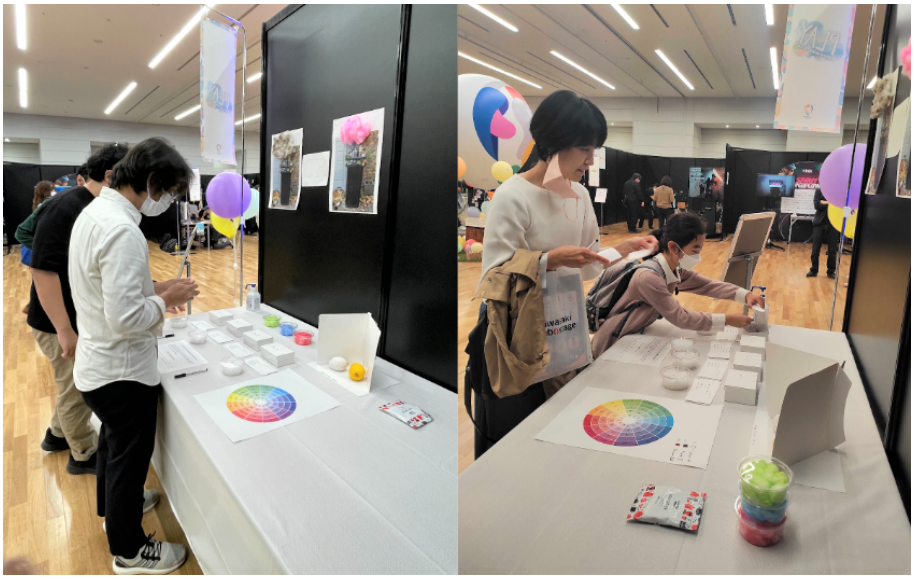


Figure 3.1 Study booth setup at the KMD Forum.

3.1.1 Study Design

For this study, four different scents (lime, peppermint, cedarwood, and lavender) were prepared. The reasons behind the four scent choices was to include scents from various scent families (floral, fresh, woody, etc.) and a mix between familiar and less familiar scents. Each scent was added to some cotton, placed in a transparent container, and tightly closed to prevent the scents from dispersing. The study was meant to be a blind testing of scents without prompting any semantic associations, meaning no verbal labels or additional information about either the scents or colors were given. By doing so, the participants made their color associations solely based on what they smelled without being induced by other

surrounding information.

For the color assessment of chromatic associations, a standard color wheel including color hues and lightness was chosen. The color wheel contained twelve sectors varying in hue, each with five levels along the radial dimension that varied in lightness. Each color was given a number from 1 to 60 (see Figure 3.2). A premade answer sheet was placed in front of each of the four scent containers, and the participants were asked to smell the scents one by one and write down their age, gender, and nationality on the sheets together with the number of the color that they associated each scent with. To prevent olfactory fatigue, a small bag with coffee beans was placed on the table for the participants to freely smell in between the process. It is important to mention that the original color wheel only consisted of 60 colors. However, due to several comments from the participants during the study about the lack of the colors white, black, and brown, these three colors were added as numbers 61, 62, and 63 on the first day of the study.

Figure 3.2 Color wheel for the assessment of chromatic associations.

3.1.2 Study Results

At the end of the study, a total amount of 316 responses were collected. From the collected data the age ranged from 5 to 60 years old, and the gender ratio turned out to be precisely 1:1 while one participant identified as non-binary. Regarding nationality, the collected data was represented by a diverse range of nationalities, including Japan, China, South Korea, Indonesia, India, Taiwan, Myanmar, Bahrain, Saudi Arabia, Belgium, Ireland, the UK, Germany, France, Mexico, and the USA. Though the vast majority were from Japan and China.

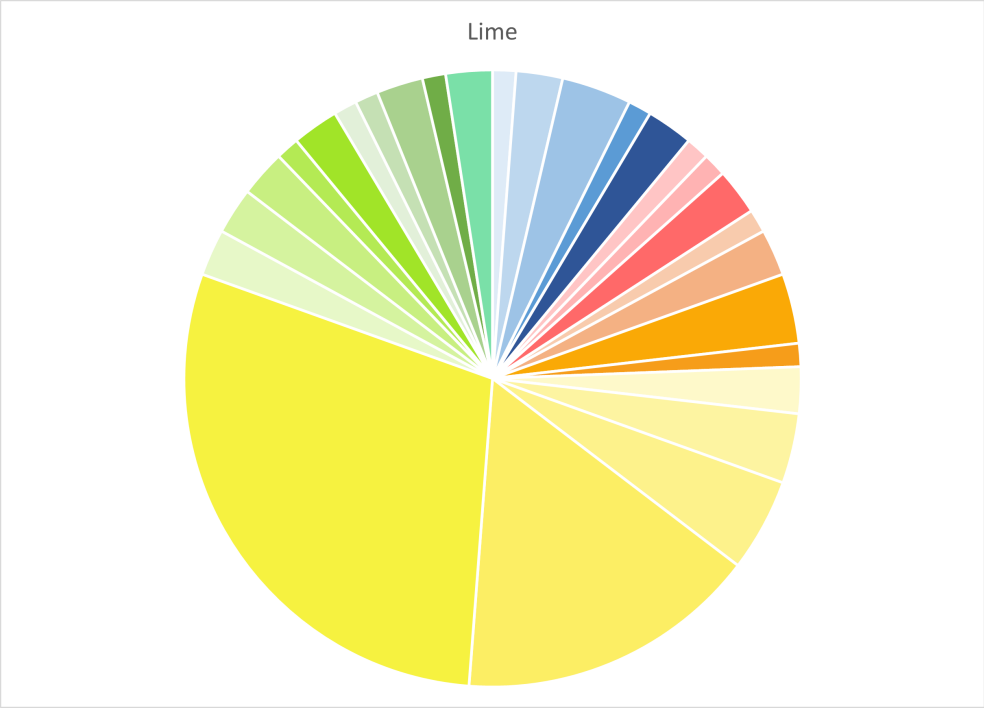


Figure 3.3 Graphical overview of the scent-color association result of scent number one, lime.

Among the four scents, the lime scent showed to have the most homogenous result in scent-color associations (see Figure 3.3). Close to all the participants easily recognized the scent as being some type of a citrus scent. However, only a quarter of those who recognized it as a citrus scent specifically mentioned that it was lime. Thus, a clear distinction between different citrus scents seemed to be a

challenging task. The chosen colors are dominated by fresh-toned colors with 60 % of the majority choosing yellow with variation in lightness. The words which were frequently used to describe the scent were “fresh”, “citrus”, and “clean”. Regarding the impression of a “clean” scent, an interesting cultural factor was discovered from the result. Approximately 10 % of the participants associated the scent with blue and all of them were of Japanese origin. From a conversation with these participants, it was shared that the scent of citrus is associated with cleaning products, and it gives off a sensation of coolness and freshness which explained their choice of blue hues. Another noticeable connection to culture and memory that occurred from the lime scent was the fact that the scent reminded them of a specific soap called “Lemon soap”, which appears to be a traditional choice of soap used since postwar days at the washing sinks in Japanese elementary schools. Thus, for some Japanese participants, the scent of lime (or interpreted as a citrus scent) had a strong connection to memory and brought them back to their days in elementary school. Consequently, the participants who mentioned the lemon soap also chose yellow in the color wheel as the appearance color of the soap itself is yellow.

Another scent that showed to be easily recognizable was peppermint. Similar to the lime scent, many described the peppermint as being “fresh” and “clean”, which is also reflected in the result with a clear dominance of fresh-toned green and blue colors (see Figure 3.4). A few participants also described it as having a “sweet” scent, which explains some of the warmer color choices shown in the result. This can derive from how peppermint is a considerably familiar scent in daily products, including toothpaste, cosmetics, and sweets, and is used to add a minty flavor and aroma. [66]. One participant from India shared that the scent reminded her of childhood and chewing gums and that the scent for many Indians is highly likely associated with pink. From post-data analysis research, it was discovered that most of the best-selling chewing gums in India have pink packaging and gum color. Nonetheless, the study results show a clear majority associating the peppermint scent with cool-toned colors creating a fairly unified visual color image of the scent.

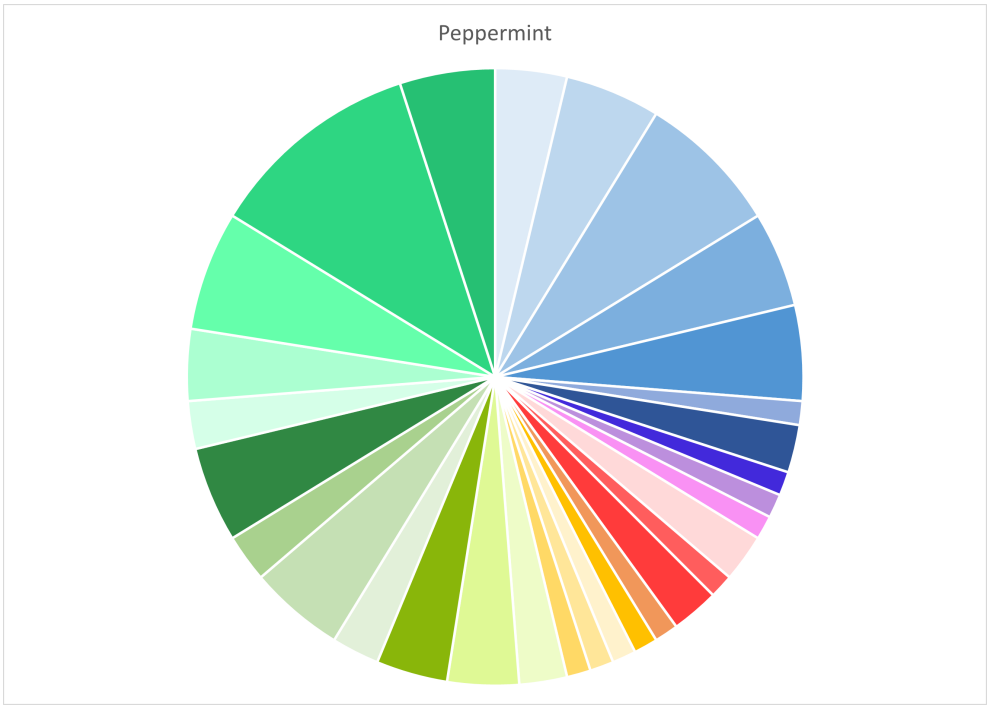


Figure 3.4 Graphical overview of the scent-color association result of scent number two, peppermint.

Following two easily recognizable scents, the next scent appeared to be more challenging and diverse in terms of scent-color association. The study result for cedarwood turned out in a color palette that includes nearly all the hues from the color wheel (see Figure 3.5). Many participants seemed to struggle in identifying the exact identity of the scent. However, the overall aromatic impressions of the scent showed to be very similar among the participants, where many described it as a warm, woody, and comforting scent. The cedarwood scent is commonly referred to as having a dry-woody, somewhat earthy aroma reminiscent of a deep forest [67].

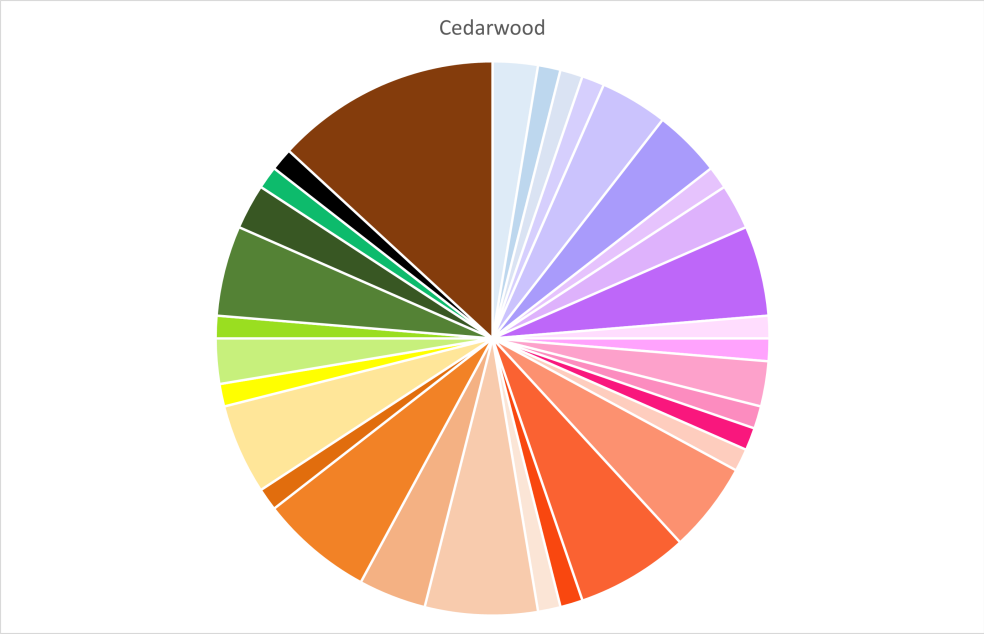


Figure 3.5 Graphical overview of the scent-color association result of scent number three, cedarwood.

The data shows a prevalence of warm-toned colors with brown taking up the most responses at 13%. However, as previously mentioned, brown was added to the color wheel on the first day upon request from the participants. This means that for the first two hours of the study, brown was not an option, thus some participants revealed that they chose orange as a substitute for the missing brown. This affects the results in a way where it can be assumed that if brown

was an option from the beginning, the diagram would show a larger amount of brown and less orange. Furthermore, phrases such as “it reminds me of a forest smell” and “it smells like nature” was often mentioned, which connects to their choices of woody and green colors. One participant mentioned associating the scent with a walk in a snowy forest. Thus, choosing an icy blue color. Another two participants reasoned their choice of purple to the calming properties of the scent. In sum, the interpretation of an earthy and nature-like scent can be very subjective as nature itself is manifold. Consequently, the diverse interpretation seems to derive from the culmination of a somewhat unidentifiable scent identity and specific setting associations within the participants.

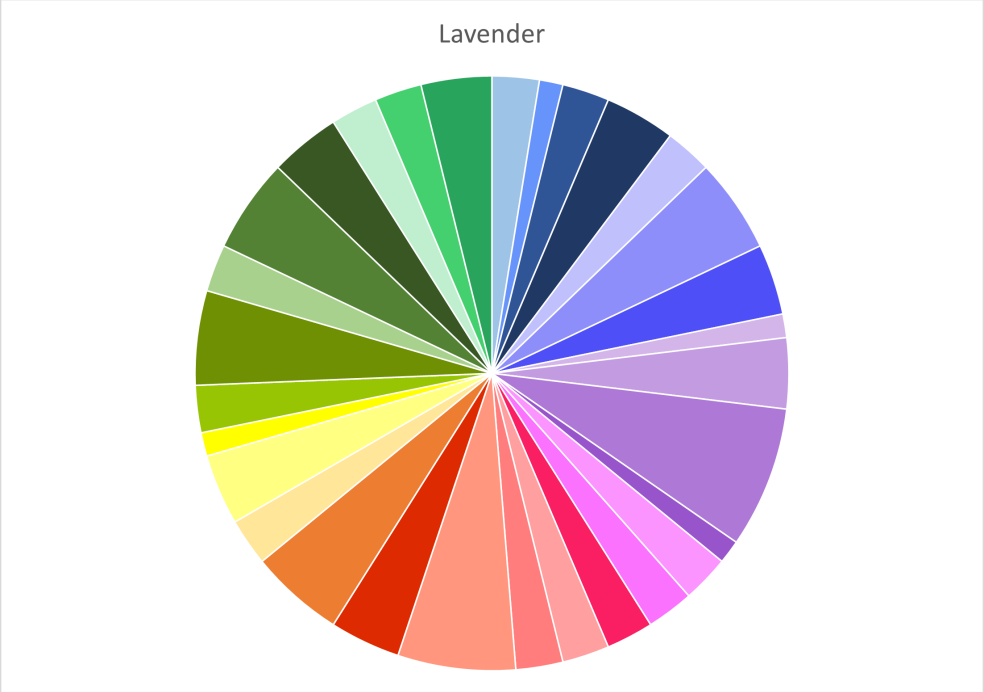


Figure 3.6 Graphical overview of the scent-color association result of scent number four, lavender.

Lastly, the lavender scent also revealed itself to be a relatively unfamiliar scent. When revealing the scent identity after the task, all participants seemed to know lavender but were not necessarily familiar with its scent. Similar to cedarwood, the reasons behind the color choices for lavender was in most cases due to its

calming and sedative properties. Meanwhile, some participants mentioned that they smelled a slight hint of citrus, explaining the association with yellow and orange hues. Other associations there were commonly referenced were “a flower field”, “garden”, and “forest”. Generally, the color associations were established from perceived scent ambiances and sceneries related to nature (see Figure 3.6).

Despite receiving responses from many participants and having a 1:1 ratio between males and females, no significant gender differences were observed. However, some participants (all males) mentioned that it was hard to choose among all the levels of brightness. They preferred fewer color options to choose from. Reflecting on the experiment, this can be considered a limitation. Since the participants were asked to choose not only a color from hue but also from an option of brightness, the chance level of finding an association between the scent and color was reduced to 1 out of 63, so 0,016%. Seen in this light, it may have been more appropriate to limit the brightness options from five to two or three, or just keep it to simply one and let the participants choose based on the hue only. However, it is also worth noting that some female participants expressed great satisfaction with the non-simplified color palette, and expressed that the difference in brightness was also an important aspect of the color association.

Regarding cultural differences, a few instances were discovered and mentioned in the results above. The cultural references were especially prominent when the participants’ scent associations were tied to their personal memories, which often were related to memories of childhood, sceneries, and specific products. The scents which were chosen for this study were relatively neutral and universal, meaning that there was no particular known socio-cultural significance or meaning associated with the scents.

Lastly, in terms of age, it was observed that children (5–13 years old) were very quick, confident, and consistent in their responses. Compared to adults who were more likely to take more time to think and contemplate before writing down their answers, the children intuitively chose their answers without any hesitation. The choice of color was also very consistent among the children. E.g., everyone

interpreted the scent of lime with color number 45 (intense yellow) and the scent of cedarwood with color number 63 (brown).

3.2. Preliminary Study 2

The second preliminary study was carried out to examine people's interpretation of scents in a more open visualizing manner. Additionally, this study aims to measure the time it takes for the participants from smelling the scent to start drawing. A total of eight participants took part in this study, divided into two groups, a group of younger participants (between 26 and 34 years old) and older participants (between 63 and 87 years old).

3.2.1 Study Design

In this study, the participants were asked to smell a scent and draw their imagined corresponding visual in a free and abstract manner. They were allowed to smell the scent as much as they wanted and to choose as many colors as they wanted for their illustrations. The participants were asked not to be too literal but to think mainly in forms and colors. The program Procreate on iPad was used to draw the illustrations.

3.2.2 Study Results

The time measurement showed a tendency for older participants to take a longer time in interpreting the scents compared to the younger participants. Simultaneously, the peppermint scent appeared to be easier identifiable compared to the lavender scent. The lavender scent occurred to be a quite unfamiliar scent among the older participants. One participant (female, 72 years old) had a particularly hard time recognizing the scent and finally, after 4 minutes started to draw some visuals (see Table 3.1). After the task, the scent identity was informed to her. She expressed that she is familiar with lavender as a plant, however, the scent was very unfamiliar to her and apparently not a scent that she has been exposed to before (at least not from what she could remember).

Table 3.1 Participants and their respective scent interpretation time (in seconds).

Participant (Gender, age)	Lavender Time (sec.)	Peppermint Time (sec.)
Female, 26	33	21
Male, 27	41	31
Female, 35	16	12
Male, 34	30	26
Mean =	30	23
Female, 63	42	39
Male, 71	67	50
Female, 72	243	68
Female, 87	86	63
Mean =	110	55

In general, lavender was a scent that was difficult to identify by most of the participants, which resulted in a diverse range of visuals. Although the color scheme among the lavender scent illustrations is coherent to some extent, the motifs show great diversity. All the participants smelled the scent several times and described a variety of impressions from the scent, such as floral, calming, citrus, and even mushroomy. On the other hand, peppermint seemed to be a familiar scent for everyone, and many had an "aha moment" reaction instantly after smelling the scent. The recognizability of the scent is reflected in the shorter interpretation times and in the relatively akin illustrations, which show a homogeneous choice of colors. See Figure 3.7 for an overview of all illustrations.

Figure 3.7 Illustrations of lavender (on the left) and peppermint (on the right).

3.3. Preliminary Evaluation

From the two preliminary studies, it can be assessed that associative learning plays a key factor in identifying and interpreting scents. There is no doubt that the autobiographical scent memory affects the first impression of a scent, but at the same time, the two studies indicate that these memories and associations tend to be similar for certain scents. Thus, it is fair to say that there exist some tendencies and generic responses to certain scents. At this point, it is not possible to determine which types of scents lead to these more homogeneous correspondences. However, from the preliminary studies, it can be deduced that the scent of lime and peppermint is highly likely to lead to similar scent-color associations.

In terms of olfactory ability and interpretation time, both studies revealed a correlation to some extent between age and olfactory reaction speed. In Study 1, the children showed quick reaction speed, creating cross-modal correlations without any hesitation. Meanwhile, older participants seemed to generally take more time after smelling the scents and to show more hesitation and uncertainty in their choice of color. However, in Study 1 the time was not measured, thus the claim is based purely on observation. On the other hand, in Study 2, where reaction

time was measured, a clear gap in time between younger and older participants was measured. While the limited number of participants in this study may be a deficiency in terms of drawing conclusions, the ability to quickly interpret the scents was observed to correlate with age.

Furthermore, associating colors and visuals with scents seemed to be an intuitive task. However, the association happens when we really concentrate on the scent and the act of smelling. Many participants were seen closing their eyes when carrying out the task to shut out other sensory distractions. Additionally, an observation of the participants indicated that it is challenging to correctly guess the identity of a scent without any visual cues or context. This solidifies the existence of the previously explained "tip-of-the-nose" phenomenon presented by Lawless and Engen [21]. In our everyday lives, we are so used to detecting smells in a context where other senses (especially vision) are present. Therefore, the task of focusing solely on the smell is not a task that we are used to, making it challenging to specify what exactly we are smelling. Though, despite being challenging, a vast majority of the participants expressed enjoyment and interest in the task, showing that there is an opportunity to incorporate it in a play context. The way that the sense of smell is actively and consciously used in these two studies is reminiscent of how it is used in olfactory training and Kōdō. Thus, the preliminary studies confirmed the potential for this cross-modal correlation to be used in the design of an olfactory stimulating game.

3.4. Game Design Document

This section will document and present the details of the game design process. While describing the design process, it also acts as a Game Design Document (GDD), which in game design is described as a blueprint for documenting the creation of a game and serves as a guide for the game design and development. Thus, it defines key design decisions, explains how the game works, while leaving room for future refinement [68]. Also included are insights that could be used by other researchers and designers when developing a game of a similar nature.

3.4.1 Design Objective

Before describing the ideation and prototyping phase of the design process, clear objectives for the final concept should be defined. Inspired by all the insight gained from the literature review, related works, and preliminary studies, the final concept is a game kit containing scent-based games for elderlies in Japan. It is a recreational game and is defined as a game as it has a set of rules, a board game design, and a point system. The objectives of the games are as follows:

1. Olfactory stimulation.
2. Increase awareness of the sense of smell and interest in scents.
3. Facilitate and encourage social interaction.
4. Activate olfactory memory recall and sharing of stories and experiences.
5. A novel and enjoyable experience.

Firstly, the main purpose of the game is to stimulate the players' sense of smell. The important point here is to make sure that the sense is activated through focused and conscious smelling in the same way as in olfactory training procedures. As previously presented, the way that the sense is activated in olfactory training is similar to how it is activated in Kōdō. Therefore, it is believed that the various scent-based plays of Kumikō in Kōdō can be as effective in stimulating the sense of smell as in regular olfactory training. Thus, the game is designed to facilitate a way to casually and affordably experience how to use the sense like in Kōdō. Secondly, the game aims to pique the players' interest in their sense of smell and scents. By raising awareness of the importance of active smelling and how enjoyable scents can be, the game attempts to nudge them towards increasing active smelling in their daily lives. Thirdly, the goal is to create a social activity that sparks conversations among the players. As demonstrated by Leret et al. [42], smelling makes individuals want to talk. The intriguing quality of the scent motivates individuals to share their past experiences with others. This was also an aspect that was mentioned during the interview with Kōdō Specialist Mr. Y, in which he stated that scents can foster conversation. It is a frequent occurrence that the

participants in a Kumikō experience are quiet before and during the ceremony, but suddenly, conversations among the participants begin as soon as the ceremony is over. It creates a unique form of social gathering, and there is something powerful about scents and their very subjectively perceivable nature that bring people closer. This leads to the fourth objective, which is the activation of olfactory memories and sharing of these personal memories and stories. As elaborated earlier, the sense of smell is closely linked to memory and emotions, and scents can bring back vivid memories from past experiences, and when individuals smell something, their emotional response precedes their understanding of what it is. Thus, it can be a great medium for facilitating social interaction, creating a deeper connection with other players, and getting a better understanding of each other. Lastly, the game must be enjoyable. Enjoyment is essential in giving the players an increased feeling of motivation, focus, and willingness to continue.

3.4.2 Game Design

In addition to the objectives mentioned above, there are three very important elements that are taken into consideration when designing the game. One is recreation, the second is the scent, and the third is the target group. Each element will be elaborated one by one.

As the game will be designed for recreational purposes it is essential to consider the key qualities of recreational games. As mentioned in the literature review, recreational games are meant mainly for enjoyment and are characterized as having socially beneficial qualities and a simple and easily approachable design. Consequently, these characteristics is kept in mind during the design process. In terms of the scents, there are many aspects to take into account. Designing with scents presents unique challenges due to the subjective nature of smell perception, cultural considerations, duration and intensity control, sustainability, and safety [69]. As known by now, scents are subjective, varying in perception among individuals. The various scents that will be included in the design should not interfere with the players' autobiographical memories in a way that triggers bad memories or traumatic past experiences. Scents that are too unpleasant are also not desirable in the game as they can lead to an overall bad impression of the

game experience and diminish the players' motivation for continuing the gameplay. Simultaneously, scent intensity is also crucial as scents that are too strong or persistent can be overwhelming and repellent, while too weak scents may go unnoticed. Additionally, sustainability and safety are significant considerations as certain scents may contain synthetic or chemical compounds that can trigger sensitivities in some individuals. The design opt for the usage of eco-friendly and non-toxic scents only.

Lastly, who the game will be designed for is a fundamental aspect to reflect on. As elderlies are the target group for this game, there are several aspects to carefully consider in creating an engaging and accessible experience. The key aspect is the ease of use. Complex or convoluted rules may be challenging for elderlies, so the game will be kept straightforward and intuitive. The game is also designed with ergonomics in mind. There may be some physical limitations for the players, so the game is designed to be played comfortably while seated and without too many small and complicated game components. Game duration is also considered. Some existing board games tend to take a long time to complete, so taking the shorter attention span or limited stamina of some players into account, the game will have a relatively short duration. Finally, the game encourages social interaction and engagement among players by incorporating elements that foster communication, collaboration, or friendly competition.

Regarding the game design, a lot of inspiration was drawn from Kōdō and the many variations of Kumikō. Unlike the way the sense of smell is used in our daily lives, in Kōdō it is used to focus on the scent and associate it with other elements. These other elements could be completely unrelated to the scents, and this is where the cross-modal associations come in. From previous literature, it was evident that individuals can create matches across modalities and that cross-modal correspondence between scent/color and scent/shapes is obtainable. Certain scents showed universal association tendencies while others are heterogenous, and in the end, it all comes down to individual preferences and learnings. Using this insight, the game rule will be centered around creating associations from the scents to colors and shapes.

Looking into the different game rules of Kumikō and after experiencing Kumikō, it was identified that the games do not encourage too much conversation or social interaction. Hence, these aspects are modified to create game rules that are fitting for recreational purposes. As a result, two game rules were developed. The first game rule is focusing on guessing the correct colors and shapes associated with the scent, while the second game is focusing on guessing the correct scent from colors and shapes. Each player takes turns to be "the main player" which equals to one game round. Hence, the number of game rounds will depend on the number of players. The main player will smell the scents and create associations while the other players have to guess either the chosen color and shape of the scent (game rule one) or guess the correct scent based on the chosen color and shape (game rule two). After each round, the game facilitates conversation among the players, as the players are respectively encouraged to share the reasons behind their scent-color-shape choices and share personal experiences or stories. Points are given according to the number of correctly guessed scents, colors, and shapes. After all the players have taken turns to become the main player, the game ends, and whoever got the highest number of total points, wins. The detailed game rules can be found in Appendix. The game rules are designed to purely enjoy the scents and create connections to visual elements and not necessarily to guess the scent identity correctly. The appropriate number of players for the game is estimated to be between three to five players. With too few players the game simply cannot be established, and too many players will inevitably make the game duration longer and may be overwhelming in terms of attention span and olfactory fatigue among the players.

Inspired by traditional board games, play cards with colors and shapes were created for the task of associating colors and shapes with the scents. A total of thirteen colors were selected. The color selection is based on the ten hues from the Munsell color system with an addition of white, black, and brown. The feedback received from the first preliminary study about the too broad amount of color variations was taken into account, so only the hue in its highest intensity was selected for this game. Regarding the shape cards, the design choice of what variation of

shapes to include and what the cards should look like was based on familiarity and associability. The shape cards include a mix of shapes and patterns that is considered to be easily associable with scents. The selection is based on what type of shapes previous studies have investigated (like “kiki” and “bouba”), feedback from participants, and the designer’s choice of what is considered intuitive associations for the scents used in this game.

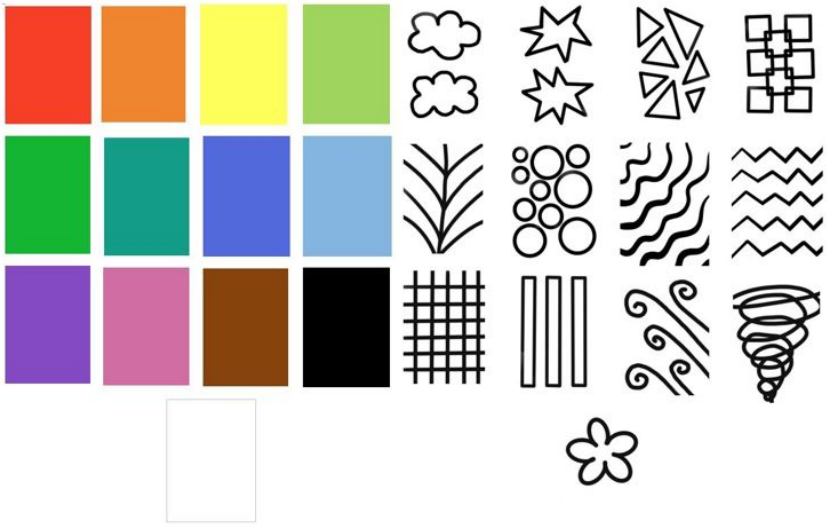


Figure 3.8 The 13 variation of colors and shapes.

Twenty different scents are included in the game. The scents are selected based on an assumption of what type of scents are somewhat familiar and perceived as pleasant for Japanese citizens. The relatively familiar and pleasant scents are expected to evoke nostalgia and encourage the participants to share their olfactory memories. The scents that are included in the games are lime, peppermint, cedarwood, vanilla, jasmine, lily of the valley, rose, sandalwood, cinnamon, tangerine, pepper, camphor tree, lavender, cypress, carrot seed, grapefruit, lily, cherry blossom, osmanthus, and earl grey. All the selected scents are eco-friendly and non-hazardous essential oils derived from natural sources. These are picked to ensure no harm or unwanted reactions are caused to the players. The scents are stored in 2 ml blackout bottles in order to preserve the quality, as light can affect

the delicate scent composition. Besides, square-shaped aroma stones were made from gypsum (hydrated calcium sulfate) with a slight hollow in the middle. One drop of the essential oil from the bottle is transferred to the hollow in the aroma stone before playing. The aroma stones are used as scent containers/carriers during the game, so the scent can effortlessly be passed on to all the players in the game.

Lastly, a simple game board with spaces to place the scents, game pieces, and cards was created concurrently with a list of all the scent identities. Each blackout bottle has a number written on the bottom, so which bottle contains what scent can be controlled. However, the list should not be used while playing the game, as the players are not supposed to know the correct scent identity. Instead, it is included for organization and control of the scent bottles. Although, the players may look at it after the gameplay if curiosity kicks in. With this, all the elements in the game kit are created (see Figure 3.9). At this point, the game kit includes:

- Game rules
- Game board
- 20 x scents in 2 ml blackout bottles
- 13 x color cards
- 13 x shape cards
- 5 x game pieces
- List of scent identity/label
- Aroma stones

Several test plays were done with participants recruited through opportunity sampling (and not the target group) to ensure the quality of the game, the usability, and overall game flow before the actual game evaluation with the elderly. As a result of these test plays, a few revisions were made to the game. Firstly, due to the relatively large amount of text, the game rules looked way more complicated

and overwhelming on paper than it is when explaining it orally. All the steps in the games are explained in detail for the sake of comprehension and to avoid misunderstandings. Consequently, this leads to a large amount of text. Considering that the target group is elderlies, the rules must be adjusted to improve readability. With this feedback, the rules were re-designed with less text and added visuals.

Figure 3.9 The first version of the game kit.

Secondly, an issue with the usage of aroma stones was detected. The usability of the aroma stones as a tangible form was good, but since the stones are not storing the scent in an enclosed manner, the scent was dispersing in the air, which led to several scents mixing in the air. Even with just one drop of essential oil, the scents spread relatively quickly in the air and made it challenging to focus on each scent. For this reason, the use of aroma stones was evaluated to be inappropriate in games. Instead, it was decided that the players should smell the scents

directly from the blackout bottles. To make this function well, the amount of essential oil in each of the bottles was reduced significantly. As essential oils are very concentrated liquids, just a small amount is enough to be noticeable. Meanwhile, some scents were perceived as weaker than others, so the amount of liquid in each bottle was continuously adjusted until participants were satisfied with the intensity of each scent. The only drawback of this method of directly smelling it from the bottle is that every time the participants smell the scent, they would have to screw the lid on and off, which can be slightly demanding for some of the participants, especially if they possess limited physical strength. Nonetheless, it is necessary to keep the scents stored in an enclosed environment, so the testing of the game will proceed with this method.

Figure 3.10 The final game kit.

Chapter 4
Evaluation

The evaluation aims to identify to what extent the research goal can be achieved. Hence, what will be evaluated is the participants' level of enjoyment, motivation, and learning outcome of the gameplay. Furthermore, their willingness to continue playing and the degree of interest in their sense of smell and scents will be examined.

4.1. Evaluation Method

The evaluation of the games in the game kit took place in a community space within a Danchi (Japanese housing complex), the Yonamoto Danchi, in Chiba prefecture. Since the game is designed to be played with up to five players at a time, each test session was carried out in two groups of five participants. The evaluation method consists of a pre-game interview, introductory conversation, observation of the gameplay, post-game questionnaire, and a final interview three weeks after the gameplay.

The pre-game interview was conducted to gather insight about the participants' current level of awareness regarding age-related olfactory deterioration and awareness of smells in their daily lives. The introductory conversation is done in order to introduce the research background and game rules to the participants. Another essential aim of this conversation is to create an opportunity for the participants to talk about the sense of smell with each other. Here the topic can be anything from personal scent preferences to scent-related episodes. This conversation can be seen as a warming-up session before beginning the actual game. After the gameplay, the participants are asked to fill out a post-game questionnaire, which

aims to measure their level of motivation and overall experience of the game.

The level of motivation will be measured using Keller's ARCS model of motivational design. The model was formulated by John Keller with the purpose of creating a framework for designing and enhancing motivational aspects in activities. The model aims to capture and sustain a participant's attention, relevance, confidence, and satisfaction (ARCS) in order to promote their motivation and engagement [70].

- Attention: The Attention component focuses on capturing the participant's interest and stimulating their curiosity. This can be achieved through various strategies such as using novel elements, incorporating surprising and engaging aspects, or posing challenging problems and thought-provoking questions and grabbing the participant's attention through cognitive engagement. Not only is it crucial to catch the participant's attention, but it is also necessary to keep their attention throughout the activity.

- Relevance: The Relevance component emphasizes the importance of connecting the activity content to the participant's needs, goals, and interests. It involves demonstrating the practical applications and benefits of the material, highlighting its significance in real-life situations, and providing examples and scenarios that resonate with the participants' experiences.

- Confidence: The Confidence component aims to build the participant's self-confidence and belief in their abilities to accomplish the activity content. This can be accomplished by providing clear instructions, offering guidance and support, and making sure that everyone is included. The content of the activity must be organized in such a way that the participants feel they have the ability to complete the activity and understand the content.

- Satisfaction: The Satisfaction component focuses on ensuring the participant's satisfaction and positive experiences throughout the activity process. Sustaining motivation can be achieved through satisfaction. The satisfaction can be either substantive or symbolic and can be achieved if they, for instance, experience gaining new knowledge, they receive a reward (e.g.,

winning the game), they are provided opportunities to apply their newly acquired insight or experience, and if they have felt that the activity was interactive, engaging, and have a sense of accomplishment [71] [70].

In addition to evaluating the motivational factors, a significant aspect of the game evaluation is to examine whether the game is replayable and if the game has succeeded in influencing the participants' perception of scents and the sense of smell in a positive way. Thus, in the post-game questionnaire, questions are asked about their enthusiasm to play the game again, whether it impacted their perception of active smelling, and if the change in perception will motivate them to be more attentive to scents in their daily lives. With consideration of the target group and the ease of accessibility, all questionnaires were printed out and handed to the participants physically.

4.2. Results

The following section will present the results from observations, questionnaires, and interviews. The testing site was visited several times before carrying out the actual tests. This was done to build trust from the participants, to build a sense of familiarity with the researcher, and to plan a preferred time and date for the test so that the testing could take place in a way that the game naturally merges with their daily activities. This creates a setting very close to how the game is intended to be used in a non-testing and real context: a recreational activity that naturally takes part in the elderly's daily lives.

4.2.1 Observations

When first recruiting the elderlies to take part in the game, they expressed a hint of hesitation. The hesitation arose from uncertainty about their olfactory ability to join the game and perform well. Within the first group of participants, two of them claimed that their sense of smell is almost gone already and showed an attitude of having given up on using their sense of smell. One of them shared her recent episode of a visit to a rose garden with her daughter, where the daughter kept telling her how good the roses smelled, but she was unable to smell them.

In the second group as well, three participants self-assessed their sense of smell to be poor and revealed that they were aware that it has deteriorated significantly. One of them was aware that olfactory deterioration can be an indication of beginning dementia and showed great concern for her olfactory ability but had not necessarily thought about doing anything to prevent it.

During the introductory conversation, it was observed that in both groups, food-related smells were mentioned as the smells they pay attention to most throughout the day. Both groups mentioned the smell of curry, particularly in the context of it dispersing from the ventilation in people's houses, revealing what the household is going to eat for dinner. Another scent that was mentioned by all the participants in both groups was the scent of Kinmokusei (Osmanthus). They all associated it with toilet fresheners, and since it is a scent that is particularly familiar among Japanese people, they explained that it might not be relatable to people in other countries. Osmanthus was perceived as a pleasant scent that also serves to signal the change of season from summer to autumn.

In regards to the game rules, they were explained to everyone just once at the beginning, and if one participant forgot or became unsure of the rules, other participants would try to help and explain them to ensure everyone understood them. After some time, the rules seemed to be completely comprehended, and the game went on smoothly. The game was filled with endless conversations and all participants seemed genuinely engaged. While one participant was sniffing a scent, the other four participants were observing, attempting to decipher the participant's reactions (facial expressions, body language, etc.). The entire gameplay was filled with comments such as "This is difficult", "I know this scent", and "I like/do not like this scent". Although the task of associating color and shape to a scent was thought to be challenging, it seemed to become easier and more intuitive for the participants as the game went on.

During the game, the subjectivities and subtle differences in interpretations of a scent were observed. However, some particular scents led to identical reactions and agreement among the participants. The scents were vanilla, rose, and pep-

permint. Especially vanilla was perceived as a pleasant and sweet scent by all the participants. And in the second group test, they all guessed the vanilla scent correctly for the color and shape card combination. Here, the color was pink, and the shape was a flower-like rounded form. Rose was also perceived as a pleasant scent with a delicate fragrant characteristic which everyone seemed to show familiarity with and preference for. Peppermint did not have a particularly pleasant association but was neutral. But the scent identity was often guessed correctly, and all the participants agreed on the notation of a fresh and cool scent often associated with green, blue, or bubble shapes.

Figure 4.1 The gameplay process.

One participant who before experiencing the game, had completely given up on smelling things in her daily life and repeatedly said she could not smell the difference between the scents during the game, showed remarkable improvement throughout the game. Around midway through the game, she brightly spoke up: “I could not smell anything in the beginning, but now I can tell the difference (between the scents)”. Her experience with increasing olfactory ability will be elaborated further in Sections 4.2.3 and 4.2.4. Another important observation

to point out is the participation of a visually impaired participant. In the first group, one of the participants has a visual impairment and due to this condition, her sense of smell is exceptionally good and sensitive. She explained that she has a great interest in scents and shared stories about how she would discover scents during walks in nature, and when she once followed her nose, she eventually found out that it was the smell of an Asian palm civet. Throughout the game, it was evident that her olfactory ability was on a different level compared to the rest of the participants, as she knew the identity of most of the scents and the distance between her nose and the scent bottle when smelling was way larger compared to others who brought it very close to their noses. Nevertheless, the difference in olfactory ability does not affect the enjoyment of the game, as the rules are not centered around who has the best sense of smell and who can guess the scent identity correctly. The one participant with an exceptional sense of smell led to interesting discussions among all the participants about scents in their daily lives and what it is like to be sensitive to smells.

After the gameplay, in the first group, one participant suggested a different game rule that she wanted to try, so a new game round spontaneously took place. The suggested game was to randomly choose one scent, which all the participants would smell too. After everyone has smelled the scent and placed their associated color and shape cards, the cards would be compared amongst each other, and afterward, talk about the differences and similarities. The goal of the game is for everyone to try and match with the same color and/or shape. The randomly chosen scent was rose, and the chosen cards can be seen in Figure 4.2. As a result, all the participants chose a similar color palette, and there was a match in shapes between two participants. The reasons behind their choices was all similar, explaining it as a clean and floral scent associated with laundry, which may derive from the frequent usage of rose scent in soaps and detergents. After playing, the participants expressed that this was another enjoyable way of playing with the components in the game kit. Hence, this game rule was later added to the game kit.

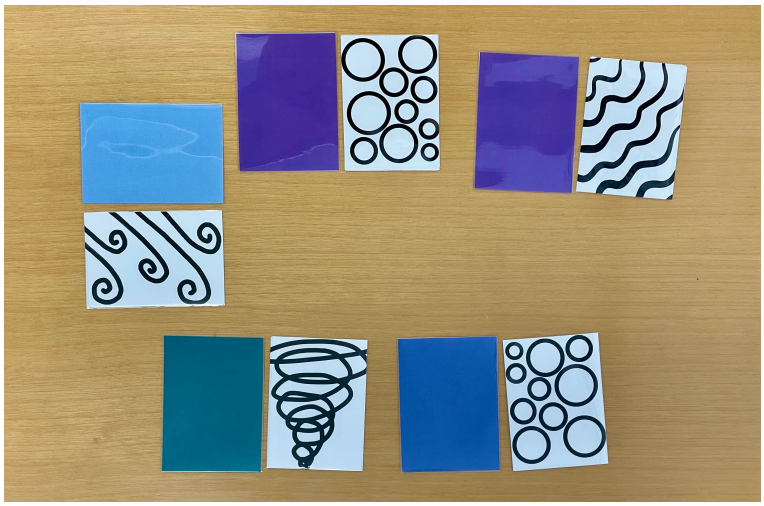


Figure 4.2 Card combination during the suggested game.

4.2.2 Additional Game Design

After the first game test, an additional game rule was developed based on feedback from the participants. Since all the participants showed great satisfaction with the first gameplay, the feedback was not received as a suggestion for improvement of the game design but as an added concept opportunity for a scent-based game. The received feedback included the participants' interest in an activity where they could freely express themselves. Since the first game design was based on pre-defined color and shape choices, they showed an interest in creating these associations freely by themselves. Inspired by this feedback, a new game rule was invented. For this game, the addition of new game rules, answer sheets, postcard-sized drawing paper, and colored pencils was prepared. The rule is to randomly choose a scent each whereafter each participant must put the scent into words and draw an illustration. There are no specific restrictions in terms of what to write and draw. It can be abstract or definite as long as it reflects the participant's individual associations with the chosen scent. After finishing the drawing and writing, the participants will take turns to show their outcome, and the other players will have to guess which scent the participant's illustration and writing expresses. All the scent bottles have numbers written on the bottom, so the participants will write down the respective numbers on their answer sheets. At the end of the

game, the scent identity will be revealed, and the participants can elaborate on their illustrations. The participant with the most correct answers wins the game. The game was tested on a different day with the same participants as the first game test.

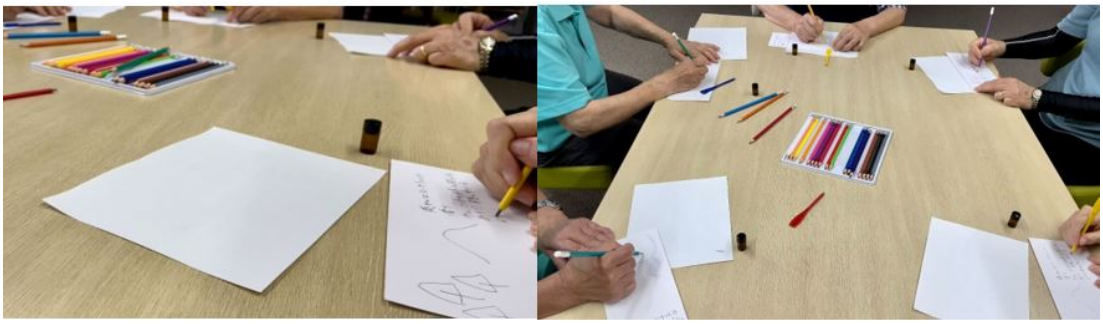


Figure 4.3 The writing and drawing process.

The game rules seemed to be easily understandable, but as for the first game, the first impression of this game was the difficulty of the game content. The participants again showed concern about whether they will be able to write and draw anything from a scent. However, the concern was gone once the game began, and they smelled their chosen scent. From what was observed, both the writing and drawing processes seemed intuitive and pleasurable. One participant was enjoying it so much that she kept adding elements to her drawing, and the other participants had to stop her as they were all finished with theirs. Once they all finished, the scent bottles were gathered in the middle of the table, and the illustrations were shared among each other.

As seen in Figure 4.4, the finished illustrations clearly reflect a subjective scent impression that each captures the characteristics of the scent and are connected to personal memories. The randomly chosen scents were tangerine, jasmine, osmanthus, vanilla, and camphor tree. All the participants chose the correct answer for the laundry illustration, which was the jasmine scent, and the rest had more mixed guesses. In the subsequent conversation, everyone started reminiscing about the scents, and the overall engagement level was very high. Expressions like “it is

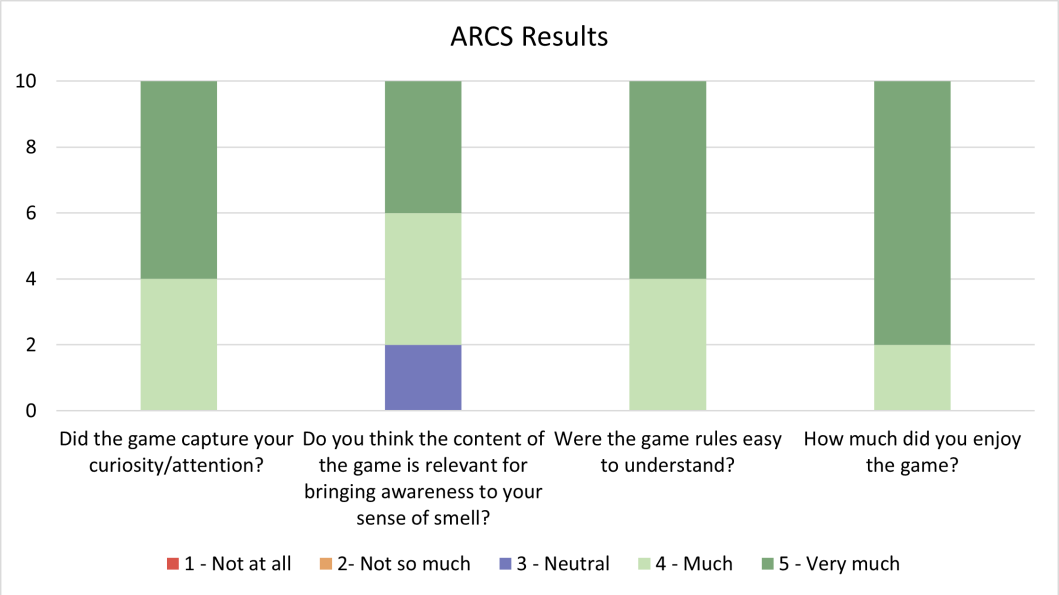
fun" and "it is interesting" was repeatedly said throughout the gameplay, indicating a high degree of enjoyment and satisfaction. One participant stated: "This will definitely be enjoyed by the elderly and those who come to daycare services", and everyone seemed to agree with this statement. This feedback solidifies the potential for the designed scent-based game to be successfully played by elderlies in other facilities like day care services, validating the aim of the game design.

Figure 4.4 The participants' illustrations.

4.2.3 Questionnaire Results

In the post-game questionnaire, Question 2 to Question 5 measure the ARCS values in a Likert scale form. Question 6 and 7 tap into the game's replay value, while Question 8 and 9 investigates the degree of change in interest and awareness of scents and the sense of smell. The full post-game questionnaire can be found in Appendix.

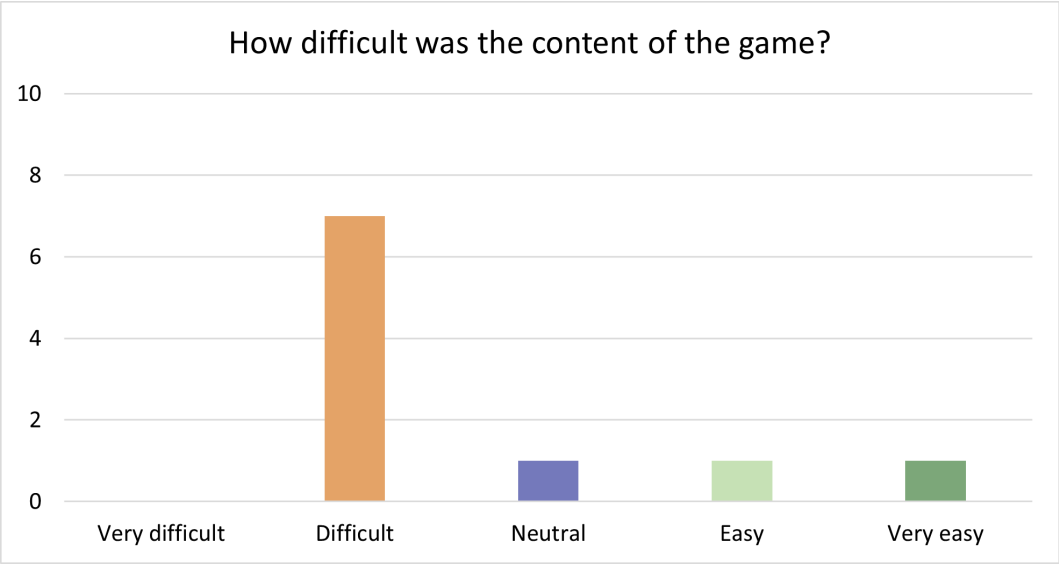
Table 4.1 Graphical representation of the ARCS value results.



The measured ARCS values indicate a relatively high motivation from all the participants with either neutral or positive responses (see Table 4.1). The neutral responses appear only in the question about relevance, revealing that this aspect may not be very clear or hard to assess for a few participants. The results display that the game succeeded in capturing the participants' attention. Furthermore, it shows that the game rules were easy to understand and that they enjoyed the experience very much, indicating high satisfaction. These results align well with what was observed during the game testing, suggesting that the participants felt motivated and engaged when playing the games.

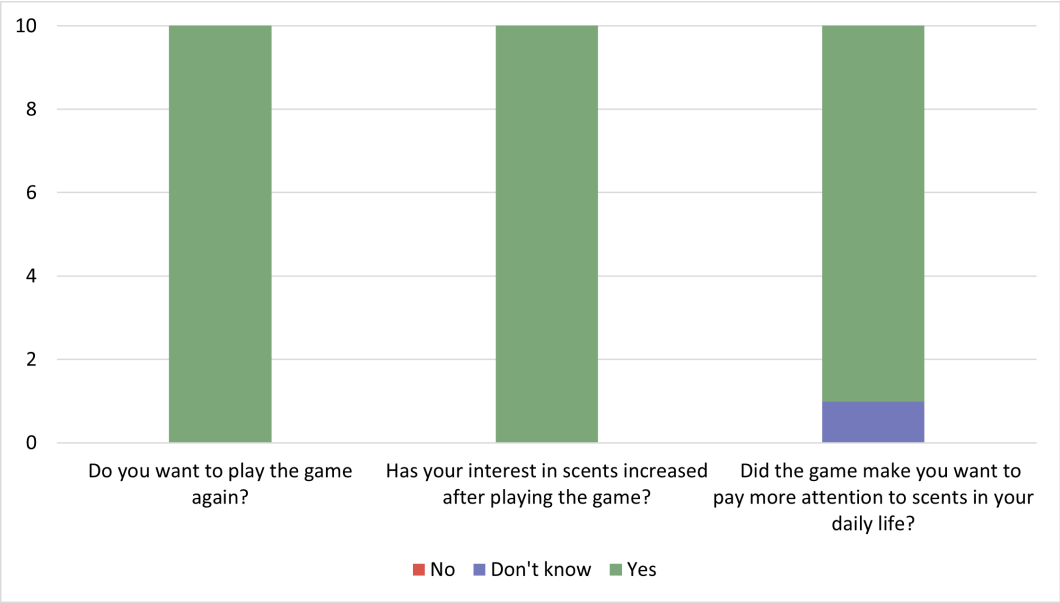
In contrast to the easily understandable game rules, the content of the game itself seems to have been difficult for the participants (see Table 4.2). Challenging game content is not regarded as a negative factor but rather indicates that the difficulty level is high enough to keep them engaged, and it may become easier with continuous play. Two participants experienced the game content to be easy and very easy, with the reason that their actions in the game were purely based on guessing, so not too much effort was put into the game activity. Ideally, the game content should not be experienced as too easy, especially not in terms of replay value, and may indicate that the game rules were not being explained thoroughly enough. On the other hand, if the game had been too difficult, it would affect their confidence and enjoyment, and their motivation to continue playing. None of the participants perceived the game as too difficult, and the difficulty level showed to be moderately challenging for most of the participants. Since it is the first time playing and the content of the game is completely novel and unfamiliar to the participants, it is considered the expected result.

Table 4.2 Graphical representation of Question 6.



As seen in Table 4.3, the desire to play the game again was measured as 10 out of 10, meaning the game has a high replay value. Furthermore, with all of the participants demonstrating an increased interest in scents after playing the game and 9 out of 10 wanting to pay more attention to scents in their daily lives, the increase in the participants' interest and awareness of their sense of smell, which is one of the essential goals of the game, has been validated.

Table 4.3 Graphical representation of Question 7, 8, and 9.



At the end of the questionnaire, a section for additional comments is made, where the participants can freely express their thoughts. Some participants shared their feedback in this section. As seen in Figure 4.5, the feedback is significantly positive, and satisfaction and joy can be sensed from the text. The first comment states: "It made me want to become more conscious of scents. There are various scents in our daily lives, so I want to enjoy it even more. Thank you very much". The comment shows a positive attitude towards becoming more aware of scents and enjoying and using the sense of smell more consciously. The following remark also expresses satisfaction with the game and an increased interest in scents, stat-

ing: “It was my first time trying a game (like this), and I had a lot of fun. I feel like my interest has increased. It was also nice to try a lot of scents that I usually cannot smell”. Another participant commented on her transformation of olfactory ability by the end of the game and how she feels pleased about experiencing her sense of smell improving throughout the gameplay. She expresses: “I could not smell scents (before the game), but midway through the game, I began to be able to smell them, and I felt kind of lucky. From now on, I want to enjoy scents a little more”. There was also a participant who was interested in Kōdō and stated that her interest in the art form increased as a result of the game, expressing that: “I think Kōdō is an ultimate hobby. I have also tried various hobbies, but I think that the last one will be Kōdō. Thank you very much for an enjoyable time today”. Finally, one participant explains: “I was usually not that interested in scents, but I realized that there are so many different scents. I usually react to food-related or unpleasant odors, but I thought it would be interesting to discover the existence of many scents. It is interesting that scents can be enjoyed (like this). (It is) a new discovery. It was a very entertaining game”. This participant described a realization or a discovery of how scents can be enjoyed more in contrast to the food-related and unpleasant scents that are the only smells she would usually pay attention to in her everyday life.

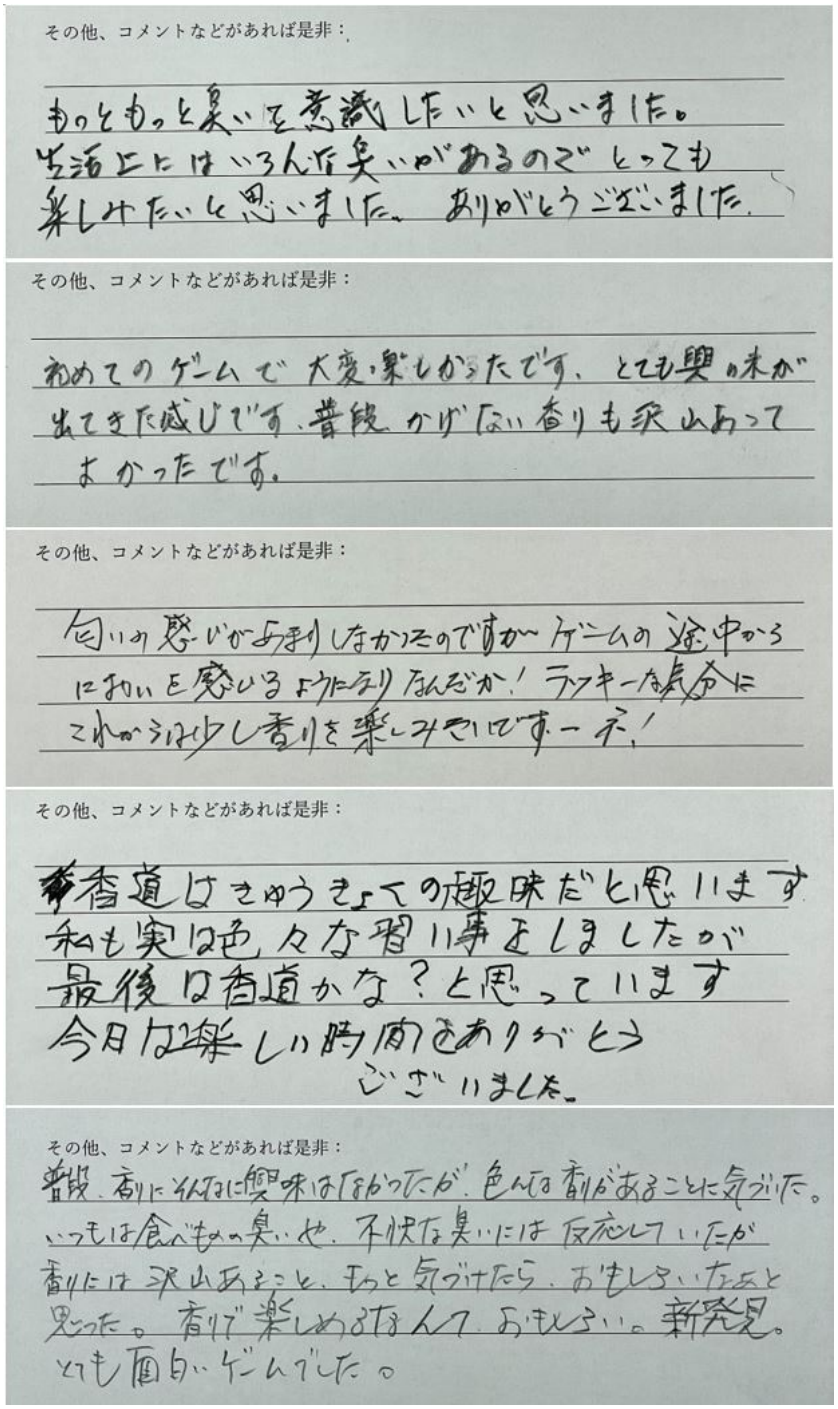


Figure 4.5 Comments from the participants.

4.2.4 Final Interview

Three weeks after the gameplay, a group interview was conducted with the participants. The interview aimed to detect any behavioral changes in terms of smelling since the first gameplay and to gather feedback on their overall play experience. Before starting the interview, the participants were asked to fill out one question about whether they have become more aware of scents in their daily lives after experiencing the game. The responses to this question were elaborated afterward by the participants in the follow-up interview. The results can be seen in Table 4.4.

Table 4.4 Graphical representation of the interview question.

Surprisingly, all the participants expressed that their awareness has been raised, some more than others. The participant who went from not being able to properly detect and distinguish the scents to being able to tell the scents apart explained in the follow-up interview that she has been paying very active attention to scents in her daily life. Her attitude had changed completely compared to before the gameplay. She shared that she would now smell things such as flowers, detergent, and even the smell of people, saying that she started paying more attention to her body odor as well. Additionally, she mentioned that she can now smell the

roses in the garden that she was unable to smell previously. Several participants explained that they have been spreading the word and told people around them about the potential consequences of olfactory deterioration and the importance of using their sense of smell actively to preserve their olfactory ability. This is also an act that confirms an increase in awareness of the sense of smell.

They also spoke about their overall experience with the games and showed great satisfaction expressing that "it was very enjoyable". The participants also voiced a sense of surprise and realization as they elucidate: "It is such a novel idea to compare scents to shapes and colors, and I have never done it before. It is a bit difficult, but once you try it, it is surprisingly possible, and it sparks conversation", and "I never thought I would enjoy it so much". These statements prove a change in perspective among the participants and underline the learning aspect of the scent-based games. Regarding the content of the games, some of the shared opinions were: "I liked the great variety of scents", "It is nice to get to know and learn about the differences in scent tastes and sensitivities among us", and "I enjoyed that it is not a game about guessing what kind of scent it is but to share our interpretations". The last two statements are especially significant, as this is one of the key aspects that sets the scent-based games in this research apart from other existing games. It is not about who has the sharpest and best sense of smell and who can identify the exact scent identity. It is rather about enjoying the scents, activating our cognitive functions by smelling consciously, associating it with visual elements, and sharing our sensitivities and stories. Very close to the core values of Kōdō. Likewise, the participants expressed contentment about the game kit containing a plentiful variety of games to play. One participant stated: "I never imagined that a game like this existed, and it is nice to have so many different ways to play with just one tool". Consequently, the interview feedback validates the objective of the games presented in Section 3.4.1 and suggests how the games might be replayed. In general, it is observed that the participants' attitude toward scents has changed significantly compared to before the gameplay, and the tone of the conversation in the follow-up interview is positive, conveying a motivation to stay curious and be more aware of scents in their daily lives.

Chapter 5
Discussion

The evaluation results of the gameplay have proved a high level of motivation, enjoyment, and an increased interest in scents among the participants. Thus, the game kit's objectives of stimulating the sense of smell, increasing awareness and interest in scents, facilitating social interaction, activating olfactory memory recall, and designing a novel and enjoyable experience were validated. The game seemed to be an eye-opening experience for most participants expressing that it motivated them to pay more attention to scents in their daily lives and in fact, actually turn it into action right away. However, despite the positive outcome of this research, several limitations and opportunities for future work is discovered. These discoveries will be discussed in the following section and lead to a conclusion summing up this research.

5.1. Limitation in Participants

Several limiting aspects in terms of participants are identified in this research, which would require improvement in future work. First and foremost, a higher number of participants would be preferred. Secondly, most of the participants were females, thus creating a gender imbalance. Since participation in the game is voluntary, this gender distribution can be seen as a natural and unplanned outcome. At the same time, this can be an interesting observation in terms of how the tendency for voluntary recreational activities among elderlies tends to be rather female-dominant. Consequently, it creates a need for more male participation, leading to new design challenges. It opens up opportunities for future work exploring how scent-based play can be designed to attract and engage more male participants. This is an important aspect to consider as olfactory deterioration

is highly prominent in males, and it is equally important to raise their awareness and positively impact their olfactory habits. This discussion also occurred during the interview with Mr. Y, where he recognized a similar tendency in Kōdō, mentioning how most people participating in and showing interest in traditional arts like Kōdō are females. However, interestingly enough, at the end of the Muromachi period, when the tradition of Kōdō had just formed, the activity was only conducted by males. At that time, it was mainly driven by warriors and generals and was close to the current role of golf in business and politics. Thus, it was an activity carried out while there was a separate main subject and purpose (often political). This insight will likely be significant when considering how to increase male participation in scent-based activities.

Lastly, the ideal test environment for the game kit would be at facilities like daycare centers or nursing homes, as recreational activities are already planned as a part of the elderlies' daily lives, and the scent-based games could be tested as a variation to these usual activities. However, the lingering precautions for COVID-19 restricted access to testing in these facilities. In general, gathering participants for testing appeared to be a challenge. When introducing something entirely novel and unfamiliar, it is important to make sure the participants feel comfortable enough to try it. Activities that involve using the sense of smell are already an unfamiliar aspect that the participants are not used to, and they were seen expressing some concern and uncertainty before participating. It is the researcher's responsibility to create a comfortable test setting, and in the case of this research, it meant that it was necessary to take time to build trust and familiarity between the researcher and participants. Hence, plenty of time was spent outside of the testing occasion as well. As the testing had to be conducted in groups, the challenges in scheduling were also a restricting factor.

5.2. Target Groups and Scenarios

The scent-based play in this research is designed with a focus on elderlies in Japan as a target group. However, it is not restricted to elderlies and can be played by anybody. Though, the proposed game in this research may be too simple and not

challenging enough for a younger audience, and modifications in the game rules and design may be needed. Investigating scent-based play in other contexts with other target groups is another suggestion for future research opportunities. With an increasing interest in implementing a multisensory approach to education due to its positive effects on cognition, motivation, and learning interest, it is believed that olfactory stimulation games like this could be beneficially used in the context of education for children and students. The Aroma Environment Association of Japan (AEAJ) has invented the term "Kōiku", meaning scent education. The term was coined to develop an initiative of hands-on scent education for children. According to AEAJ, the focus on olfaction through a scent experience of essential oils can cultivate a rich sensitivity and flexible imagination and convey the relationship between humans and nature to children [72]. This type of initiative indicates the rising interest in developing scent-based activities, and it is believed that this interest and need will keep growing as our lives become increasingly digitalized. The more advanced our lives become, the more primitive activities become necessary.

5.3. The Replay Value

Another research limitation is the lack of continuous play. Since the game has only been played once by each group of participants, the validity of the replay value can be put into question. The game may have to be played voluntarily several times in order to conclude that the game has a replay value. For future work, it would be relevant to, for instance, leave the game kit at the community space and come back after enough time to gather information about how many times the game was played voluntarily. This could be an effective way to measure the replay value of the games and the participants' motivation to play. Nevertheless, the players expressing their motivation and willingness to play again can be an indication of the current replay value. Moreover, the final concept is a game kit including several game rules and is therefore not limited to one way of playing. This allows for variation in gameplay and adjustments based on factors such as mood, players, and setting. While having a variety of ways to play can be an essential sustainable factor, it is believed that the game will still have replay value even if only one rule

is applied. As Boyd [73] states, the game's vitality resides in the creative process of playing it, even though games are constrained to the precise rules necessary as ordered guides and as supports to maintain stability. No matter how many times it is played or how constant the members of the playing group are, the gameplay is dynamic and never identically the same twice. For this reason, games can be played repeatedly with great satisfaction [73]. Furthermore, uniquely for this game, the scents are the variables, meaning that the scents can be changed to create variation. Currently, twenty pre-selected scents are included in the game, but these can be freely replaced with other preferred scents by the participants. Thus, contributing to another aspect of creating replay value. Testing gameplay with scents selected by the participants themselves could be another interesting future investigation.

5.4. Game Design

In spite of mostly positive feedback from participants, there were still some challenges identified during gameplay that need to be addressed. One crucial challenge that has not been successfully resolved in this research is how to handle scents in the games. The scents need to be stored in an enclosed environment, but the on-off screwing of the bottle lids is not suited for the target group. During the second group test, one participant stated that her fingers were numb, and she had difficulty opening the scent containers. Therefore, all the lids had to be slightly loosened when playing. Consequently, this led to all the scents slowly mixing in the air, and by the end of the game, making it hard to distinguish between the scents and creating an undesirable indoor air quality. In addition, some scents were stronger than others, and the participants expressed that some scents were hard to detect. Especially the woody scents were discovered to have a slightly weaker intensity compared to other scents, so it is necessary to adjust the amount of essential oil depending on the scent type and sometimes it can also depend on the individual smelling it. Several physical constraints need to be taken into account when designing activities for elderlies, and improved solutions for storing and playing with scents are necessary.

It is worth clarifying that the final game concept designed in this research is not claimed to be the best solution. It is one of many ways to design scent-based games and leaves space for further improvement. In this regard, the possibility of digital design must be discussed. While a lot of emerging technology allows for innovative ways of designing olfactory training and games, there is still room for the development and improvement of olfactory displays and other scent-dispersing technologies and their accessibility. At the same time, it can be argued that some essential aspects of olfactory immersion and beauty are best preserved with a more analog and simple olfactory activity. Using interfaces and other powerful visual cues can diminish the core aspect of the focused and active smelling. Considering the target group of this research, simplicity, and tangibility is crucial in securing engagement and comprehension. Moreover, as the primitive and emotionally tied sense that olfaction is, a design that evokes some sense of nostalgia may be suitable and felicitous. With that being said, the development of olfactory technologies has been emerging rapidly in recent years, enabling greater opportunities for designing digital olfactory games. When thinking about the future, when Generation X and the generation of digital natives will become the older generation, the preference for scent-based play is likely to change to digital solutions. At that time, a lot of opportunities for smart olfactory technology and games are assumably developed.

Furthermore, this research does not aim to measure an improvement in olfactory ability among the participants. Instead, it aims to identify design principles for olfactory stimulation games tailored specifically toward elderlies in Japan. Therefore, evaluation methods that measure the level of olfactory ability have not been implemented in this research, and it is also a research aspect that is believed to require a long-term investigation period. Additionally, the games only include relatively pleasant scents, so there is no evidence that these games will affect the elderly's awareness of unpleasant and dangerous odors in their daily lives, such as smoke, gas, etc. In recreational games, it is not recommended to use unpleasant scents as it diminishes the elderly's motivation to continue playing and may trigger bad memories or traumatic experiences from their past. Moreover, it is believed that stimulating the sense of smell through pleasant scents can have an impact on the improvement of an individual's overall olfactory ability. However,

this cannot be proved without a further long-term investigation and is currently not the aim of this research. This research should be considered a soft approach to olfactory training, and it is about designing socially engaging and enjoyable scent-based games for elderlies.

5.5. Conclusion

Novel tools for self-initiative rehabilitation and combating olfactory deterioration are necessary, as age-related olfactory deterioration comes with several consequences that should not be ignored. For such tools to have any impact on the user, they must be enjoyable, comprehensible, and motivating. In this research, possible design principles for scent-based games targeted at elderly people were investigated. Based on the participants' feedback from the observations, interviews, and questionnaires, the key design principles for scent-based games for elderlies were identified to be simple game rules, relatively short play duration time, proper scent control, variation in ways to play, and social activity. The evaluation results of the game kit have proved a high level of motivation, enjoyment, and an increased interest in scents among the participants, validating the design objectives of the game kit. A significant change in attitude and interest toward the sense of smell was detected among the participants, and even a few instances of self-assessed improvement in olfactory ability resulted from playing the games. The novel and unfamiliar approach of using scents in playful activities for elderlies comes with several design challenges, and there is still plenty of room for improvement, especially in terms of dispersion and storing of scents for a more user-friendly game design. Nonetheless, the findings from this study suggest that scent can be used as a playful medium in the development of engaging recreational activities for elderly people to stimulate the sense of smell and to increase their enjoyment and interest in scents. For most of the participants, the games led to an eye-opening experience in which they became more attentive to scents in their daily lives and actually took action right away. To investigate whether this change in action is continuous and if an improvement in olfactory ability can be measured, a long-term study will be needed. Since no previous research has been conducted in this field, the work done in this research can be

seen as a stepping stone for further exploration and development of scent-based recreational activities for elderlies as well as providing valuable insights for future work.

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Appendices

A. Game Instructions

Following are the original game instructions (in Japanese).

香 ゲーム１: ルール

香りゲーム

参加者：３～５人

準備: 各自が１３枚の色のカードと１3枚の形のカードを持てるよう、参加者全員にカードを配る。

1) 主役のプレーヤーを決める。
2) 主役は、２つの香りを無作為にゲームキットの箱から選び、その中からまず一つを選んで、その香りを嗅ぐ。
3) その香りから連想する色のカードと形のカードを選ぶ。この時、他の参加者にはカードを見せないこと。
4) 主役は、他の参加者に何を選んだか分からないよう、表側の白い部分を上にして、カードを自分の前に置く。

5) 次に、主役は自分が嗅いだ香りの説明をする。
その香りが自分にどんなことを思い起こさせたか、他の参加者に話す。
例えば、
- その香りは、何かの記憶を思い出させたか。
- その香りを嗅いだ時、どんな気持ちになったか。

ここでは、感情、場面、記憶（思い出）につながる説明をし、間接的にその香りを表現することが重要になる。例えば「バニラのような匂いだった」など、その香りを特定できるような説明はしないこと。

6) 次に、他の参加者が同じ香りを嗅ぐ。それから、主役がした説明を思い出しながら、主役が選んだと思う色と形を当てる。（匂いを当てるのではないことに注意！）
7) 選んだ色と形のカードを自分の前に置く。今回は他の参加者にも見えるよう、色や形が描いてある方の面を上にする。
8) 最後に、主役は自分が選んだカードを見せる。もし参加者が色や形を正しく当てることができていたら、ポイントを獲得する。
色と形の両方が正しかった場合は、２点の得点となる。一つの時は１点。

9) 上の手順は、同じ主役で合計２回行う。その後、別の参加者と交代し、その参加者が主役になる。参加者全員が主役となり、それぞれが２回ずつゲームを順番で行う。
例）５人の参加者の場合：５x２＝１０回
10) 全員が主役になってゲームを終えたら、各自の得点を計算する。
一番多くの得点をした人が勝ち。

注意：香りを嗅ぐ時、香りを鼻に近づけすぎないよう気を付けてください。

香 ゲーム２：ルール

香りゲーム

参加者：３～５人

準備：　参加者各自にゲームのコマを１つずつ配り、中央に「ゲームボード」を置く。
１３枚の色のカードと１３枚の形のカードを１セット準備する。
（このセットは主役のみが使用する。）

1) 主役のプレーヤーを決める。
2) 主役は３つの香りを無作為にゲームキットの箱から選ぶ。ここからは、他のプレーヤーは主役がしていることを見てはいけない。目を覆ったり、そらしたりすること。

3) 主役は３つの香りを嗅ぎ、その中から一つだけ香りを選ぶ。主役は選んだ香りから連想されるものに一番近い色と形のカードをそれぞれ一枚セットの中から選び出す。選んだカードを色と形の面を上にしてゲームボードの上に置き、他の参加者が見えるようにする。さらに、選んだ香りもゲームボードに置く。

4) ここから他の参加者は何が行われているのか見て良い。続いて他の参加者も、先に主役が選んだ３つの香りを全部嗅ぐ。そして主役が並べたカードから考えて、主役がどの香りを選んだのかを推測する。そして、ゲームボード上にある正しいと思う香りの前に自分のコマを置く。
5) 全員がコマを置き終わったら、主役は自分が選んだ香りを教える。正しく当てたプレーヤーが得点する。

6) ここまでの手順が終わったら、主役はなぜ自分がその色と形のカードを選んだのか理由を説明する。例えば:
- その香りはどんなことを思い出させたか。
- その香りを嗅いでどんな気持ちになったかなど。
他のプレーヤーは、何か聞きたいことがあれば質問する。

7) 主役を交代し、全員が同じ手順で繰り返してゲームを続ける。全員が主役をやり終えたら、得点を計算する。一番多く得点したプレーヤーが勝者となる。

注意：香りを嗅ぐ時、香りを鼻に近づけすぎないよう気を付けてください。

香 ゲーム3: ルール

香りゲーム

参加者：３人〜

準備: 回答シートと表現用紙を全員に一枚ずつ配る。
色鉛筆を準備。

1) まず、一人ずつ香りを一つ無作為にゲームキットの箱から選ぶ。
2) 回答シートの「名前」と書いてある欄に、参加者一人一人の名前を記入する。
3) その後、自分が選んだ香りの下に書いてある番号を確かめ、回答シートの「自分の香り番号」と書いてある欄に番号を記入する。
書いたら、他の参加者に見られないよう、回答シートを裏返す。

4) ここからは、参加者はそれぞれ自分の香りを嗅ぎ、思い浮かんだものをそれぞれ絵と言葉にして表現する。表現用紙の左側に絵を描き、右側には単語または短い文章を書く。
どちらも具体的ではなくて良いので、雰囲気や香りにまつわる思い出など、自分がその時に思い浮かべたものを書く。
制限時間は10分。又は、参加者が全員書き終わるまで。

5) 書き終わったら、全員の香りをテーブルの真ん中に置く。
6) ここからは、一人一人が順番に自分が描いた絵と言葉を全員に見せる。
真ん中に置いてある香りを嗅ぎ、自分以外の参加者がどの香りを表現したかを当てて、その香りの番号を回答シートの「香り番号」の欄に記入する。
ここで、自分の回答シートに記入されている香り番号が他の参加者に見られないよう気を付ける。

7) 全員が記入し終わったら、答え合わせをする。
ここで、自分が表現したものについて話す。正しい香りを当てたら、回答シートの「正解」欄にチェックマークを入れる。
正解が一番多い参加者が勝ち。

注意：香りを嗅ぐ時、香りを鼻に近づけすぎないよう気を付けてください。

B. Post-game Questionnaire (Original)

1. あなたの年齢を教えてください。

☐ 60 代 ☐ 70 代 ☐ 80 代 ☐ 90 代

2. ゲームに興味を持てましたか？

☐ とても興味が持てた

☐ 興味が持てた

☐ どちらでもない

☐ 興味が持てなかった

☐ 全く興味が持てなかった

3. ゲームの内容は嗅覚に意識を向けるための役に立つと思いますか？

☐ とても役に立つ

☐ 役に立つ

☐ 少し役に立つ

☐ 役に立たない

☐ 全く役に立たない

4. ゲームのルールは分かりやすかったですか？

☐ とても分かりやすかった

☐ 分かりやすかった

☐ どちらでもない

☐ 分かりにくかった

☐ とても分かりにくかった

5. ゲームはどれくらい楽しめましたか？

☐ とても楽しかった

☐ 楽しかった

☐ どちらでもない

☐ つまらなかった

☐ とてもつまらなかった

6. ゲームの内容はどれぐらい難しかったですか？

☐ とても難しかった

☐ 難しかった

☐ どちらでもない

☐ 簡単だった

☐ とても簡単だった

7. このようなゲームをまたやってみたいと思いますか？

☐ はい

☐ 分からない

☐ いいえ

8. 香りへの関心は、ゲームをする以前と比べて高まりましたか？

☐ はい

☐ 分からない

☐ いいえ

9. 今回のゲームをきっかけに、これから香りに意識を向けようと思いましたか？

☐ はい

☐ 分からない

☐ いいえ

その他、コメントなどがあれば是非：

_____

_____

_____

_____

ご協力ありがとうございました。

C. Post-game Questionnaire (English Translation)

Following is the English translation of the questionnaire.

1. What is your age?

60s - 70s - 80s - 90s

2. Did the game capture your curiosity/attention? (Attention)

Very much - much - neutral - not so much - not at all

3. Do you think the content of the game is relevant for bringing awareness to your sense of smell? (Relevance)

Very relevant - relevant - neutral - not so relevant - not relevant at all

4. Were the game rules easy to understand? (Confidence)

Very easy - easy - neutral - difficult - very difficult

5. How much did you enjoy the game? (Satisfaction)

Very much - much - neutral - not so much - not at all

6. How difficult was the content of the game?

Very difficult - difficult - neutral - easy - very easy

7. Do you want to play the game again?

Yes - Unsure - No

8. Has your interest in scent increased after playing the game?

Yes - Unsure - No

9. Did the game make you want to pay more attention to scents in your daily life?

Yes - Unsure - No

10. Please share if you have any other comments.

Thank you for your participation.