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Master's Thesis
Academic Year 2019

AromaCue: A Scent Toolkit to Cope with Stress Using the 4-7-8 Breathing Method

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

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Abstract of Master's Thesis of Academic Year 2019

AromaCue: A Scent Toolkit to Cope with Stress Using the 4-7-8 Breathing Method

Category: Design

Summary

In this paper, I present AromaCue, an design for a toolkit to cope with stressful situations using scent conditioning. The AromaCue Toolkit is composed of two parts: a breath training device using multiple stimuli and a wearable scent emitting device (with a stress ball as an activator). Scents are ambient and evocative media. It can bring back emotional memories without being consciously aware of it. Our involuntary acts can be easily affected by it. In this design, I utilized the properties of scents as retrieval cues for consciousness breathing. In a comparative experiment, participants (8) showed that a significant heart rate decrease several minutes after a stressor (STROOP test) was introduced for the scent condition compared to the no scent cue condition. One week of user study revealed significant improvement on DASS-21 scores. Thus, AromaCue has a positive tendency to help users to cope with stress.

Keywords:

Scent conditioning; Smell-assisted learning, Scent-based notification.

Keio University Graduate School of Media Design

Zilan Lin

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Chapter 1
Introduction

The course of history has consistently challenged human beings with numerous problems. Whether calamities or human-made disasters, over a long time, people succumbed to privation, famine, plague, and infectious diseases. Thanks to the growth of new technologies, effective counter-measures have quickly been developed to overcome incidences [1]. In the 21st century, the new issue that people need to cope with is not malnutrition or hunger anymore; the world health organization announced stress as "Health Epidemic of the 21st Century [2]." Dealing with any obstacle which stops us from pursuing happiness is a future significance to be put on the agenda. Every year, people costs a fortune on stress-related problems. Opportunities for related businesses have never been prosperous. The American Institute of Stress reveals that in the United States stress continually costs more than $300 billion every year, and shortens life expectancy in national wide [3].

Numerous office workers and students have reported suffering from work-related stress worldwide. People have been seeking for possible solutions to avoid stress. However, negative habits are adopted in the processes of overcoming stress(such as the over-consumption of food and coffee).

The thesis introduces a scent toolkit for stress reduction using the 4-7-8 breathing training. The goal of this design helps individuals to cultivate the habit of deep breathing through olfactory conditioning. Repetitive pairing the 4-7-8 breathing exercise (CS) with a customized smell (US) helps to elicit a relaxation response (deep breathing). The Aromacue comprises the breathing training device and the scent emitting system, assisting users in dealing with stressful moments.

This chapter introduces the social background of work-related stress from physiological and behavioral aspects and emphasizes the power of deep breathing. Moreover, it outlines the thesis structure and proposes research questions.

1.1. Work-related Stress: A Social Issue

The determinants of stress are complicated. Whether to fulfill social responsibilities or to pursue personal desires, fast-paced lifestyles, indeed, make stress become a significant issue in global scales. In general, work-related stress derives from fatigue and overwork: intensified workload, tight deadline, and excessive working hours. It is hard for individuals to balance personal lives with works. In 2014, the American Psychological Association summarized top determinants of stress in the United States. Among all problems, Job pressure was the primary matter in nationwide. In 2017, work-related stress, ranked in the third place, was a significant cause of stress [4].

In Japan hundreds of people have suffered from karoshi(a phenomenon of death due to overwork). As presented in the definition of karoshi by the Japanese laboratory ministry, karoshi consists of two types: work-related illnesses and suicidal exhaustion. The consequences of prolonged stress are overwhelming and may bring psychological and physical discomfort to individuals. In fiscal 2017, Japanese labor ministry certified one hundred ninety people died of "karoshi." Besides, ninety percent of victims worked more than 80 hours per month [5].

College students are another group, sharing the same pain with people who are stressed in the workplace. People, over half of the population in The United States, feel overwhelmed due to academic responsibilities. It is an inexorable fact that stress has become an obstacle which brings negative impacts on academic performance and interferes with daily activities. Students under severe stress have been diagnosed with depression, general anxiety disorder, constant worries, and physical health problems [6].

1.2. Motivation: The Power Of Breath

Stress management is a significant approach for cognitive and emotional self-regulation. Numerous guidelines have been provided for combating with work-related stress. The ideas of designing the stress management processes start from prevention, management to the amelioration of work-related stress [7].Deep breathing is one of the rudimentary strategies for beginners who desire an easy and

less time-consuming relaxation method. Stress managements apply deep breathing technique to achieve inner and outer balance. For example, Biofeedback training helps people to get control of the stress response by acquiring stress-coping skills. It uses deep breathing, visualization, and meditation to calm physiological arousal. Besides, mindfulness meditation requires the deep abdominal breathing practice to achieve better relaxation and self-awareness.

However, the majority of population always underrate the power of breath. They believe that breath is similar to other bodily functions(such as heart rate, and digestion), which are controlled by the automatic nervous system. However, breath is different. Breathing pattern can be trained through intentional practices. Likewise,breathing has been found important in treating diseases stemming from negative emotion. For example, the Stanford research institute made a significant achievement in reducing post-traumatic stress disorder by employing breathing-based meditation [8]. Breath is an essential step of relaxation. It has no side-effects and is simple to learn.

The domination of using visual interactions to train respiratory patterns have been found common in treating work-related stress, such as using visual and verbal instructive approaches to train respiratory muscle. Besides, using the aroma inhalation for stress management is a prevalent mood-altering solution. In this thesis,It is expected to make people become aware of deep breathing and create a sustainable stress relief method for cultivating a new habit of deep breathing.

1.3. Contribution

In this research, I apply scent conditioning to cultivate mindfulness and conscious breathing to handle stress. The main contributions of this paper are (1) a breathing training device mingling multiple stimuli (visual and olfactory stimuli) that allows users to train the 4-7-8 breathing technique, (2) a wearable scent-based notification that sends aroma cues to elicit the relaxation response(deep breathing) to cope with stress in stressful situations, and (3) user studies examining the users' perceptions of Aromacue in a realistic scenario.

1.4. Research Question

- Can Aromacue help users to cultivate a habit of deep breathing?
- Can Aromacue become an effective and sustainable solution for stress reduction ?

1.5. Thesis Organization

- **Chapter 1** discusses the research background of work-related stress. It introduces key ideas of this design.
- **Chapter 2** introduces the concepts of stress, the power of breaths, and the characteristics using smell in design.
- **Chapter 3** describes the concepts of AromaCue through the design thinking process: empathise, define the problem, ideate, prototype, and test. Essential features of the design are addressed in this chapter.
- **Chapter 4** validates the olfactory conditioning effects and user experiences with the scent toolkit.
- **Chapter 5** summarizes importance of the previous chapter.The limitation and the future work are also discussed.

Chapter 2
Related Works

This chapter provides overall perceptions of relevant design examples which assist the author in concept development. Related works are chosen from different fields of studies to interpret main ideas in this thesis: the definition of stress, the power of breaths, and attributes of scents. The characteristics of each product are analyzed. All positive features of related works contribute to creating this project.

2.1. Understanding and Recognizing Stress

People feel stressed when they work under time pressure. The ability to handle work-related stress varies between individuals. On the one hand, working under time pressure can accelerate work productivity, but on the other, fulfilling occupational and academic responsibilities in a short time challenge physical and mental health.

Understanding stress helps to expand strategies of stress management and prevent further exacerbations in health status. Theoretically, the autonomic nervous system is composed of the sympathetic and parasympathetic nervous systems, which plays a significant role in response to stress. It actuates the physiological functions of body systems to be ready for coping with any threat. The sympathetic system, on the one hand, enables quick reactions to life-threatening situations. In response to various stressors, physiological responses are instantaneously activated (such as increases in heart rate and blood pressure, changes in body temperature,and shortness of breath). On the other hand, the parasympathetic system is responsible for compensating for the sympathetic activity, assisting the body systems in maintaining their functionalities. It serves as a complement to the sympathetic nervous systems.

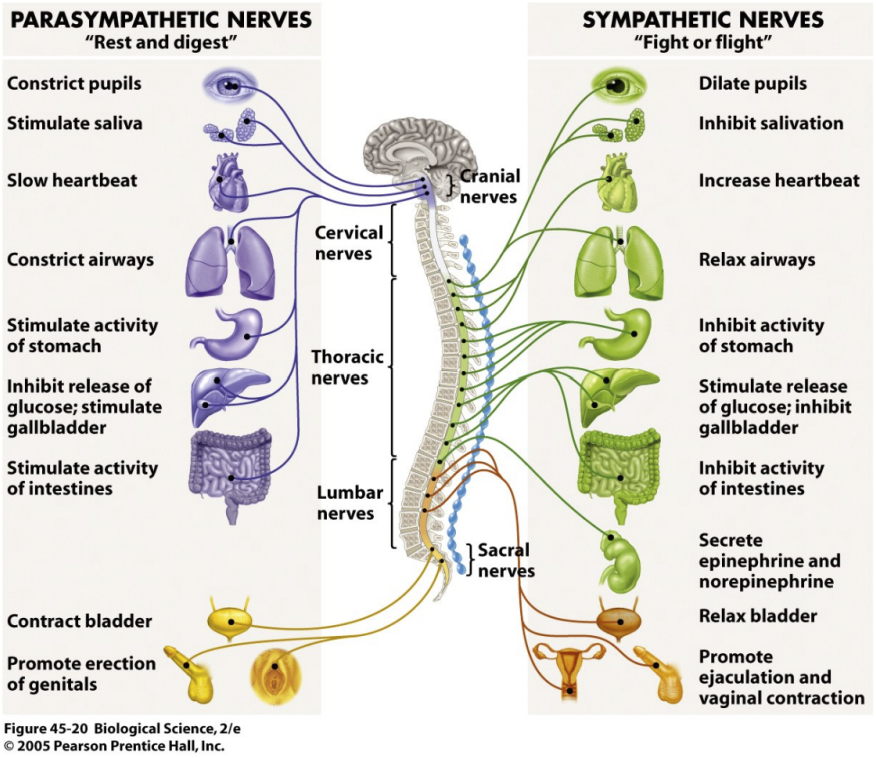

Figure 2.1 The Autonomic Nervous System
[9]

However, the definition of stress is a controversial and prevalent topic in academia. Hans Selye, known as the father of stress, coined the word "stress" in his theory of generalized adaption syndrome. He first defined stress as"the non-specific response of the body to any demand for change." Later in life, he altered his definition of stress to "the rate of wear and tear on the body." His generalized adaption syndrome model comprises three stages: alarm, resistance, and exhaustion stages. The discovery reveals that if the body systems fight against either aversive or pleasant stressors, health problems may occur due to fatigue and exhaustion [10]. Prolonged stress often emerges from facing a wide range of chronic stressors, which may wear and tear each nervous system. Human used to be stressed out even though they have the inborn ability to deal with stress. The breakpoint of work-related stress is hard to identify until it deteriorates their health conditions.

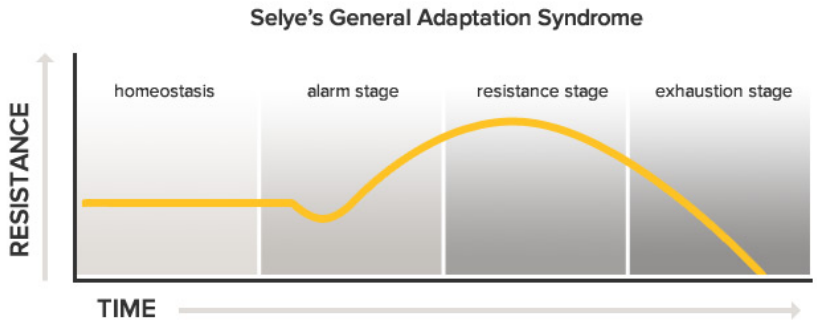

Figure 2.2 General Adaptation Syndrome: The Three Stages Of Stress [11]

2.1.1 Stress Vs. Anxiety

People use "anxiety" and "stress" interchangeably to describe their feelings because It is hard to distinguish the differences. Anxiety and stress are correlated and share similar physical symptoms. Stress is a physiology response to any threat in a situation which may bring either negative or positive experiences to individuals. For example, negative stress results in poor concentration, and loss of memories, while positive stress helps people to become aware of hazards and boost productivity and motivation at work.

Anxiety, in short, is a mental disorder, triggered by chronic stress. It emphasizes on internal feelings of individuals. Unlike stress, anxiety still causes internal damages without any stressor, and it continually threats to human health status(such as "anxiety disorder, panic disorder, phobias, social anxiety, obsessive-compulsive disorder, and post-traumatic stress disorder"). The American Psychological Association (APA) defines anxiety as "an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure. [12]" The main difference between stress and anxiety is that stress is a physical response to threats ,while anxiety is a specific reaction to stress.

In stress regulation, it is essential to take control of physiological reactions to stressors and develop a relaxation method for preventing physical and emotional overwhelms. The process of releasing brain signals to stop people overreacting from pressure is called "a relaxation response," which can be trained and used as

a countermeasure to mitigate the"fight or flight" response. The term"the relaxation response" was proposed by Dr.Herbert Benson, who is a pioneer in mind-body medicine. The relaxation response(the counterbalancing mechanism) assists people in returning to a healthy and relaxed state by activating the brain areas where control its reduction. The relaxation response can be elicited through a number of approaches(such as meditation, breathing techniques, yoga). Breath focus, as one of the most common features among all the strategies mentioned in Dr.Herbert Benson's studies, helps people to balance their inner and outer health and clear their minds. It allows people to train their ability to deal with stress and to prevent chronic stress.

2.2. The Healing Power Of Breath

Breath as a low-risk and simple strategy for stress reduction demonstrates its effectiveness in treating stress, anxiety, and depression. Human respiration is an in-built ability, and it is controlled consciously or unconsciously. It is well-known that breath can benefit health and mental well-being. However, the majority of populations worldwide breathe involuntarily and unconsciously, which may lead to a negative consequence of deficient oxygen levels in the blood. A manipulation of deep breaths, featured by decreased blood pressure and heart rate, helps to balance and reset the autonomic nervous system. [13]. Previous studies demonstrated that rhythmic breathing techniques (Sudarshan Kriya and Pranayam) are stress management solutions for alleviating stress, anxiety, and post-traumatic stress disorder (PTSD) [14].

The following related works considering breath as an integral skill provide effective design strategies for stress reduction. This section covers deep breathing techniques and introduces how different technologies impact the design of stress relief.

BREATHE: 4-7-8 Breathing Method

The 4-7-8 breathing technique is an effective strategy for stress reduction and regulations of negative emotion and insomnia. This relaxing technique is introduced and promoted by Dr. Andrew Weil. He describes the method as "natural

tranquilizer for the nervous system [15].” This breathing technique, helping users to achieve a state of relaxation in a short time, is inspired by an ancient yogic breath (pranayama). It is useful for control of respiratory pattern, reduction of stress-induced physiological responses, and development of breath awareness.

Practicing breathing technique with mobile applications is a convenient and prevalent method for stress relief. Plenty of breathing-related mobile applications share a similar goal, helping users to gain steady breaths and disengage from anxiety and stress. BREATHE is a deep-breathing application, employing the 4-7-8 technique in the format of a breathing circle. The conventional breathing circle provides a direct guideline for each breath inhalation and exhalation. However, the in-built visual and audible notification systems are hardly used as sustainable and long-term support of stress alleviation.

Figure 2.3 Breathe: 4-7-8 Breathing App [15]

DEEP &LIFE TREE: Deep Breathing In Virtual Reality

DEEP and LIFE TREE demonstrate innovative breathing training games in virtual reality worlds. Combining traditional therapeutic breathing practices with

multi-sensory techniques breaks conventional breath training for enhancing respiratory muscle memories.

DEEP is a Virtual reality breathing-based meditation game. It transports users to a mysterious ocean. People can control their movements inside this virtual scuba diving game through conscious and deep breaths. Inhaling moves users upwards to the shallow water, while exhaling sends users to the whimsical deep ocean. The game helps users to practice the diaphragmatic breathing technique to alleviate stress levels and negative emotion [16]. The developers of the game transformed the traditional medical-based stress management method to an engrossing virtual reality breathing-based meditation game. People can unwind themselves with DEEP after a long day of back-breaking. Diving in a virtual reality world, indeed, can perk up their moods, helping to wash all troubles away.

Figure 2.4 DEEP: Breathing VR Game
[16]

The pursed-lip breathing technique, recommended in pulmonary rehabilitation, helps to prevent and control dyspnea. [17]. LIFE TREE utilizes this breathing technique to create a multi-sensory breathing training game. The audible and visual instructions guide users to learn details of this breathing technique. The

virtual environment (a giant tree trunk with floating leaves in the air) changes through each breath inhalation and exhalation. The visual reinforcement (filling colors on the giant tree) helps trainers to concentrate on the moment of practice [18].

Figure 2.5 LIFETREE: Breathing VR Game [19]

Building respiration muscle memory through entertaining interactions in a virtual reality world is a sustainable approach for cultivating mindfulness breathing. DEEP and LIFE TREE emphasize on isolating people from physical environments to improve the breath focus. Moreover, LIFE TREE provides an insight into the multi-sensory learning. Using multi-sensory simulations in design approximates natural learning settings, simplifying the learning procedure. Integrating all senses in education helps to obtain information and reinforce memories. Furthermore, the self-satisfaction is built up by coloring the tree, which increases engagement rates in this breathing game.

2.3. Using Scent as a Medium for Design

A smell-based design requires to consider the characteristics of scent. Scent itself is an ambient media for exchanging information, altering the mood and evoking memories. In comparison with other animals, the olfactory system in human has its limitation in sensitivity and detecting subtle information. However, the sense of smell is highly associated with and emotion. The following section deliberates essential properties of scent: healthy benefits, an ambient retrieval cue, and emotional notification.

2.3.1 Essential oils: Healthy Benefits

Aromatherapy is an alternative treatment for stress and anxiety. History of using extraction of plant oils to heal diseases dates back to ancient civilizations. However, the effectiveness of using essential oils has been demonstrated in scientific fields lately. People not only search for the pleasure of using aroma but also focus on medical reasons.

A comparable experiment of using lavender and rosemary essential oils to examine their effects on relaxation, alertness, mood, and anxiety was conducted in 1998. A math computation task and EEG activity were employed as an assessment. The result indicated that the rosemary oil linked to alertness, while lavender oil was associated with a better emotion [20]. Another experiment, using ambient smell of orange, lavender, and no odor, analyzed the impacts of essential oils on calmness, anxiety, mood, alertness in dental clinic patients. The final findings indicate that orange and lavender oils are capable of reducing anxiety and altering mood . [21]. Previous researches provide evidence of therapeutic usages of essential oil for making improvements on mood and anxiety.

2.3.2 Olfactory Memory: Smell Memory Kit & Boutonniere

Olfactory memory differs from visual and auditory memory due to the anatomy of the olfactory system — the olfactory nerve links closely to the amygdala and the hippocampus. The uniqueness of the olfactory system in the brain region

contributes to the essential features for developing retrieval cues for olfactory memory. Researches in recent year have demonstrated that using scent as an evocative stimulus for emotional memories. Besides, it also serves as an aid for learning.

Smell Memory Kit is a capsule-like device helps users to capture and preserve the most precious memories. A smell-based amulet was co-designed by Sissel Tolaas and SUPERSENSE. Today we are living in a world where is dominated by visual contents. People take photos, record video, and audio to restore memorable moments. It makes Sissel Tolaas rethink the definition of memory. The concept of Smell Memory Kit borrows the idea of the Proust effect to help people to relive in memories through aroma. If the owner wants to record the moment; they can take out the metal amulet, release the abstract smell, and take a deep breath. It is an appealing concept of connecting abstract scent molecules with precious memory [22].

Figure 2.6 Boutonniere (left), Smell Memory Kit (right) [22] [23]

Boutonnière is mini vase designed by Omer Polak. The wearer attaches each glass vessel with a brass pin on their clothes for decoration.The blown-glass con-

tains enough water for a real flower to fresh all day long. In the concept development, the designer emphasizes the feasibility of scent on amplifying and creating emotional memories. An anosmic persona, who has either lost the sense of smell or never have smell experience before, is built to understand the appreciation of olfactory experience [23].

2.3.3 Emotional Notification Channel: inScent

inScent is a wearable olfactory amplifier for mobile notification. Smell has a unique intimacy with emotion, which helps to retrieve olfactory memory and influence mood. InScent proposed a concept of using smell as a notification channel to enrich emotional and sensorial experiences. The wearable pendant is an adjunct for mobile notifications, amplifying received mobile information through artificially scents [24]. The concept of using artificial emitted scents as an additional emotional notification channel helps the wearer to recognize and experience the moment. The idea of creating an emotional bonding between the wearer and mobile contents with scent is vital in this design.

Figure 2.7 inScent: Emotional Notification [24]

2.4. Summary

This chapter discusses the definition of stress, the healing power of the breath, and characteristics of using scent in design. The significant components of this design are addressed and emerged through reviewing related literature and works. It has been noticed that scent-evoked memory is associated with deeper emotions and feelings. It provides the possibility of developing retrieval cues for memory and emotion. Related works also demonstrate the effectiveness of using multi-sensory learning to enhance immersion and reinforce memory, which accelerates learning processes. Moreover, psychologically, scent, as a potential stimulus, can modify behaviors and foster new habits. Thus, Aromacue focuses on using the attributes of scent to develop a sustainable solution for stress management. It considers the importance of creating human-computer interaction through a sensory integration design, which assists in retrieving olfactory memories and experiencing emotional arousal. The characteristics of scent are essential for designing classical conditioning for cultivating deep breathing.

Chapter 3
Aroma

3.1. Design Objective

AromaCue is a scent toolkit to cope with stress using the 4-7-8 breathing method. It refers to the classical conditioning theory to develop a learning procedure for stress reduction. This stress management device is composed of two principal components(a breathing training device and a wearable scent emitting device for adopting a mindful breath. The uniqueness of the olfactory system contributes to eliciting emotional states and retrieving memories, which makes scent a perfect stimulus in this design. The multi-sensory respiratory training device mingling visual and scent stimuli that provides instruction for breathing training. It creates an interactive and immersive learning experience for understanding the relaxing breath technique (4-7-8 breathing technique). Moreover, the wearable scent emitting device is an olfactory trigger for inducing a conditioned response from the previous scent and visual association, helping the wearer to be able to cope with stress in a real condition. The final prototype, developed to examine the effectiveness of stress reduction and olfactory conditioning effects, provides further insights into the future improvement of AromaCue.

3.2. Design Processes

The design procedure is an iterative process of understanding and redefining the needs of target users. Design thinking contains five essential methods: "empathize, define, ideate, prototype, and test." This procedure, employed for defining and redefining the original assumption, assists in achieving the final goal of creating an effective and sustainable relaxation method. Through a comprehensive analysis of user needs, essential features of AromaCue were created. The

following section will address the methodologies in the design thinking process.

- **Quantitative Research Method:** Defining work-related stress as a social issue utilized the generalized anxiety disorder 7 item scale questionnaire. This questionnaire investigated how many participants may have suffered from anxiety syndrome over the last two weeks. The initial quantitative analysis helps the author to get to know the participants and the issues they are facing.
- **Qualitative Research Method:** In-depth interviews provided a comprehensive understanding of user needs. It helped to corroborate essential ideas for designing a stress management method. The final relaxation method, the target persona, and user cases were developed after this section.
- **Participant Observation:** Participant observation in the discussion room offered insights into understanding how graduated students coped with stress in a real situation.
- **Ideation & Concept Sketching:** Ideation and concept sketching were addressed through literature reviews, which supported the essential concepts of this design.
- **Prototyping** The prototype was developed to test the solution for stress management. The testing part explored user experience with the product.

3.3. Empathize & Define

3.3.1 Generalized Anxiety Disorder 7-Item Scale

The questionnaire employed the generalized anxiety disorder 7-item scale questionnaire to find out how many percentages of participants might suffer from generalized anxiety disorder over the last two weeks. Besides, this questionnaire also inquired about the physiological arousal to stressors.

The survey design used *Generalized Anxiety disorder 7-item scale* [25]. The Generalized Anxiety Disorder 7-item scale is a tool for self-assessment of the severity of anxiety disorder. The result of this survey provided a general idea of how

many percentages of participants might be troubled by the stress-triggered issue and helped the author to understand the problem of work-related stress and define target users. The sample included N=47 randomly included volunteers (59.6% female; 40.4% male; age range from 18-50). As the description of this questionnaire indicates that the cut-off points for mild, moderate, and severe anxiety are taken from the score of 5,10, and 15. It is recommended to do a further evaluation if the score reaches 10 or higher than 10 [25]. In this survey, 51% participants showed no symptoms of generalized anxiety disorder; the rest 49% participants suffered from different degree of the generalized anxiety disorder severity. (illustrated in Figure 3.1). The survey results exposed the fact that the majority of participants might have stress-induced issues and anxiety problems.

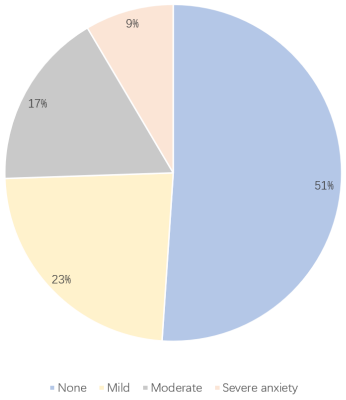

Figure 3.1 The Generalized Anxiety Disorder 7-item scale

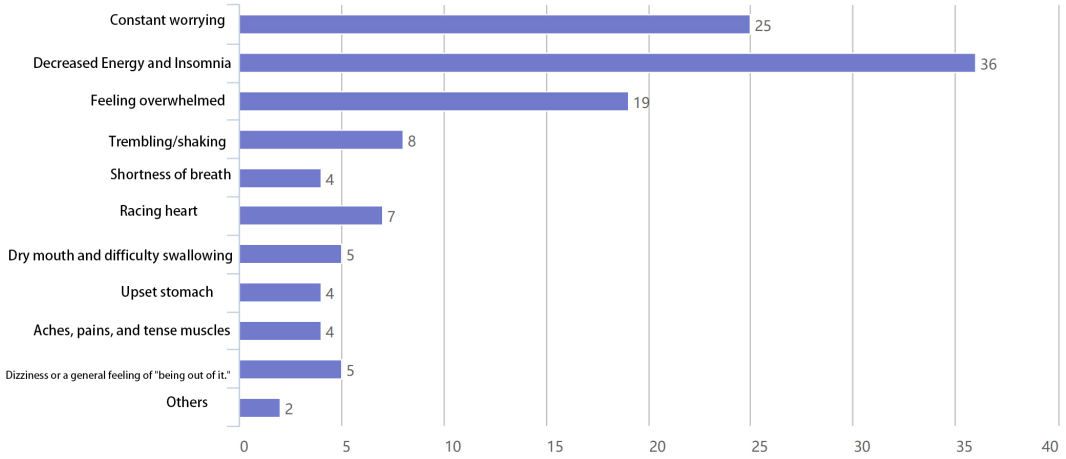

Figure 3.2 Stress Symptoms

3.3.2 In-depth Interviews

A qualitative research method was used for understanding the topic of stress and developing an effective and sustainable solution for stress relief. The participants were voluntarily signed up (10 people)for the In-depth interviews (May 1st to May 15th,2019). The contents of meetings included common strategies and expectations for stress management.

Participants identified significant challenges for stress management. A bad habit of over-eating is a common issue discovered in the interview. 80%of the population tried to consume extra carbs to relieve stress. 50%of participants tried yoga and meditation before, but the processes of practicing were hard to persist because these are time-consuming exercises. Likewise, it is hard to cultivate mindfulness because balancing movements are difficult for beginners. However, the interview revealed that none of the participants practiced breathing techniques before even though they were aware of the benefits of deep breathing. They considered breath as an involuntary process for maintaining lives. One of the participants had encountered shortness of breath. She found the importance of deep breathing, but it was hard to control her breathing pattern in a stressful situation.

Participants discussed expectations for stress management. The biggest issue

is that today, people spend less time on professional psychologists even though they have been struggling with personal problems and work duties. Participants showed interested in using health tech gadgets to provide daily health assistance because those devices are less time consuming and simple to use. Besides, they expected relaxation methods that are not limited by spaces and time. Another issue is that half the population of participants were not willing to share their lives with their parents and friends. Dealing with stress is a process of working with themselves. They did not want to talk about their problems since these were personal issues. Thus, self-regulation is an essential element to be considered for developing an effective solution for stress reduction.

3.3.3 Participant Observation

An overt, unstructured, participant observation research was conducted two weeks before the deadline of the first thesis submission(June 21st, 2019) in discussion room 04 and 06(Keio University, graduate school of media design). The whole observation analyzed the activity before the deadline. Students in 04 and 06 showed tiredness and exhaustion before the deadline.

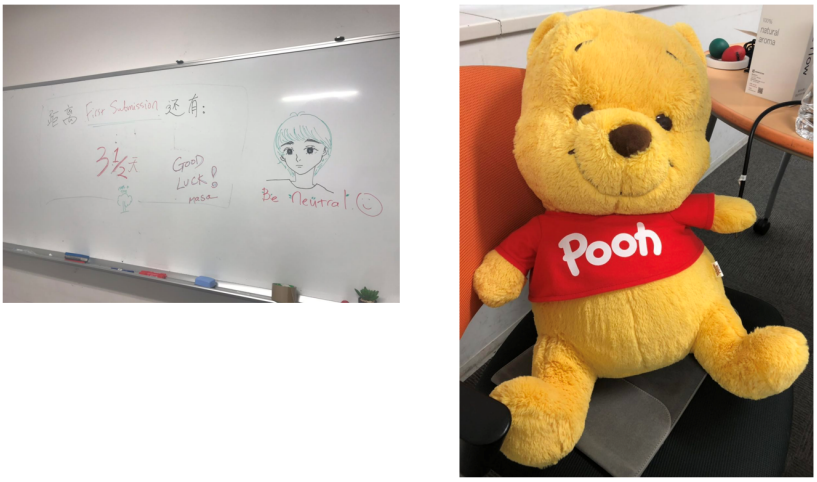

Figure 3.3 A Participant Observation

Students utilized numerous approaches to relax them before the deadline. Significant changes in environmental settings were found in the discussion room.

Student A drew animation characters and wrote slogans to motive the rest of people to finish their thesis. Drawing on the whiteboard not only served as decorations but also as a relaxing strategy in spare time. A few days later, Student B bought her fluffy stuffed animal to comfort her when she stressed out. It somehow inspired others to bought their stuffed animals. There were three stuffed animals in the discussion room. Students were interested in either holding it or using it as a cushion to support their back. Besides, essential oil and gentle rain sound were utilized to refresh moods and reduce stress. During the observation period, orange oils and grapefruit oils were used. The observation revealed that changes in environmental settings could help people to improve mood and reduce stress. Multi-sensory simulations can accelerate the relaxation process.

3.3.4 User Personas

The target persona was created based on qualitative and quantitative research discoveries and provided guidelines for the design process. The target users are students and office workers who have been struggling with work-related stress and shortness of breath while facing stressors. Besides, they may also have insomnia for a long time due to busy work schedules. They want to search for a less time-consuming and sustainable stress management strategy. Bibliography, frustration, personality, demographic information, and goal were addressed to understand the details of the target persona.

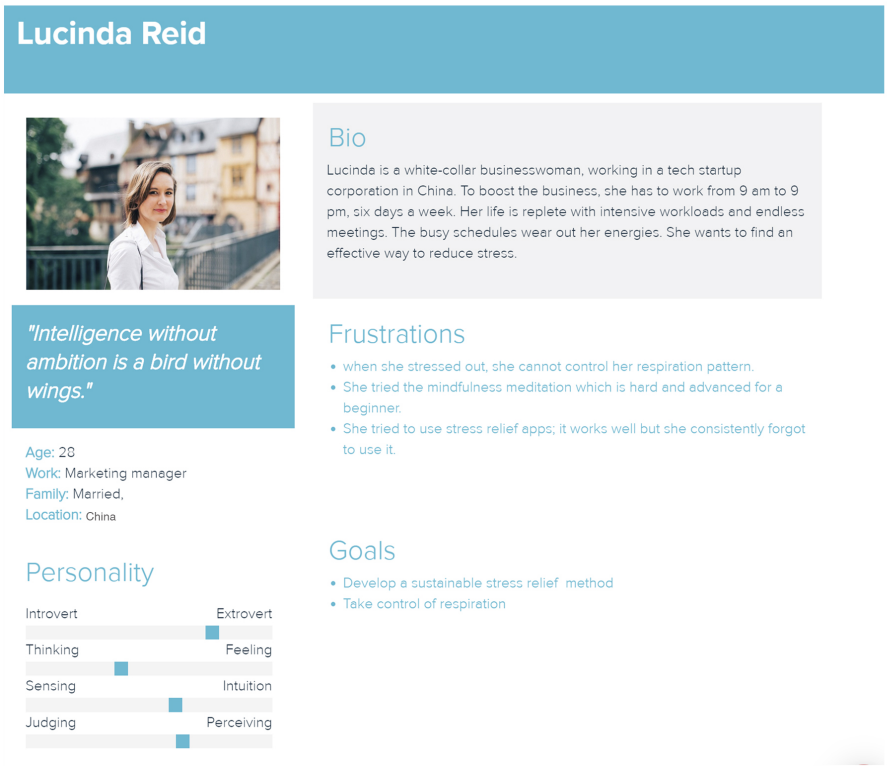

Figure 3.4 Persona: The Office Worker

3.4. User story

The office worker:

Lucinda Reid is a businesswoman, working in a start-up corporation. She gets used to feeling stressed all the time because of the intensive workload and responsibilities of achieving greatness at work. If she feels stressed, especially before public presentations and meetings, she will suffer from shortness of breath and has an upset stomach. Instead of feeling suffocation before an important event, she has had insomnia and anxiety, which start to interfere with her life. She decides to try AromaCue, which helps the users to regulate breath and develop a sustainable method for stress reduction. She is attracted by the concept of practicing the 4-7-8 breathing technique with a stuffed animal since she always desires a pet companionship. She practices with the breathing training device at least

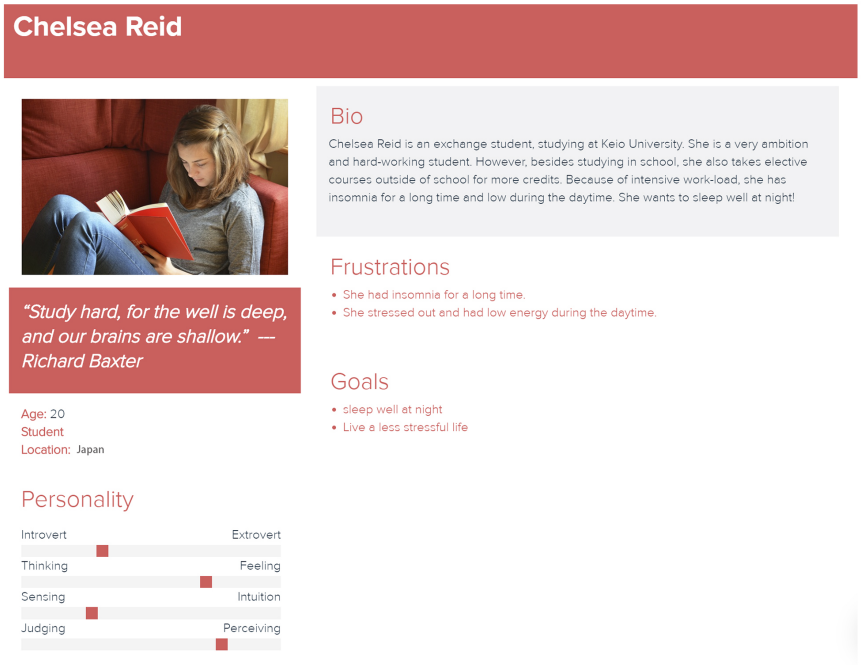

Figure 3.5 Persona 2: The Student

twice a day to relax and learn the rhythmic breathing. Every time before a big presentation, she squeezes the stress ball to activate the wearable scent emitting device for inducing deep breathing. After using the product, she feels calm and relaxed. Besides, her chronic stress symptoms are reduced.

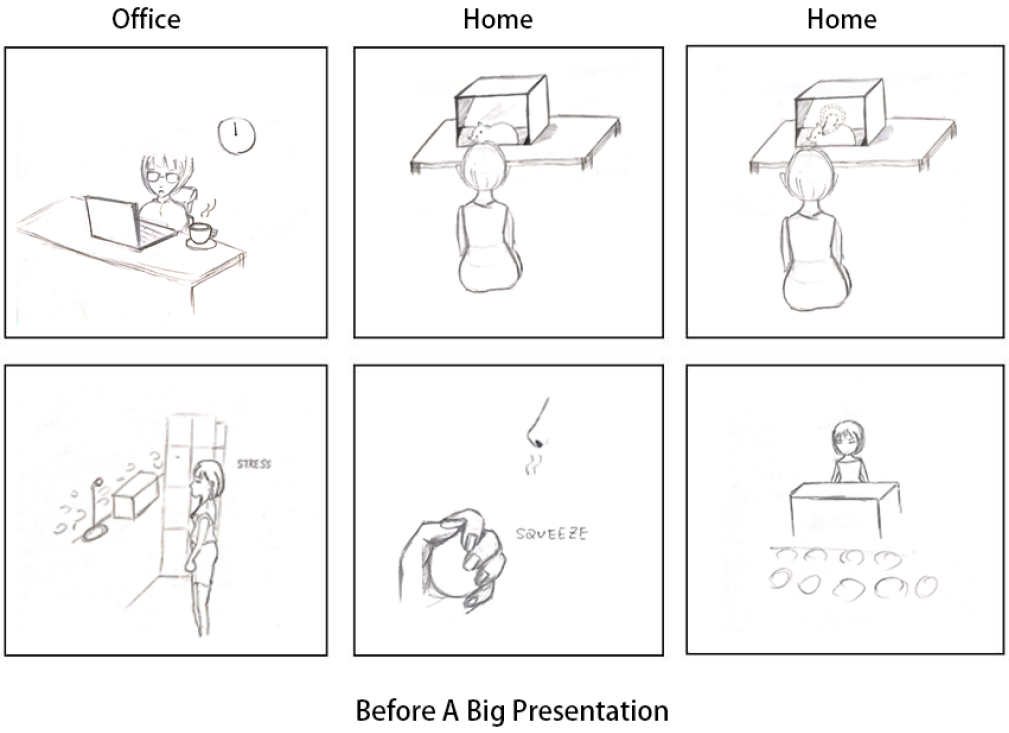

Figure 3.6 Storyboard 1: The Office Worker

The Student:

Chelsea Reid is an international student, studying at Keio University. She is a very ambitious and hard-working person. However, besides studying in school, Chelsea also takes elective courses outside of school for more credits. Because of intensive workload, she has insomnia for a long time and feels low during the daytime. She wants to sleep well; therefore, AromaCue is perfect for her since the breathing technique helps her fall asleep quickly. She practices the breathing technique in her room twice a day before and after school. She feels energetic after that. Every time she cannot sleep, she squeezes the stress ball to emit essential oil to relax.

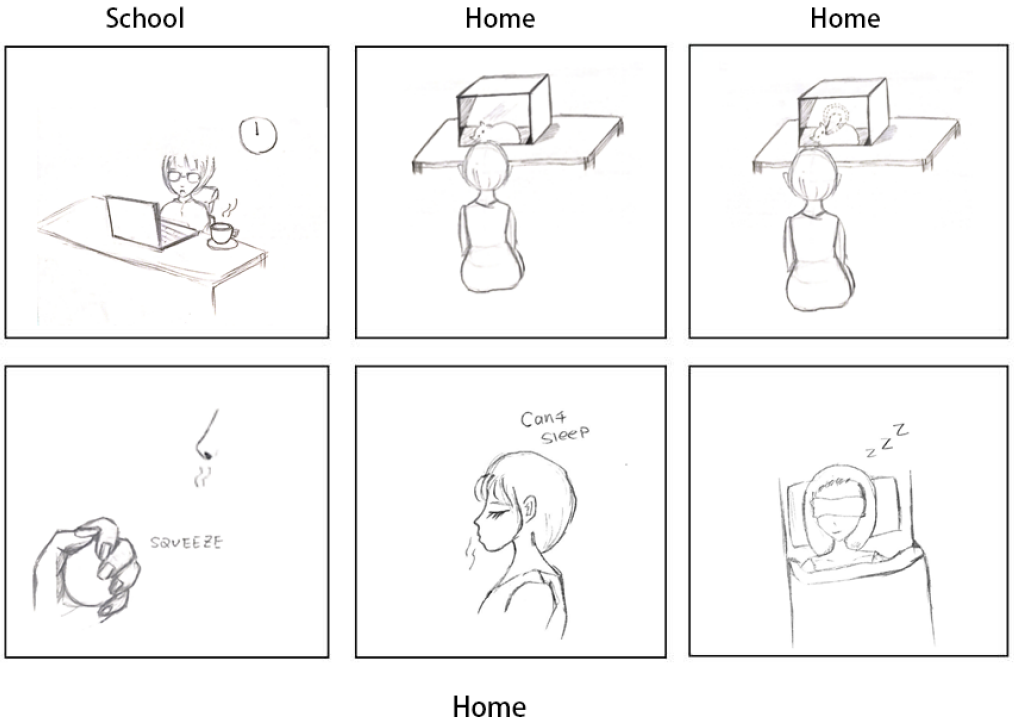

Figure 3.7 Storyboard 2: The Student

3.5. Scenarios

Two design scenarios in the storyboards present instruction to show when and where the scent toolkit can be employed. The multi-sensory breathing training device (visual and smell senses) used in the first stage of training guides users to practice deep breathing in a place where they feel safe and comfortable, such as homes. Furthermore, the scent emitting system, as illustrated in the storyboards, assist users in performing deep breathing in stressful moments.

3.6. Ideation & Concept Sketching

The previous researches provide insights into developing a sustainable and effective stress relief treatment. The field works highlight the importance of multi-sensory simulations in learning and relaxing environments. Therefore, creating a multi-sensory device for breathing instructions can accelerate the relaxation process and reinforce memory. The classical conditioning method, used to create a learning procedure, links the behavior people have learned into new behavior. The classical conditioning paradigm, as an integral concept, contributes to the flow of this design.

3.6.1 Classical Conditioning

The design refers to classical conditioning theory, which assists users in deep breathing. Adopting the habit of deep breathing requires an unconditional stimulus (US) and a neutral stimulus (NS). Placed before the natural reflex, the neutral signal helps to produce a learned response. Pavlov's classical conditioning of salivation in dogs illustrated the details. Before conditioning, dogs produce saliva in response to food(US). However, dogs show no reaction when there is only the sound of whistles (NS). Through the repetitive association of the two stimuli (the sound of whistles and food), the sound of whistles alone can trigger the salivation in dogs [26].

Odors have been demonstrated its effectiveness widely as a stimulus in the classical conditioning paradigm — previous studies conducted in animals and humans exhibit the conditioning effects and behavior changes. A previous work of olfactory conditioning in human illustrated that repetitive association of a specific odor with an anxiety-inducing task led to higher anxiety responses to this particular scent [27]. It depicts the association of odor with negative performance can consciously control human behaviors. In 2008, the first olfactory conditioning study on positive influence on human behavior was discussed in *Olfactory Conditioning of Positive Performance in Humans*. The study associating an ambient scent with a paper-and-pencil task demonstrated positive changes in human behaviors [28]. Hence, the previous work proves the possibility of using olfactory conditioning in design can help people to strengthen skills and bring positive impacts on human

behavior. The design of the stress relief method borrows the concept of olfactory conditioning to produce the learned response (deep breathing).

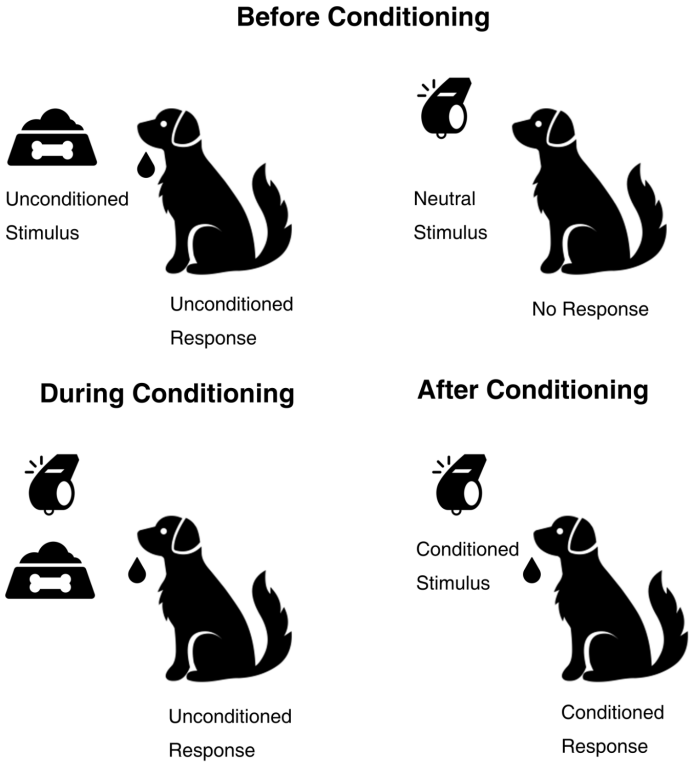

Figure 3.8 Classical Conditioning

Figure 3.9 AromaCue

Aromacue is composed of two parts: the multi-sensory respiratory training device (illustrated on the left side)and the wearable scent emitting device(illustrated on the right side). The scent toolkit satisfies the expectations of the olfactory conditioning paradigm, used separately during and after conditioning stages.

- **Before conditioning**

  performing the deep breathing technique in a secure place is an unconditioned stimulus. The natural reflex of pleasant and secure feelings is evoked. Users show no effects on the ambient scent(NS) at this stage(illustrated below).

- **During conditioning**

  The multi-sensory breathing training device is present at this stage. The visual instruction of 4-7-8 breathing technique with an ambient scent, activated by the ultrasonic distance sensor, helps users to practice deep breathing. Though repetitive pairing the ambient scent(NS) with the breathing exercise(US), The scent alone can elicit the relaxation response (deep breathing).

- **After conditioning**

  Once the new association is built between deep breathing (US) and scent (NS). The scent alone can evoke a learned response without the multi-sensory breathing device. The scent emitting device (CS) assists people in performing deep breathing(CR)in real condition.

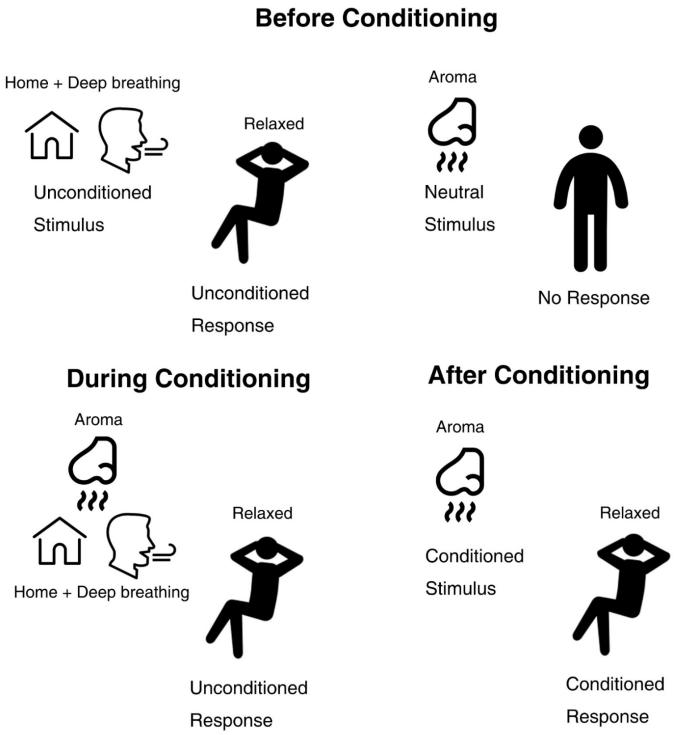

Figure 3.10 Design Olfactory Conditioning

3.6.2 Multi-sensory Breathing Training Device

Figure 3.11 Multi-sensory Breathing Training Device

The breathing training device employs a customized scent and the visual content of 4-7-8 breathing technique to create a mixed reality learning environment. Creating virtual contents on familiar surroundings contribute to achieving spatial alignment. The term "mixed reality" is derived from virtual reality. Virtual reality system sets a properly designed environment for users to interact. Users are limited and isolated inside an unfamiliar world, which makes them hard to build emotional connections with physical surroundings. However, mixed reality is built on a real physical world. The creation of mixed reality breaks the barrier of human and computer interaction. Information is not restricted inside the computer box anymore. Creating a mixed reality world provides the possibility of labeling or presenting computer-generated information on real objects [29]. It enriches the meanings of physical environments and expands the interaction between human and computers. Through integrating virtual contents with physical space, it is easier for users to build up a sense of comfort with the customized scent.

Pepper's ghost was used in this design for constructing a mixed reality world. Pepper's ghost is an optical illusion technique used to present a floating ghost-like

image for audiences. This optical technique has popularized since the 1800s in the entertainment industry, such as amusement parks, music concerts, and museums. It boosts immersive and dynamic atmospheres in creating visual contents. John Pepper presented the first stage performance of using pepper's ghost technique in 1862. A piece of transparent glass was placed between the stage and the audience. Below the scene, a beam of light spotted on the actor, creating a reflected image on the glass [30]. This performance utilized the law of reflection to create an optical illusion, which successfully brought out unexpected and impressive visual effects. This visual presentation delivered an eye-catching experience. The multi-sensory breathing learning device applied the pepper's ghost technique to shape a mixed reality world which facilitates and enriches the learning experience.

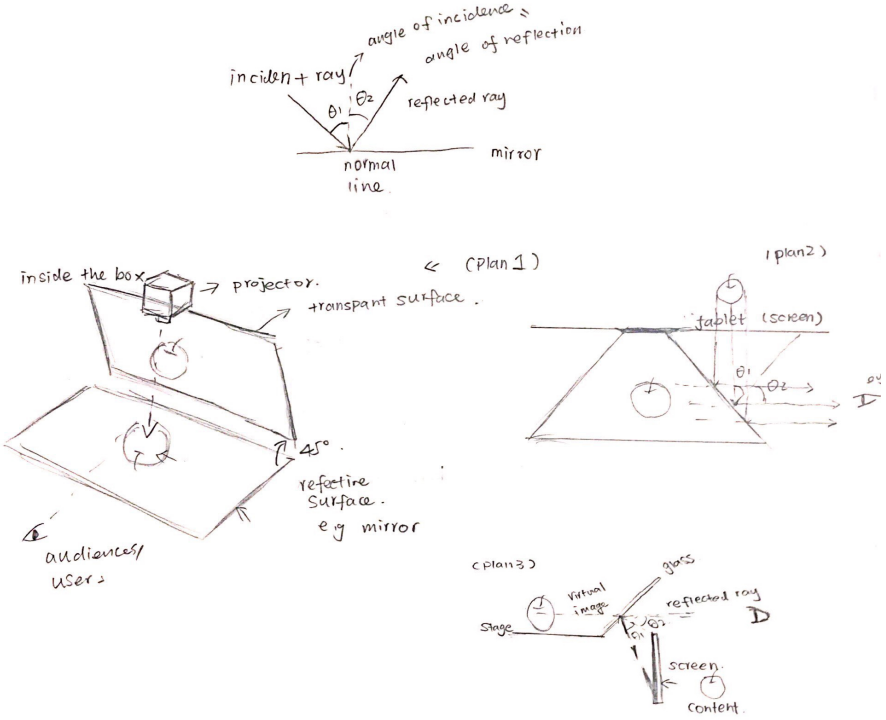

Figure 3.12 The Law Of Reflection

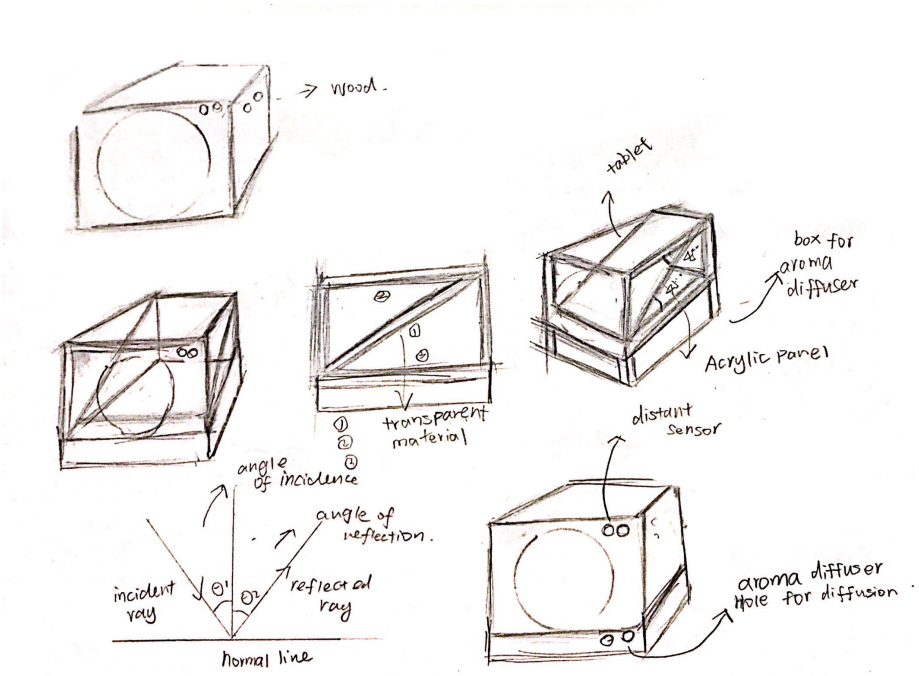

Figure 3.13 The Mixed Reality Device: Final Concept Sketching

Virtual Content Design: Using the 4-7-8 Breathing Technique

The interface design for breathing exercise was inspired by the conventional breathing circle. In this case, computer-generated contents, shown on the stuffed animal, simulate a scene that a sleeping cat is snoring with a bubble coming out from its nose. The content design visualizes the 4-7-8 breathing technique. The expansion and contraction of the breathing circle represent rhythmic breathing.

Interacting with pets helps people to assuage their stress and brings positive influences on human health. Overall it can improve health condition through this emotional attachment. Previous researches have demonstrated that socialization with pets can enhance intimate bonding and closeness. The emotional connection with their pets is similar to how people share moments with their close friends and relatives. Moreover, interacting with stuffed animals also contribute to perking up moods. There is a similar link of emotional attachment between companion ani-

mals and stuffed animals. In this research, the animal attachment theory applied in designing the mixed reality device creates an intimate relationship between the physical object and people. The theory explains that animal companionship can provoke more secure feelings. The comforts people can get from animals could provide psychological health benefits, preventing individuals from being lonely [31].

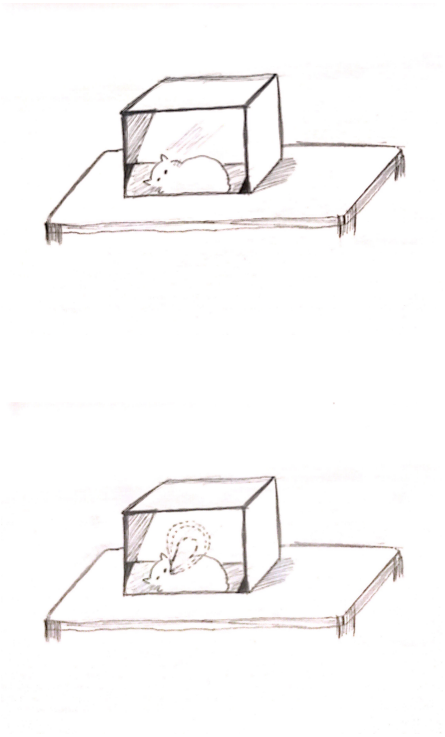

Figure 3.14 The User Interface Sketch

AromaCue: Scent As An Ambient Design Tool

Using scent qualifies as an essential feature in olfactory conditioning theory. Scent as a conditioned stimulus is used in retrieving the learned response(deep breathing), olfactory memory, and associated emotion. The following section assembles characteristics of using scent in the toolkit.

The Proust effect characterizes as a vital attribute of scent. It emphasizes that olfactory stimulus help people to relive in a memorable past. The ambient aroma can smoothly bring up associated emotion and memory. [32]. Combining scent with other media to co-create exhibitions is commonly used in art industries. The

public has embraced the concepts of its conjunction with other media, which help people to remember information and shape immersive feelings. During the learning process, The usage of scent reminds users to be present at the moment and pay more attention to the breath focus. Relaxation, to some extent, is gradually increasing during the training process. Interactions with multi-sensory stimulation reinforce the memory of the breathing technique and foster relaxation and comfort. Furthermore, scent, in this case, is also utilized as the conditioned signal to recalling the relaxation response.

3.6.3 The Wearable Scent emitting System

Figure 3.15 The Scent Emitting System

The scent emitting device as breathing notification reminds people to perform deep breathing in a real stressful situation. Scent itself can provoke olfactory memory, associated emotion, and the previously learned response(deep breathing). The scent emitting system contains two parts: A stress ball and a wearable scent emitting brooch. When people encounter threats, squeezing the stress ball(tightening muscles)concentrates the mind to cope with stressful situations. The gesture of

clenching fists is a common physical response to stress-related events. The cat-paw-like stress ball is a switch to control the scent emitting brooch. Besides, the wearable scent emitting brooch is designed like a glass bubble which contains the customized scent to match with the previous visual content. The rest parts(a fan, a battery, and a mini aroma diffuser)assemble in a mini box. The scent emitting device as breathing notification reminds people to perform deep breathing in a real stressful situation. Scent itself can provoke olfactory memory, associated emotion, and the previously learned response(deep breathing). The scent emitting system contains two parts: A stress ball and a wearable scent emitting brooch. When people encounter threats, squeezing the stress ball(tightening muscles)concentrates the mind to cope with stressful situations. The gesture of clenching fists is a common physical response to stress-related events. The cat-paw-like stress ball is a switch to control the scent emitting brooch. Besides, the wearable scent emitting brooch is designed like a glass bubble which contains the customized scent to match with the previous visual content. The rest parts(a fan, a battery, and a mini aroma diffuser)assemble in a mini box.

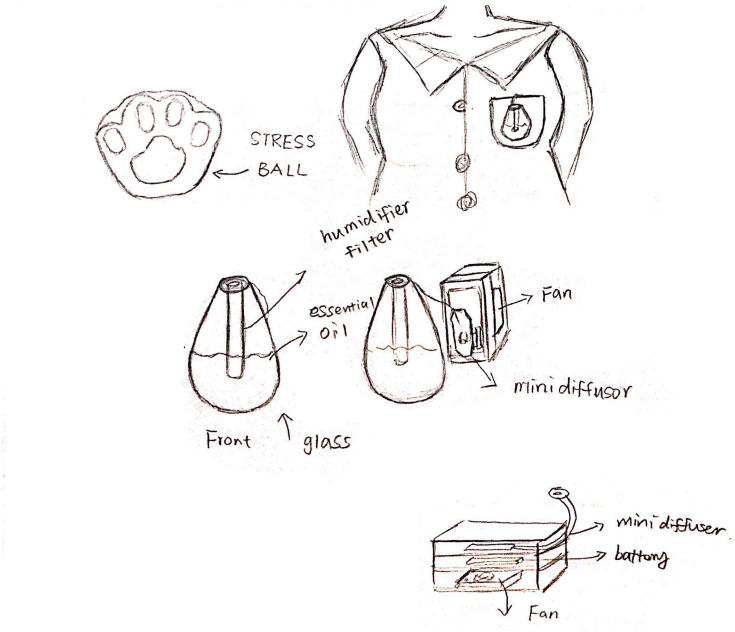

Figure 3.16 Concept Sketch: The Scent Emitting System

3.7. Prototype Development

3.7.1 The Mixed Reality Device

There are two plans, using the pepper's ghost technique, for creating the multi-sensory learning device. The frist one manipulated plastic sheet into a shape of trapeoid (Base:1cm,Base:6cm,Leg:4.5cm). However, the original design requires to set the stuffed animal as a physical background. In this case, this method cannot achieve the goal of creating a mixed reality environment.

Figure 3.17 First Prototype

The final prototype of multi-sensory breathing training device (26.5cm x 20cm x 19.5cm)satisfied all the criteria for creating a three-dimensional illusion.Placed on the top of the device, IPad air 2(24 cm (h) x16.9 cm (w)x0.61cm(d)) plays the video clip of 4-7-8 breathing technique. The transparent and reflective surface (the acrylic panel with holographic film: 20cm x 25cm) slant 45 degree angles in middle of the device, assisting in generating a virtual image on the panel. The YouTube tutorial [33] provides an instruction for building a mixed reality machine. The whole concept is similar to this prototype, but the author made few changes on the structure. The ultrasonic distance sensor, which connects to the Arduino and the raspberry pi, is a switch to the video content and the aroma diffuser. The Arduino sends distant data to activate the video in raspberry pi. Therefore, when the users are close enough to the multi-sensory breathing learning device, the video clip and scent are generated automatically.

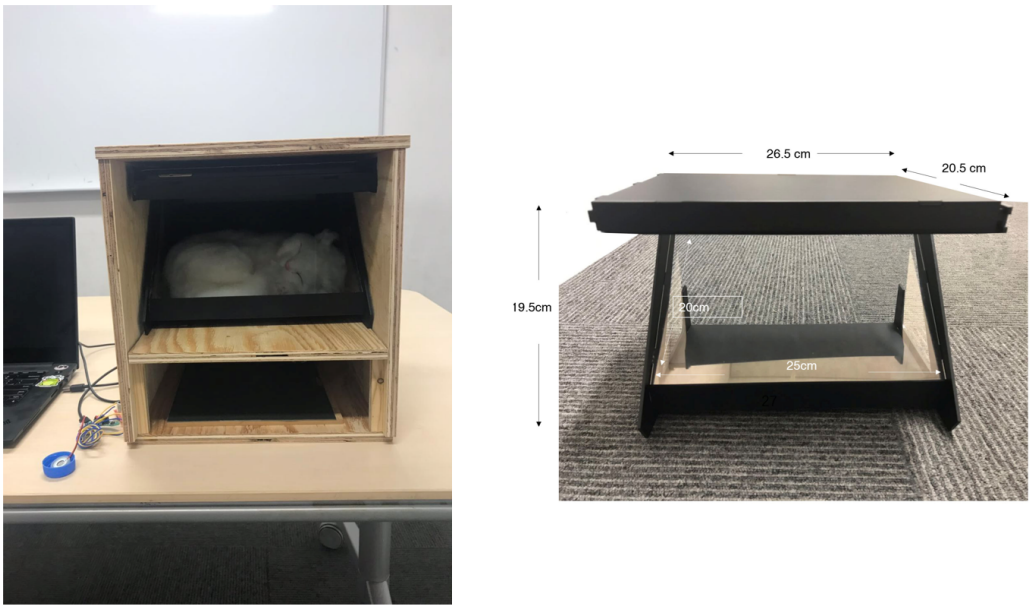

Figure 3.18 The Mixed Reality Display

Figure 3.19 A Stuffed Animal
[34]

3.7.2 Scent In Design

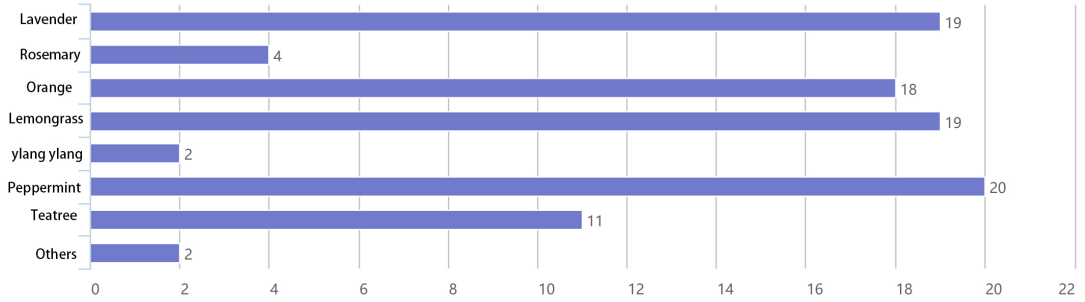

Figure 3.20 Questionnaire: Aroma Preferences

Previous survey (N=47, 59.6% female; 40.4% male; age range from 18-50)inquired about personal preferences to aroma. The result indicted top vote for aroma preferences from a relatively large sample size. However, A smelling test may contribute to a more precious result which help the author to choose essential oil(The set of essential oil was purchased from amazon [35]) in this design scenario. In this case, ten participants were selected.According to the result,all participants liked citrus essential oils, such as orange sweet, grapefruit white and bergamot calabria. Participants chose orange sweet as final selection for this design.

Figure 3.21 Essential Oils Preferences

3.7.3 The Scent Emitting Device

The scent emitting device constituted two parts: the stress ball and the brooch. A push-button was built inside stress ball to detect the external pressure. A mini humidifier is used to diffuse the essential oils [36]. When the user holds the stress ball tight enough, it will automatically turn on the mini humidifier.

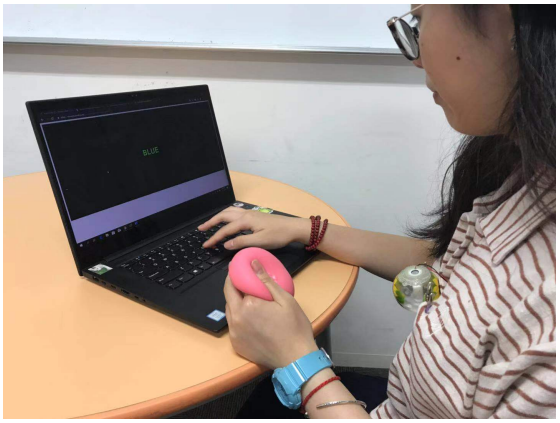

Figure 3.22 The Scent Emitting Device

3.8. Design Summary

The goal of Aromacue is to help the target users who are suffering from chronic stress to adopt a sustainable relaxation method. The concept applies classical conditioning theory. The multi-sensory breathing training device helps users to learn and practice the 4-7-8 breathing technique. Besides, the wearable emitting system assists in evoking the relaxation response. The prototype was developed to test the concept of the scent toolkit.

Figure 3.23 The AromaCue Concept: Training a breathing at home using scent conditioning. After breath training the user can receive the scent, if she presses a stress ball.

Chapter 4
Validation

The research aims to assess the user experience with the multi-stimuli breathing learning device and the scent emitting system. The experiment analyzes the feasibility of the scent kit used in a real physical environment. It is vital to demonstrate whether the scent kit can lower the stress levels and is capable of being used as a relaxation method. Besides, the olfactory conditioning effect is analyzed in observations and interviews. The first part of the experiment requires one week of associating orange sweet with the 4-7-8 breathing technique. The second part explores whether users can perform deep breathing in response to olfactory stimulation. The duration of the experiment takes over a week to complete.

4.1. Procedure

Eight participants (Female:7, Male:1, age mean 24, std 6) signed up for the experiment. All of them with an academic background (students of a graduate program or workers, researchers at university). Participants were not familiar with the 4-7-8 breathing technique and had no allergic symptoms to the essential oil (orange sweet). Before the experiment, participants were asked to fill out DASS-21. The experiments tested the user experiences with the multi-stimuli breathing training device and wearable scent emitting system. In a pre-test, I selected the essential oil out of 6 different options from aroma sets (previous purchased from amazon). Participants rated them according to pleasantness and unfamiliarity. The " Orange Sweet" scent was rated the best with high pleasantness and medium unfamiliarity. Therefore I picked it for the experiments for all participants. The experiments were conducted in Keio University Graduate School of Media Design (discussion room 06) [37].

4.2. Experiment Design

Part 1:The Multi-sensory Breathing Training Device

Before Experiment	During Experiment	After Experiment
DASS-21	The MR device	HRV
The Smiley Face Likert Scale		The Smiley Face Likert Scale
HRV		

Table 4.1 The First Part Of Experiment (Training)

Part 2: The Scent Emitting System

Before Experiment	During Experiment	After Experiment
The Smiley Face Likert Scale	The Stroop test	HRV
HRV	The Stress ball	The Smiley Face Likert Scale

Table 4.2 Comparative Experiment: Without Smell

Before Experiment	During Experiment	After Experiment
The Smiley Face Likert Scale	The Stroop test	HRV
HRV	a mini diffuser	The Smiley Face Likert Scale
	Orange essential oil	USQ
		DASS-21

Table 4.3 Comparative Experiment: With Smell

The experiment designed to examine the user experience of the scent toolkit contains two parts. The result analyzed whether participants can adopt a new breathing habit or deep breathing. The first part of the experiment conducted a week before the second part of the experiment since it was essential to making the participants familiar with the smell(orange sweet). It is an essential process of pairing smell with the breathing exercise. The participants were asked to practice the breathing technique with the essential oil(orange sweet) twice a day for one week. The second part of the experiment is a comparative experiment which investigates whether participants could cultivate a learned response through the previous training.

4.3. Methodology

The experiments were conducted in a controlled setting. The olfactory effect and the stress reduction method were analyzed by methodologies and analysis tools introduced below.

- **Wizard Of Oz:** The experiment design used the Wizard of Oz technique to simulate the system responses behind the scenes, which made the participants believe that they interact with the real product [38]. This technique allowed users to be able to experience the product and provides thoughtful ideas afterward.

- **User Experience Questionnaire:** User experience questionnaire provided a comprehensive understanding of the user experience with the scent toolkit. This measurement claims its effectiveness in analyzing the perspectives of usability and user experience. It helped to provide general user impressions of the product [12].

- **DASS21:** The DASS-21 is a short version for DASS-42 items. It contains three self-report scales, analyzing states of depression, stress, and anxiety [39]. This self-assessment, used in this experiment, gave a general idea of the mental states of participants. It was used before and after the experiment.

- **STROOP Test:** The Stroop color-word interference test was applied as a stressor to stimulate the "fight and flight" response [40]. The previous study proved that the Stroop test could be an effective stressor to induce stress [41]. In this design, the Stroop test helped to create an imposed stressful situation.

- **Heart Rate Variability:** Heart rate variability is the simplest approach to track fitness levels. It defines as a variation in the time interval between each heartbeat over the measurement period. It has been discussed in the research field for monitoring the stress level as well. The high variation between each heartbeat is associated with a relaxed state, while the low variation between beats indicates physical exhaustion. Thus, increased HRV can be an index for physical well-being [42]. In this experiment, the Wahoo

heart rate sensor and Elite HRV APP were used to record the physiological data(HRV & HR). Elite HRV applies the Root Mean Square of Successive Differences (RMSSD) to the R-R intervals. RMSSD is an industry-standard measurement for autonomic nervous system activity in a short period(5 minutes or less) [43]. Elite HRv APP generates a useful score from 0-100, indicating physiological changes before and after the experiment.

- **The Smiley Face Likert Scale:** The Smiley Face Likert Scale uses pictorial measurement to analyze emotional changes before and after the experiment. An in-built the smiley face likert scale in Elite HRV helped Participants to record their emotional changes every time after measuring the physiological data [44].

4.4. Testing & Evaluation

4.4.1 The Multi-sensory Breathing Training Device:

Heart rate variability is an assessment tool for measuring the stress level. Previous researches have demonstrated that after the deep breathing exercise, heart rate variability will increase. However, the result of the pre-testing showed decreased heart rate variability after using the multi-sensory breathing training device. The result exposed the fact that people paid extra attention to keep up with the video clip because of unfamiliarity with the breathing technique. It would be a significant issue, contributing to increased stress level after deep breathing. Therefore, the further improvement of this experiment was made. The participants were asked to study the 4-7-8 breathing technique before the actual experiment, which increased their familiarities with the content.

NO.	Before Experiment(HRV,HR)		After Experiment(HRV,HR)	
1(v)	HRV:58	HR:88	HRV:54	HR:87
2(x)	HRV:80	HR:85	HRV:57	HR:76
3(h)	HRV:54	HR:73	HRV:47	HR:74
4(k)	HRV:62	HR:69	HRV:58	HR:71

Table 4.4 Pretesting

NO.	Before Experiment(HRV,HR)		After Experiment(HRV,HR)	
1(v)	HRV:52	HR:90	HRV:54	HR:86
2(k)	HRV:57	HR:80	HRV:63	HR:81
3(h)	HRV:60	HR:75	HRV:70	HR:75
4(x)	HRV:64	HR:83	HRV:69	HR:77
5(hy)	HRV:63	HR:85	HRV:66	HR:81
6(kc)	HRV:54	HR:72	HRV:69	HR:73
7(czy)	HRV:40	HR:87	HRV:43	HR:80
8(l)	HRV:65	HR:68	HRV:66	HR:70

Table 4.5 First Part of The Experiment(Training)

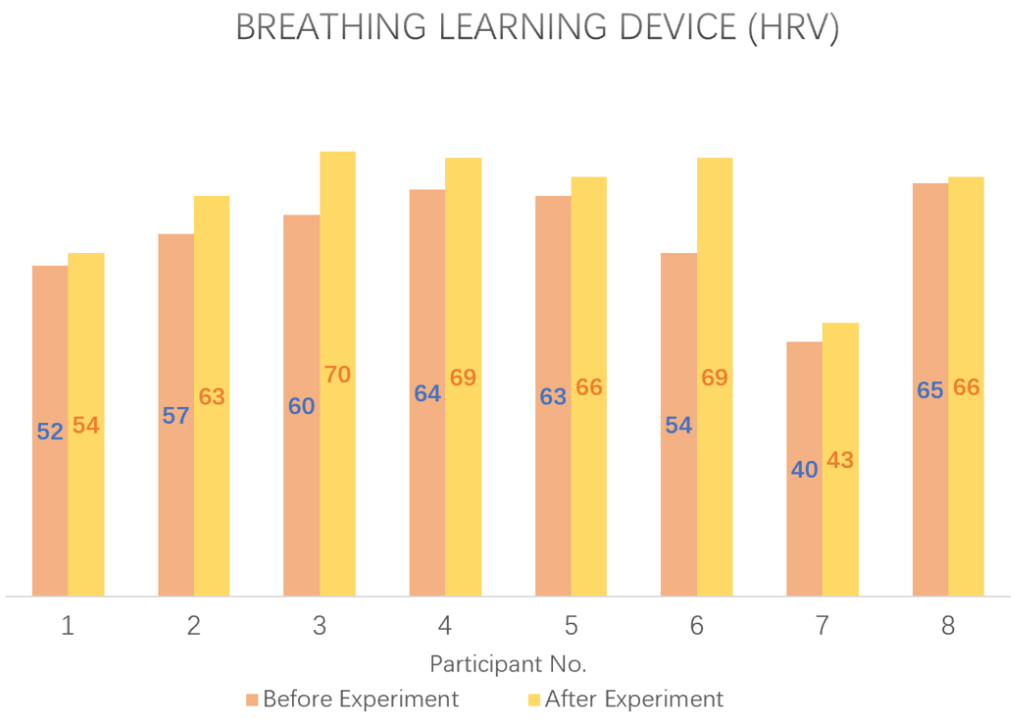

Figure 4.1 Heart Rate Variability Before and After MR device with Participant No. on the x-axis.

The previous result of pre-testing indicated the learning stage could become a stressor which may interfere with the accuracy of testing. Being familiar with the deep breathing technique helped participants to be in a more relaxed state while using the breathing training device. Fostering familiarity with breathing technique is essential before the actual experiment, providing a more accurate result for analyzing user experiences. As the table shows, the heart rate variability slightly increased after the breathing exercise, which indicates participants were in a more relaxed state. All in all, the Increased heart rate variability and decreased heart rate potentially suggested deep breathing with the multi-sensory device could lower stress levels.

The Smiley Face Likert Scale

The emotional response was recorded before and after each testing. This Likert scale measures from negatively Excited(-2), to negatively mellow(-1),to neutral(0),to postively mellow(1) to postively excitied(2). 75% participants reported their mood had improved after using the breathing training device.

4.4.2 Part2: The Comparative Experiment

NO.	Before Experiment(HRV,HR)		During Stroop Test(HRV,HR)		After Experiment(HRV,HR)	
1(h)	HRV:68	HR:78	HRV:66	HR:75	HRV:70	HR:76
2(x)	HRV:69	HR:77	HRV:67	HR:78	HRV:70	HR:77
3(k)	HRV:56	HR:90	HRV:48	HR:94	HRV:46	HR:91
4(v)	HRV:46	HR:93	HRV:44	HR:94	HRV:43	HR:97
5(hy)	HRV:66	HR:80	HRV:66	HR:82	HRV:68	HR:86
6(kc)	HRV:58	HR:75	HRV:57	HR:76	HRV:55	HR:79
7(czy)	HRV:43	HR:80	HRV:48	HR:81	HRV:41	HR:87
8(l)	HRV:66	HR:70	HRV:55	HR:66	HRV:61	HR:64

Table 4.6 The Second Part Of Experiment(Without Smell)

NO.	Before Experiment(HRV,HR)		During Stroop Test(HRV,HR)		After Experiment(HRV,HR)	
1(h)	HRV:62	HR:80	HRV:69	HR:80	HRV:71	HR:75
2(x)	HRV:70	HR:77	HRV:65	HR:78	HRV:65	HR:78
3(k)	HRV:54	HR:84	HRV:55	HR:85	HRV:50	HR:87
4(v)	HRV:43	HR:97	HRV:43	HR:94	HRV:48	HR:90
5(hy)	HRV:68	HR:86	HRV:67	HR:79	HRV:67	HR:81
6(kc)	HRV:55	HR:79	HRV:56	HR:80	HRV:60	HR:76
7(czy)	HRV:41	HR:87	HRV:45	HR:84	HRV:45	HR:81
8(l)	HRV:66	HR:70	HRV:68	HR:60	HRV:70	HR:75

Table 4.7 The Second Part Of Experiment(With Smell)

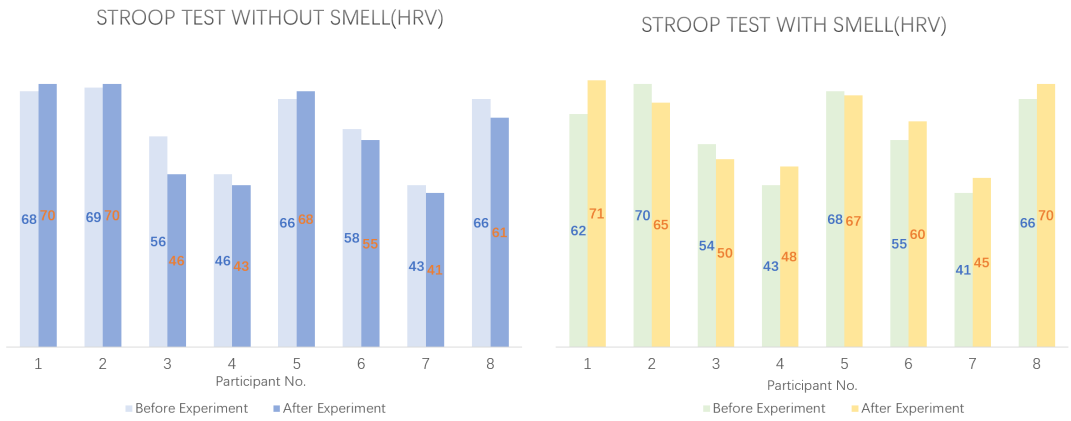

Figure 4.2 Heart Rate Variability after the Stroop Test With or without in msecs with Participant No. on the x-axis.

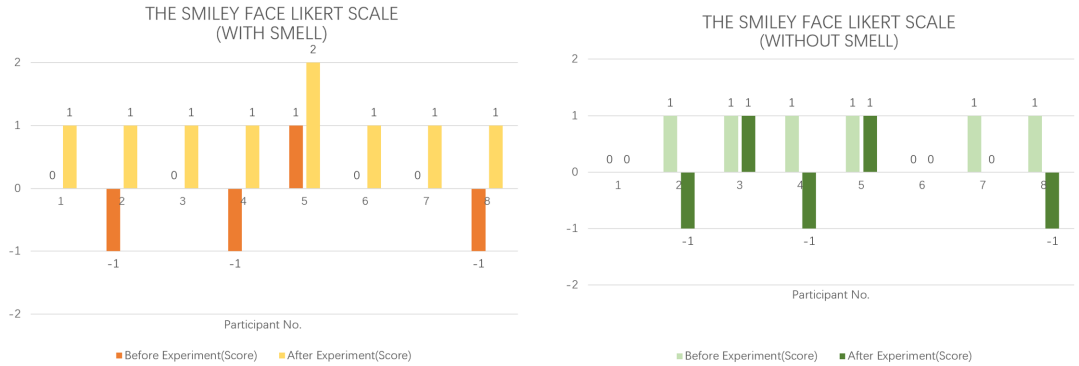

Figure 4.3 The Smiley Face Likert Scale

In the comparative experiment (scent/without scent), the decrease in heart-rate (before minus after the STROP test) is significantly higher for the scent condition. The heart beats per minute decrease more for the scent condition (M= -3.1, SD = 3.7) compared to the control (slight increase, M=3.28 STD=3.7) ($t = 2.62, df = 7, p = .010162$). The result is significant at p $<$ .05. This can indicate a more relaxed participant.

The heart rate variability (the higher, the better) increases during STROP for 6 participants in the scent condition versus only 3 in the control condition (without the smell), as seen in Fig. 4.4.2. However, the change is not statistically significant.

Regarding the qualitative results: the emotional response was recorded before and after each test. This Likert scale measures from negatively Excited(-2), to negatively mellow(-1),to neutral(0),to positively mellow(1) to positively excited(2). 75% of the participants reported their mood had improved after using the breathing training device.

The smiley face Likert scale was used to detect emotional changes. 50% (4) of participants reported that the Stroop test would not influence their mood. 50% of participants rated negative change after the Stroop test (without scent); However, The second test indicates that orange essential oil could improve their mood; all of the participants reported positive emotional changes.

To evaluate the severity of stress, depression, and anxiety over the whole experimental time, the DASS21 was applied. Participants filled it out before starting the

training and at the end of all experiments. The DASS21 gives us indications if our overall design works in an intended way, lowering indicators for stress, depression, and anxiety.

4.5. DASS-21

DASS-21 analyzed the severity of depression, anxiety, and stress. The evaluation chart indicates details for analyzing the data. The participants were asked to fill out the questionnaire online by using the tool provided by Breakthrough [45]. The result automatically generated after each submission. After one week of training, the overall result improved.

Subscale	Depression	Anxiety	Stress
Normal	0-4	0-3	0-7
Mild	5-6	4-5	8-9
Moderate	7-10	6-7	10-12
Severe	11-13	8-9	13-16
Extremely severe	14+	10+	17+

DASS=Depression anxiety stress scale

Figure 4.4 DASS-21 Assessment Scale
[46]

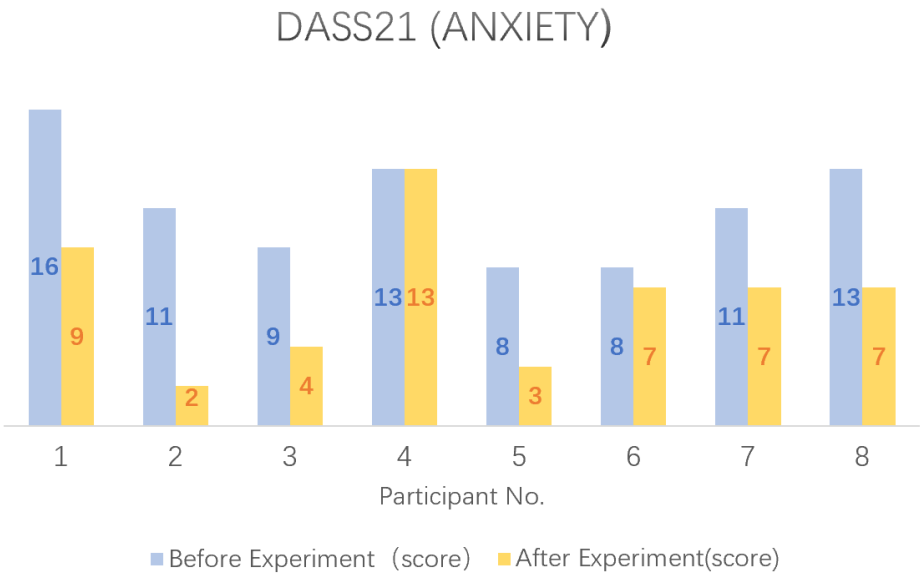

Figure 4.5 Results for the Depression Scale for the individual participants (x-axis) before and after all experiments (DASS21).

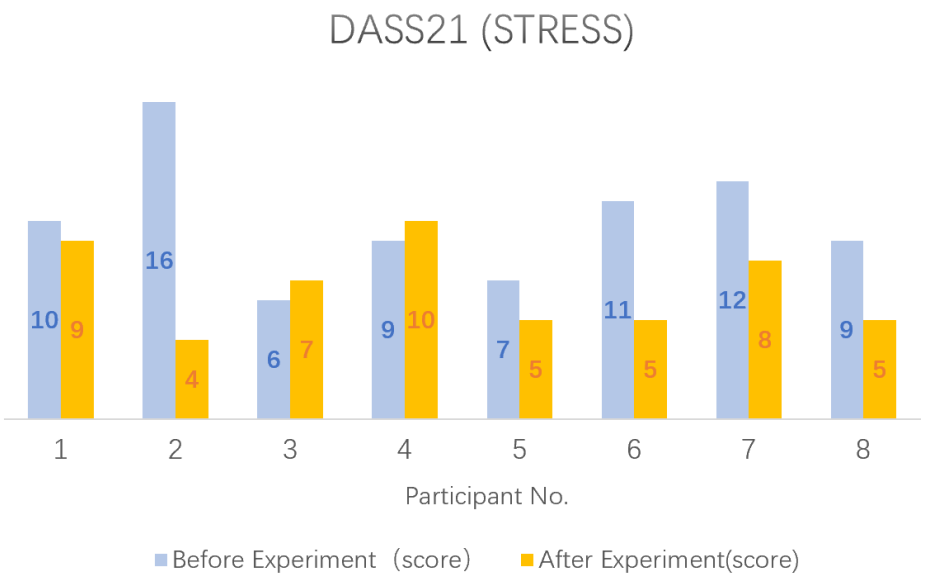

Figure 4.6 Results for the Anxiety Scale for the individual participants (x-axis) before and after all experiments (DASS21).

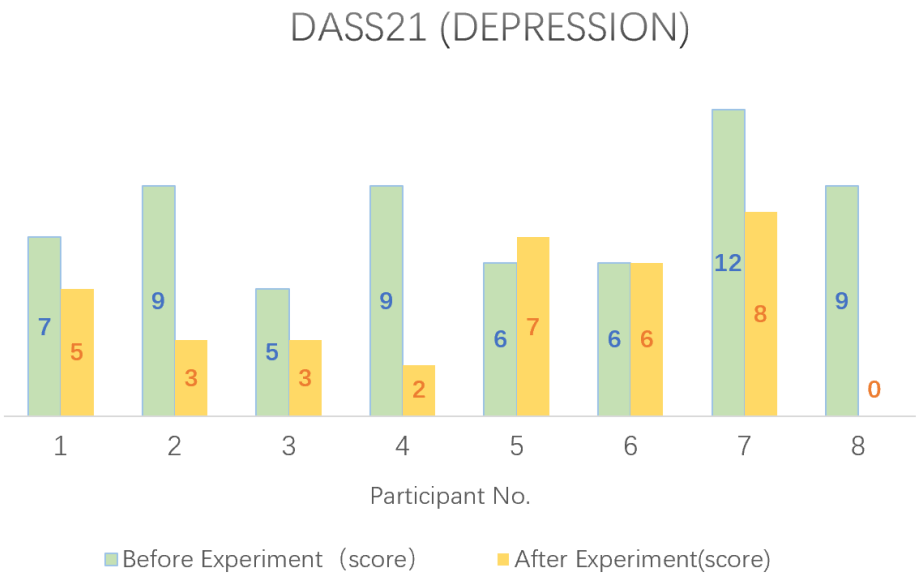

Figure 4.7 Results for the Stress Scale for the individual participants (x-axis) before and after all experiments (DASS21).

The results for all three (perceived long term stress, depression and anxiety) are statistically significant using a paired T-test. All indicators decrease over the design intervention (see Fig. 4.54.64.7). There is a decrease in depression indicators from before (M=10 points STD=7.4) to after (M= 3.11 STD=1.90237946) ($t = 2.21, df = 7, p = .002$), the same holds for the anxiety indicators before (M=8 points, STD4.25) and after (M=2.4, STD = 2.71) ($t = 2.88, df = 7, p = .005$), as well for the stress indicators of the DASS21 Scale before (M=11.125, STD = 6.428571429) and after (M=2.799872446, STD=3.823486317) 2.89 ($t = 2.89, df = 7, p = .005$). As expected the intervention has big impact on the perceived stress level.

4.6. User Experience Questionnaire Result

The User experience questionnaire provides an overall perception of the design. The questionnaire contains eight linear scales. The scale range is between -3

(horribly wrong) to 3(extremely good), helping to analyze pragmatic quality and hedonic quality(as the chart shows below). Values between -0.8 and 0.8 represent a neutral measurement; values are higher than 0.8, indicating a positive evaluation; values are less than -0.8, denoting a negative assessment [47]. In this case, the mean value per item scored greater than 0.8, which indicated positive feedback from participants. The final result of pragmatic quality (1.656)and hedonic quality (1.438) are the overall perception(1.547) that the participants scored for the design. However, due to the small sample size, the result cannot represent public opinion. However, the result implies that the scent toolkit (AromaCue) has a positive tendency to satisfy the needs of consumers.

Item	Mean	Variance	Std. Dev.	No.	Negative	Positive	Scale
1	1.5	0.6	0.8	8	obstructive	supportive	Pragmatic Quality
2	1.9	0.4	0.6	8	complicated	easy	Pragmatic Quality
3	1.6	0.6	0.7	8	inefficient	efficient	Pragmatic Quality
4	1.6	0.8	0.9	8	confusing	clear	Pragmatic Quality
5	0.9	0.4	0.6	8	boring	exciting	Hedonic Quality
6	1.6	0.8	0.9	8	not interesting	interesting	Hedonic Quality
7	1.8	0.2	0.5	8	conventional	inventive	Hedonic Quality
8	1.5	1.1	1.1	8	usual	leading edge	Hedonic Quality

Figure 4.8 Mean Value Of Each Item

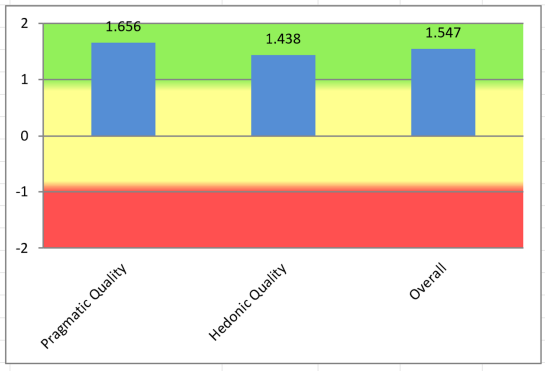

Figure 4.9 UEQ: Assessment

4.7. Interview

In the first interview, two participants mentioned they paid more attention to the virtual contents and ignored the stuffed animal. It was hard to bond relationship with the toy if they could not touch it. However, the idea of learning the breathing technique with a stuffed animal was appealing since it can visually improve their emotion and reduce stress. All participants were satisfied with the multi-sensory learning experience. The aroma could make them concentrate on training procedures. The first interview suggests an attentional demand of adding haptic input since the visual instruction would somehow increase the stress level, and the overall HRV scores were slightly improved.

The second interview was conducted after the comparative experiment. Seven participants reported they squeezed the stress ball and took deep breaths during the Stroop test (with smell). The smell-emitting system, indeed, served as an ambient notification. Even though they did not strictly follow the 4-7-8 breathing technique, participants took deep breaths in response to orange essential oil. One of them said it was hard to hold the breath for seven seconds in a stressful condition. Six people said the smell of orange reminded them of the breathing technique, which changed the way they usually breathe. Besides, the stress ball itself is a stress alleviator. Using it as a switch to diffuse aroma could help them to get rid of tension and stress. Overall, the interview revealed that the scent toolkit could help them cultivate a breathing habit.

4.7.1 After Using Scent Toolkit: Before The Final Presentation

Eight people participated in the previous experiment, and six people were going to do a final presentation in the following days. After the presentation, the author was informed that at least five people performed deep breathing exercise before the presentation. They found this stress relief method, indeed, helped them to produce a relaxation response. Although the training process only had continued for a short time, participants started to recognize the importance of deep breathing, which improves conscious awareness of their body. This report proved that AromaCue and the 4-7-8 breathing technique help them to adopt a breathing

habit.

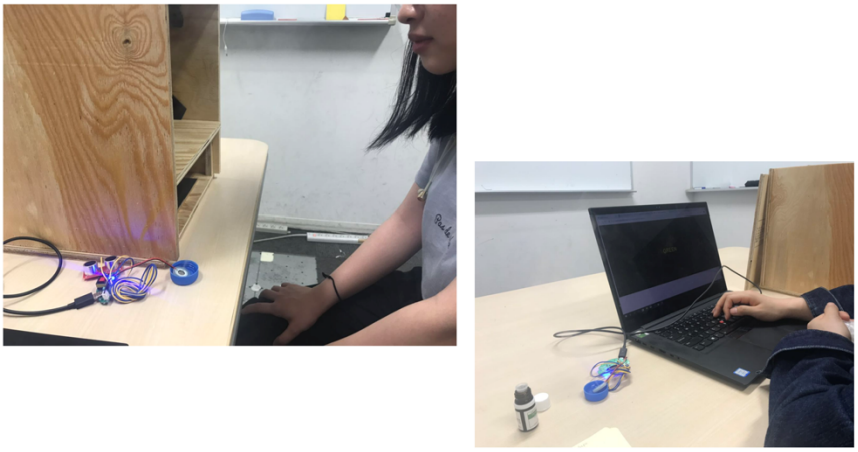

Figure 4.10 Experiment

4.8. Conclusion

This chapter analyzes the user experience by using the qualitative methods: user experience questionnaire, heart rate variability, heart rate, and smiley face Likert scale. The evaluation proves that the AromaCue can potentially help people to reduce stress and cultivate a breathing habit. There are several drawbacks of this design, which will be covered in chapter 5.

Chapter 5
Conclusion

AromaCue is an scent toolkit for cultivating a breathing behavior. It comprises two parts: the multi-sensory breathing learning device and the scent emitting system. The concept development refers to olfactory conditioning theory. Though repetitive associating scent with the 4-7-8 breathing technique with the breathing learning device, individuals can adopt a useful skill for coping with work-related stress. The wearable scent emitting system, employed as a breathing notification reminds users to breathe. The toolkit not only enriches the learning experience but also facilitates individuals to recall olfactory memories and accelerate the relaxation response.

The design approach followed the procedure of the design thinking process: empathize, define, ideate, prototype, and test. This process was vital to understanding the communities and problem they were facing and assisted in developing the target persona. Qualitative and quantitative research methods helped to define user needs and values of this project. As a result, cultivating a breathing habit was selected as the final goal for this design. Concept sketching and storyboard provided instruction for users to understand the design structures and essential components; Prototypes were used to test the design concept.

The testing part revealed several drawbacks of the scent toolkit. The pretesting indicated that participants concentrated more on the visual contents than their breaths, which somehow increased their stress level. Besides, participants found that even though it was hard to develop object attachment with the stuffed animal since they could not touch it, the breathing training device, indeed, enhanced the learning experiences. Used the stress ball as a switch, the scent emitting system is a breathing notification. Overall, qualitative research methods offered positive evaluation of user experience.

5.1. Limitation

Demonstrating the effectiveness of olfactory conditioning effects and positive user experience require a large sample size of the population, which will provide more precise experimental results on the design concept. Besides, theoretically, eliciting a relaxation response needs more than one week to train; therefore, results of the experiment only provides positive feedback which can be investigated in the future study.

5.2. Future work

Using visual instruction to explain the breathing technique can put extra pressure on participants. However, replacing visual cues with haptic feedback can minimize any outside distraction. The future design will compare a haptic simulation with a visual aid to distinguish the differences in user experience.

Closing eyes and feeling the belly movement of the stuffed animal can be the future improvement for this project(illustrated below). It is easier for users to build object attachment by holding and touching fluffy artificial hairs. Moreover, It may enhance the experience of multi-sensory learning.

Figure 5.1 Future Work

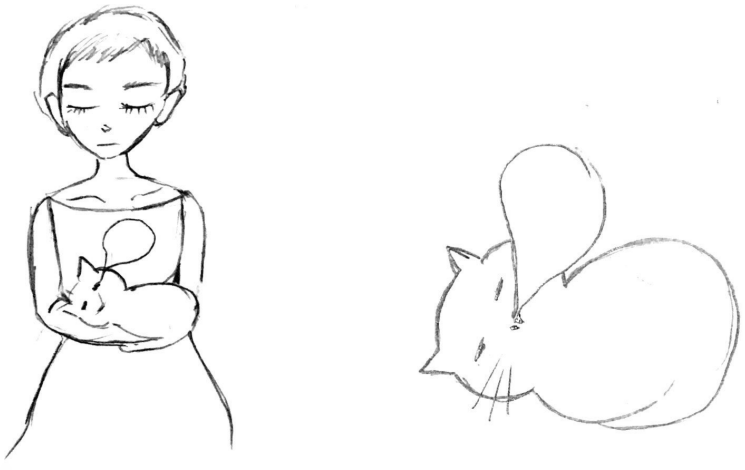

Figure 5.2 Future Work Sketch

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Appendices

A. Code1

getDistanceBySonicNonBlocking

```
  #include <NewPing.h>

#define TRIGGER_PIN 10
#define ECHO_PIN 13
#define MAX_DISTANCE 200

// NewPing setup of pins and maximum distance
NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);

void setup() {
  Serial.begin(9600);
}

void loop() {
  delay(100);
  unsigned int distance = sonar.ping_cm();
  Serial.write(distance);
}
```

Figure A.1 The Breathing Training Device, Credited to Professor Atsuro Ueki

B. Code2

```
from sys import exit
from time import sleep
from os import path, sep, system
import signal
import serial
import threading
from omxplayer.player import OMXPlayer
from pathlib import Path


# definitions for thread1
def handle_data(data):
    global buffer
    buffer.extend(data)


def read_from_port(ser):
    global connected
    while not connected:
        connected = True
        while True:
            reading = ser.readline()
            handle_data(reading)


# definitions for thread2
def execute_app():
    global buffer
    mode = 0
    oldmode = 0

    while True:
        if(len(buffer) == 0):
            continue

        distance = buffer.pop(0)
        print(distance)

        if mode == '1':
            threshold = [40, 60, 100]
```

Figure B.1 The Breathing Training Device, Credited to Professor Atsuro Ueki