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Master's Thesis

Academic Year 2017

Folding Fan - Exploration of Creativity in an Interactive Multimedia Environment Using Body Extension

Keio University Graduate School of Media Design

Gina Fitria Adita

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

Gina Fitria Adita

Thesis Committee:

Professor Kazunori Sugiura	(Supervisor)
Associate Professor Kai Kunze	(Co-supervisor)
Associate Professor Nanako Ishido	(Member)

Abstract of Master's Thesis of Academic Year 2017

Folding Fan - Exploration of Creativity in an Interactive Multimedia Environment Using Body Extension

Category: Design

Summary

The society and civilization we are living in are built by the chemicals in our brains. It is a result of people trying to find more ways to make their lives easier. To come up with such advancement, people keep on researching about how to escalate the quality of ideation and creativity process. The problem is that creativity is often perceived as a mere trait that only handful of individuals may possess. This leads to many people believe that they have 'no creativity' at all. However, creativity is essential for everybody to increase the quality of their daily lives. Not many people understand that the instruments to enhance creativity can be found everywhere.

Some researches have pointed out that the combination of environment, action, sensory stimulation, and physical attribution to be able to enhance the quality of emotional expression as well as ideation process. On the other hand, multimedia design has many traits that can cover most of those factors. For that reason, this project is to design an interactive multimedia environment that can respond to user through action and movement, embodied with gesture stimulating object, which is folding fan. With its fluid movement, people are expected to change their perspective in space utilization and gesture exploration while interacting with the multimedia environment.

In this project, we will discuss how folding fan, combined with body movement can give an increase in one's emotional quality through data evaluation and analyze, and other impacts towards user's mental and physical demand.

Keywords:

Creativity, Folding Fan, Interactive, Multimedia

Keio University Graduate School of Media Design

Gina Fitria Adita

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Although this project does not end here and it is still ongoing with thorough improvements, the author hopes that this will help those with similar projects and give insight and inspiration. It is such a privilege and satisfying experience to be able to contribute in society under this project with the help and support from such great and kind people.

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Chapter 1
Introduction

1.1 Background

It is intriguing to think that the development of society and civilization are built and run by the chemicals in our brains. If we trace back history from the period when people invented wheel that resulted in the boost of civilization, the invention of lamp that became the foundation of our daily life, the invention of computer that highly contributed to modern society, until this era of digital information and communication we are living at the moment, it is clear that there is one red thread that connects the development of society and civilization regardless of the time; people are always thinking for a way to make their lives easier. There is a high chance that the objects or environment surrounding us right now are the results of people feeling unsatisfactory of their experience or the curiosity for improvement.

The generation of visual creativity is essential for the contribution of advancement of technology and scientific innovation. It applies to a wide range of fields, from education, innovation, business, arts and science, and society as a whole (Florida, 2002; Runco, 2007; Simonton, 1997).

Everyday Creativity

Most people would largely assume that creativity is only linked to arts. Furthermore, they tend to have unrealistic standards that they believe would not meet however much effort they give. They would compare their own skills to that of renowned artists. For instance, their painting should be on the same standard with Salvador Dali's paintings, they should take pictures as great as Wolfgang Tillman's photographs, their musical skill should match with Beethoven's, and so on, resulting in thinking they have 'no creativity' at all. Eventually, it would lead them to thinking that creativity is only possessed and celebrated by certain

amount of gifted individuals and does not correlate with them at all. This belief would tend to refrain them from maximizing the potential they have. In contrast, creativity is possessed by everyone in different amount. It is not only universal, but also necessary to our survival as individuals [10]. Humans are not creatures of instinct that build their nests the same way. Throughout the day, whether at home or work, we adapt and innovate. We improvise our matters in life, at times acting from our 'gut feelings', but other times we learn and systematically take steps. Our creativity may involve any of our action, from the smallest thing, such as making breakfast to solving bigger problems or making important decisions at work.

1.2 Design Concept

While it is not possible for designers to create experience out of people, it is possible to create a product that triggers their emotions and inspires them into thinking and taking action in certain ways. That is one of the points that designers in all fields of design should pay attention to, be it graphic, product, game, UI/UX, interior, fashion, and multimedia design. After having experience with various multimedia installations by working on multiple projects in creative industries and going to showcases and exhibitions of multimedia arts, the author has learned that immersion is one of the key factors that makes people focused on the surroundings. The combination of audio, visual, and time that stimulates their senses plays a major role into planting a mood and leading them to thinking into the desired way.

The concept here is not specifically to raise one's level of creativity, as creativity is a multifaceted phenomenon that requires more careful approaches. However, the proposed concept here is to encourage people to emotionally express themselves through gesture and movement in a multimedia environment. This project will facilitate the medium for people to explore their gesture and movement that will lead to emotional and ideational expression, with the help of interactive multimedia.

1.2.1 Multimedia Design as Medium

According to Frank Popper, a historian in art and technology, virtual art is identified by a techno-aesthetic foundation enabled by the logic of the individual artists

and informed by the extra-artistic implications of their works. Virtual art offers a new model of thinking about humanist values in technological age. It is more than the injection of usual aesthetic material into the new medium, but also the deep investigation into the ontological, psychological, and ecological significance of such technologies. Oliver Grau, a German art historian and media theoretician, also describes virtual art as an essential relationship of humans to images and demonstrates how this relationship is evidenced in both old and new media of illusion.

Modern society holds a great dependence on multimedia technology on daily basis. It is nearly unmissable for people to spot an object with multimedia technology everyday, from morning commute,working in an office, shopping, to time spent at home. The purposes of multimedia design range from daily life assistance, work enhancement tools, to creative expression. In this project, multimedia design supports the exploration of emotional expression that can affect the quality of ideation and creativity.

According to Marie-Laure Ryan in her book Narrative Across Media; The Languages of Storytelling (2013) [11], below are the characteristics of multimedia design that allow it to not only be as what it is now, but also how it can help it develop in the future;

- **Reactive and interactive nature**

  This means the ability of digital media to respond in changing situation. Reactivity refers to responses to changes in environment or unintentional user actions. Interactivity is a response to a deliberate user action.

- **Multiple sensory and semiotic channels**

  The capabilities of multimedia lie in the multiple sensory system that both multimedia and the audience have so it can intertwine with each other.

- **Networking capabilities**

  Digital media connect machines and people across space and bring them together in virtual or real environment. This opens the possibility of multi-user and live / realtime as well as delayed communication.

- **Volatile signs**

  Computer memory is made of bits whose value can switch back and forth between positive and negative. Unlike books or paintings, digital texts can

be refreshed and rewritten without having to throw away the material support. This point explains the unparalleled fluidity and dynamic nature of digital images.

- **Modularity**

  Due to the fact that the computer makes it so easy to reproduce data, digital works tend to be composed of many autonomous objects. These objects can be used in many different contexts and combinations, and undergo various transformations, during the run of the work.

1.3 Objective and Hypothesis

The objective of this project is to design an interactive multimedia environment combined with using folding fan as a tool to extend user's emotional expression through gesture and movements. Folding fan is chosen as a physical attribution because of its fluidity. When using folding fan, people tend to make gestures that are different and have more flow. This kind of gesture exploration may alter one's perspective of their surrounding, creating a new one that may be able to stimulate the creativity.

The hypotheses proposed here is that using folding fan as a body extension in an interactive multimedia environment, people may explore their creativity expression through gesture and movements.

1.4 Contribution

As said on the Background section, creativity is a thing that can be explored by ourselves with the right instrument. With this project, encouraging people to explore their emotional expression that may stimulate their creativity is expected.

While developing the concept and visuals, this project was also proposed to a newly-built fashion management company called VINT-AGE. The company has taken an interest and has formed a collaboration with the author. This project will be implemented into their first fashion show on 18th - 19th of November 2017. During the experiment process, the company also participate in the user tests and qualitative evaluations.

1.4.1 Vint-Age

VINT-AGE is a fashion management startup company founded by Shu Koike, Kaori Tsuda, and Ikuta Kijima in 2016. The name VINT-AGE shares the profound meaning as the word *vintage*. When hearing the word, people would tend to immediately think of old things that have rare values, making its radiance timeless and treasured. Those things are usually packed with nostalgic memories. Therefore, vintage objects are cherished by people. The name also shares the etymology of 'building an era' . The objective of the company is to combine fashion industry with modern entertainment and also to support many rising creators to collaborate with their projects.

On 18th to 19th of November 2017, VINT-AGE is going to hold their first event that consists of fashion show and fashion competition for fashion design students located in Yoyogi Park, Keyaki Namiki Street, in between Shibuya and Yoyogi, called Be-VINTAGE. The author is going to make collaboration with VINT-AGE by implementing this project as an interactive installation room in the exhibition.

The plan to collaborate will be applying the concept of this project onto the kimono exhibition by VINT-AGE's fashion designer, Kaori Tsuda. This exhibition will be held indoor with a few models and mannequins as the target of the virtual painting. Still keeping the original concept, audiences will get the freedom to create their own paintings on the white kimonos displayed during the free time period.

Figure 1.1: VINT-AGE Logo

1.5 Thesis Structure

CHAPTER 1 (Introduction): introduces creativity, emotional expression, and its context, brief objective of this project, and overview of the contribution on a fashion event.

CHAPTER 2 (Related Works): presents the literature review and related works about visual cognitive and creativity researches, interactive multimedia artworks, and body extension based performance arts.

CHAPTER 3 (Design Process): explains the design concept, including the concept illustrations and visual development.

CHAPTER 4 (Implementation): describes the technical method to achieve the experimental setup.

CHAPTER 5 (Evaluation): shows the qualitative and quantitative result achieved and analyzes the data using evaluation method.

CHAPTER 6 (Conclusion): concludes the result of the evaluation and discusses its limitation, possible improvement, and how it will be developed in the future.

Chapter 2
Related Works

2.1 Visual Cognition and Creativity

Creativity is a complex phenomenon that requires various studies and approaches in order to deepen the understanding. Since hundreds of years ago, it has been something that intrigued many scientists and researches to analyze. Numerous studies and researches regarding creativity have been rising in order to comprehend this essential part of human mind. Therefore, many theories have been rising to identify what creativity really is and how we can utilize it for our benefits. There is so much to learn about it, both by moving ahead with new research and also by looking back on what has been researched. However, not all theories are alike. To understand more about the creativity theories that have come up, it is helpful to narrow down points and elements of comparison. By classifying existing theories, it will help us in choosing which approach works the best on our project. In their book, The Cambridge Handbook of Creativity (2010), Aaron Kozbelt, Ronald A. Beghetto, and Mark A. Runco have reviewed major theories about creativity and classified them into ten major categories of theories [6]. In order, *Developmental*, *Psychometric*, *Economic*, *Stage & Componential Process*, *Cognitive*, *Problem Solving & Expertise-Based*, *Problem Finding*, *Evolutionary*, *Typological*, and *Systems*. *Developmental theories* imply that creativity develops over time and is mediated by the interactions of person and their environment. It explains the natural way people develop their creativity from early stage of life. *Psychometric theories*, on the other hands, do not describe the developmental background and thinking patterns or motives. Rather, they focus on consistency and accuracy of scientific measurement, such as traditional intelligence, IQ, and convergent thinking. *Economic theories* imply that creative ideation and behavior is influenced by market forces and cost-benefit analyses. *Stage & Componential Process theories* describe that creative expression proceeds through a seris of stages or components, and that the process can have linear and recursive elements. *Cognitive*

theories are influenced particularly on ideational thought processes and accomplishments of the individual. *Problem Solving & Expertise-Based theories* relate closely with *Cognitive theories* as it results from a rational process, which relies on general cognitive processes and domain expertise. *Problem Finding theories* explain that creative people proactively engage in a subjective and exploratory process of identifying problems to be solved. *Evolutionary theories* describe the eminent creativity results from evolutionary-like processes and selective control. In *Typhological theories*, creators vary along key individual differences, which are related to both macro- and micro-level factors and can be classified via topologies. Lastly, *Systems theories* suggest that creativity results from a complex system of interacting and interrelated factors. Referring to all of these theories, there are a few theories that can be looked up to as the base of working on this project, particularly theories that rely on mental action and process of acquiring understanding through thoughts, experiences, and senses. For this purpose, two related theories, *Cognitive theories* and *Problem Solving and Expertise theories* may serve as the foundations of this project. However, the second one is more conditioned to problem-oriented situation where a sense of expertise and ample amount of knowledge is needed to achieve the solution of certain issues. In this project, the aim is targeted more into the exploration of visual cognition and creativity expression of people, rather than rational procedure in eliminating problem. Therefore, *Cognitive theories* are selected as the base of this project.

It is largely assumed that creative achievements or performances have some basis in cognition, as well as creative people are highly believed to have special cognitive abilities. There is an indication that cognition and creativity are linked and affecting each other. Cognitive theories emphasize the creativity process and person. Process means emphasizing the role of cognitive mechanisms as a basis for creative thoughts, and person means considering each individual has their own differences in such mechanisms. These theories are divergent from one another. Some focus on the relation of attention and memory, others focus on individual differences in thinking. Others also focus on conscious operations and action, but on the other hand, there are also those who focus on preconscious and unintentional processes. One notable cognitive theory states that creative insights can result from associative processes. Mednick (1962) described how ideas are linked together and how remote associates tend to be original [7]. Associations between ideas may be formed by various reasons, such as being functionally related. However, some individuals tend to move quickly from obvious associates to

remote associates. In other words, more creative individuals have stronger sense of association of ideas.

2.1.1 Design and Emotion

Visual cognition and emotion strongly link to each other. Our perception of objects, artworks, and designs often involves an emotional response. That perception is crucial to not only our daily life but also innovations. Many years ago, the design field had simpler objective. People designed chairs, cars, clothes, and other daily objects for the sake of its functionality. But as the time goes by, people began to understand the importance of engaging their customers or targets into their design through experience. In recent years, we have started to witness an unprecedented emphasis placed on the concept of emotion in design. The need for an emotional appeal in designed products has been unanimously voiced and designers have been called for creating products that address human emotions. As the technology advanced, many researches had been centered into design that evokes people' s experience. These design researches then might help us understand more about the intangible, yet crucial aspect of our lives, which is emotional expression.

This research is based on two prominent approaches to emotion and experience expressed by Art as Experience (1987) by Dewey and Experienced Cognition (1997) by Carlson. These approaches represent the fields of philosophy, cognitive science, and social science, the fields that coverage in design research and practice.

Emotional Expression

In their books, Dewey and Carlson split the structure of what we generally call emotion into two types of responses. Carlson makes a differentiation between emotion and mood (Carlson, 1997). Emotion is defined as short, sharp waves of feeling, arising without conscious effort or reflection, which is usually accompanied by the increased activation of the autonomous nervous system. Meanwhile, Dewey differentiates between emotional statements and emotional expressions (Dewey, 1934). An emotional statement is a momentary descriptive response that may seem expressive, but is an automatic action. In contrast, an emotional expression is an ordered response that references the emotions of previous experiences. While Carlson and Dewey use different terms, what is important is that they share the recognition of two types of emotion; one that is short and reflexive, and another

that is sustained and reflective.

Emotional Expression Stimulating Factors

A research called An Accessible Framework of Emotional Experiences for New Product Conception [3] conducted by Carl DiSalvo, Bruce Hanington, and Jodi Forlizzi from Carnegie Mellon University, USA, has analyzed and gathered data about what would be effective factors in triggering one's expression of emotional state.

- **Environment**

  According to Carlson in his book Experienced Cognition (1997), the state of arousal that comes with emotion and and mood shapes how we relate ourselves to the real or imagined state of the world. [1] This concludes that emotional expression and creativity is highly dependent on the environment.

  The environment is constituted of objects that can function as

  - Stimuli for new experiences
  - Extender for current experiences
  - Proxies for past experiences

- **Action**

  Many studies have proven that our gesture and movement have a deep connection with our brains. It affects and reacts to each other. Most of the times the brain sends different signals to the body, leading to the body react voluntarily or involuntarily. External factors such as external information, environment's condition, and action from other people may prompt people into thinking and taking action as the result. However, there are also studies that prove that doing certain voluntarily movement may affect and enhance our brains, leading it into giving more productive feedbacks. Take the example of a research done by Marily Oppezzo and Daniel L Schwartz in demonstrating how walking may increase the convergent and divergent thinking part of our brains [8].

- **Sensory Stimulation**

  As a multi-sensory being, humans have deeper impact towards physical sensation.

- **Physical Attribution**

  The body alone may be enough to interpret our emotional expression, but an attribution of certain object on to our bodies may be able to alter our perspectives. [8]

2.2 Interactive Multimedia Design

This section will cover the related works about interactive multimedia design that share the same concept or objective as this project.

2.2.1 Body Paint

Memo Akten is an artist from Istanbul, based in London, United Kingdom. His artworks explore the collisions between nature, science, technology, ethics, ritual, traditions, and religion. Using data computation and complex algorithms, Memo Akten collaborates across various other disciplines ranging from video, sound, software, light, dance, performances, and installations.

One of his works has been notably successful and on tour for six years to so many galleries, events, and festivals around the world, including the Decode exhibition at the Victoria and Albert Museum, London, Tate Britain, Holon Museum in Tel Aviv, and Garage Center for Contemporary Culture, Moscow, Russia. Body Paint is a visual instrument allowing people to paint on a virtual canvas using their bodies. The movements are interpreted into an evolving compositions. The piece is more about the interaction experience between the audiences and the installation, and less about the result of the painting. Analogous to playing musical instruments, the motivation for playing a piano or guitar is not always to compose or record a song. Sometimes every note is just for the moment, a natural response coming from within, without any concern for the final output or recording. Similarly, when you stop moving, your painting slowly fades away, leaving only the memory of your interaction.

Body Paint shares the same objective as this project, which is to expand the emotional expression through exploration of body movements, as our body is a vessel for our emotional state. We have a natural instinct to express ourselves through gesture and movement. For this reason, the role of multimedia is to portray the motion into visual compositions.

Figure 2.1: Body Paint by Memo Akten (2009)

2.2.2 Google TiltBrush

Tilt Brush is a virtual reality experience that lets people paint in three-dimensional space made by Google and provided for Vive and Oculus Rift. The app comes with a wide range of 'Dynamic Brushes' that make it possible to apply paint that are not possible to be used in daily life, such as light, fire, snow, etc. It also provides a color picker that lets the user pick their color of choice and various style of brushes. And as this is made in virtual three-dimensional space, the user can immerse themselves by walking through their creations. This lets the user to build their own creations into a virtual environment, which is something that conventional medium are not possible to produce. These features are convenient for not only sketching or painting, but also quick prototyping.

This work is significantly relevant to this project in term of the function that the product serves; painting in virtual space.

2.2.3 Collide

Inspired by the phenomenon of synaesthesia, or the union of senses, Collide combines original chamber music and painterly visuals to reinterpret recorded motion data and act as a conductor for the musical score composed for the installation. This interactive installation, made by a digital art and design studio based in Berlin called Onformative Studio, generates surreal visuals and an engaging

Figure 2.2: Google Tilt Brush

soundscape to create an immersive space capturing the essence of motion, color, and sound to visualize a synaesthetic experience of letting go and losing oneself in the creative process. Originally commissioned by Dolby Laboratories in San Fransisco, this 62-foot long digital screen, site-specific installation explores the union of senses by transforming recorded motion data and producing abstract visuals and sound as the result. By mixing, reversing, and eliminating restrictions of time and space, a new vision of the human body and mind is discovered. This work is a multisensory experience exploring the subjects from an emotional perspective, examining the feeling of being immersed in the creative process and attentive to the present moment as the senses combine and become one. Ephemeral figures emerge out of a colorful void and fade into a surreal environment where movements appear in an abstract landscape of shape and color. Using the onsite 54-channel speaker system, sound travels through the space, immersing visitors as they become part of the experience.

2.3 Body Extension in Artwork Creation

Body is the medium of soul and mind. The way we see what is around us can be reflected through our gesture and body movements. Body also may resemble our mind and even personality. Sometimes it is as simple as the eye movements, hands position, or eyebrows twitching. Other times it is the way people walk, stand, and other overall body gesture. It is no wonder that psychologists observe the way

Figure 2.3: Collide by Onformative Studio

people think through their gestures. It is also discovered that body movement is one of our ways of communication. People are likely to use specific gestures to accentuate what they communicate, for instance, nodding heads in agreement, folding both hands to ponder, and so on. Other broader gestures have been studied as a symbol of certain aspects in life. Spreading both hands in speeches done by organizational leaders or presidents are used as a sign of power and dominance, bowing your body in a necessary angle represents respect, standing or sitting with your back straight and keeping a considerable amount of eye contact signs confidence in someone, and so on. In other words, body language runs the society.

In the world of art, the same thing is applied, especially in performance arts or works that physically interact with people. In performance arts, artists communicate and express emotions, messages, and values through body movements.

2.3.1 Folding Fan as Body Extension

Since the purpose of this project is to extend the emotional expression through making visual composition using object that has the ability to affect the sense of space and environment, an object with a good fluidity and natural movement is required. For this reason, folding fan is chosen as a medium to virtually paint.

The Relationship Between Human and Folding Fan

Folding fan has been an object many people use on daily basis with a variety of usage. The most common reason people utilize this object is to fan themselves to produce wind and relieve the heat, making it a popular item to sell around the time of spring to summer.

2.3.2 Torque Starter

Enra is a Japanese Performance Arts Company that is known for fusing dynamic performance arts with projection mapping that unite as a single form of expression. Established in March, 2012, this company is comprised by collective motion graphic and animation designers, choreographers, and art performers concentrating on various fields, such as Chinese martial arts, rhythmic gymnastics, classical ballet, animation dance, juggling, street dance, and many other disciplines. One of their works, called Torque Starter, is especially relevant to one of the concepts of this project. In Torque Starter, a yo-yo is used as a body extension of the performer. Throughout the performance, it can be seen that the performer himself does not change his positions a lot. Most of the works are done by his both hands and the yo-yo itself.

Figure 2.4: Torque Starter by Enra

2.3.3 Sakura Sakura Traditional Japanese Dance

Sakura is a Japanese term of cherry blossom. It is the iconic symbol of Japan, known for its presence that signs the coming of spring. It is especially cherished by the Japanese people that it is promoted into various products, such as delicacies, clothes, perfume, and even dance. Sakura Sakura is a Japanese traditional folk dance that tells the story of spring, the season of cherry blossom. It was popularized in edo period and from since adopted as a piece for students who begin learning koto, a Japanese traditional musical instrument.

This work serves as a base of various gestures that people tend to make while holding a folding fan. From observing the videos, it is comprehended that there are three steps of 'opening' a folding fan.

Figure 2.5: Sakura Sakura Traditional Dance

Chapter 3
Design Process

3.1 Concept

In accordance to the research conducted by Carl DiSalvo, Bruce Hanington, and Jodi Forlizzi from Carnegie Mellon University, USA, called An Accessible Framework of Emotional Experiences for New Product Conception, we have learned that a combination consisting of environment, action, sensory stimulation, and physical attribution is the key factor that contributes to triggering expression in emotion and creativity [3]. To maximize the expression of an individual, the utilization and arrangement of those elements are essential. Referring to that research, an arranged set of interactive environment combined with a body embodiment object that can stimulate a person's sense in order to explore their gestures and movements is needed in order to increase one's emotional expression. Therefore, the concept proposed here is to design an environment that can stimulate one's emotional and creativity expression with the combination of folding fan as the body embodiment object of the user that lets them explore their gestures more. As the first chapter mentioned, multimedia design has many strong points that can stimulate a person's sense while being capable of holding interaction between the person and the multimedia itself. Accordingly, this chapter will discuss about the development of the environment plan, visual design, and also audio element in order to build a set of interactive multimedia environment.

3.1.1 Multimedia Environment

Setting up a responsive environment that stimulates a person's multiple sensory and, at the same time, offers direct interaction with people might be easier said than done. The environment must be able to 'speak' with the user. For all of those needs, the author decided that multimedia design is a good solution to enhance the interactivity and provides a stimulating environment for the users, due to

its interactive nature, multiple sensory and semiotic channel, and its ability to connect people and machines together in both virtual and real environment. From the perspective of the creator too, multimedia that is comprised with digital data tends to be easy to generate. It is also made easy to switch back and forth between positive and negative value, since it is changeable. Therefore, modification and maintenance of data are convenient with multimedia.

In this project, the designed multimedia needs to be responsive to user's movement. It will also act as a canvas to accommodate the visual resulted from user's body and folding fan's movement. Since this project relies on user's gesture and movement, the environment must be able to provide enough space for the user to move around, as well as space for the multimedia setup. A set of visual is necessary in this project not only as the interpretation of user's movement onto the canvas, but also to enhance the ambiance and immersion as the whole body of environment. To support that, an audio background should be provided too during the experiment. The involvement of contrasting and colliding visual also requires the environment to have very few lighting as possible. For these reasons, the environment needs to be located indoor, in a closed room with good acoustic system. Below are the concept illustrations as part of the initial design plan and measurements of the environment.

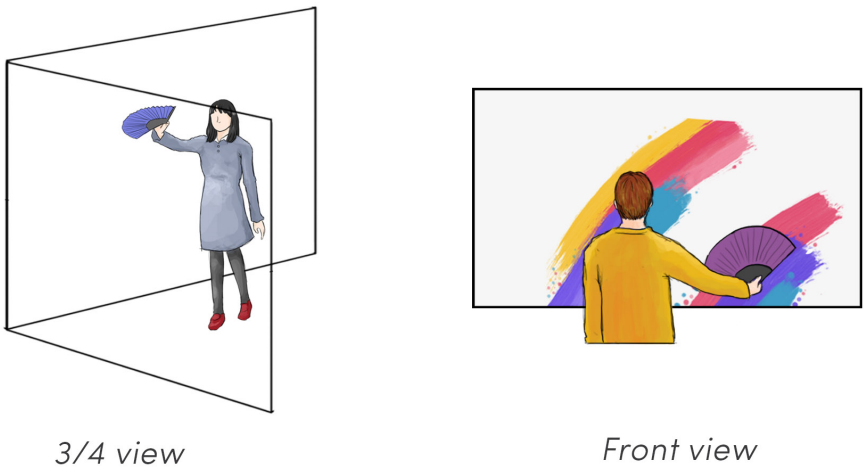

Figure 3.1: Concept Illustration 1

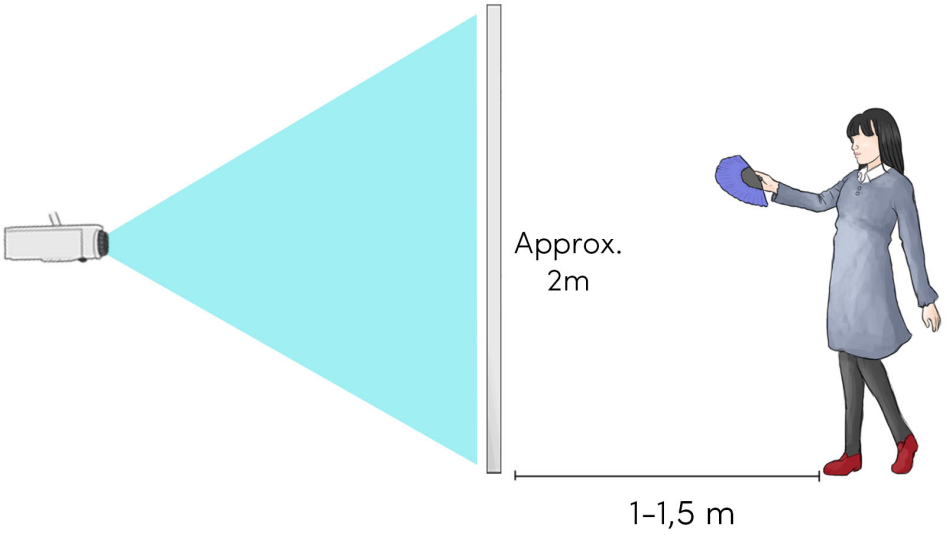

Figure 3.2: Concept Illustration 2

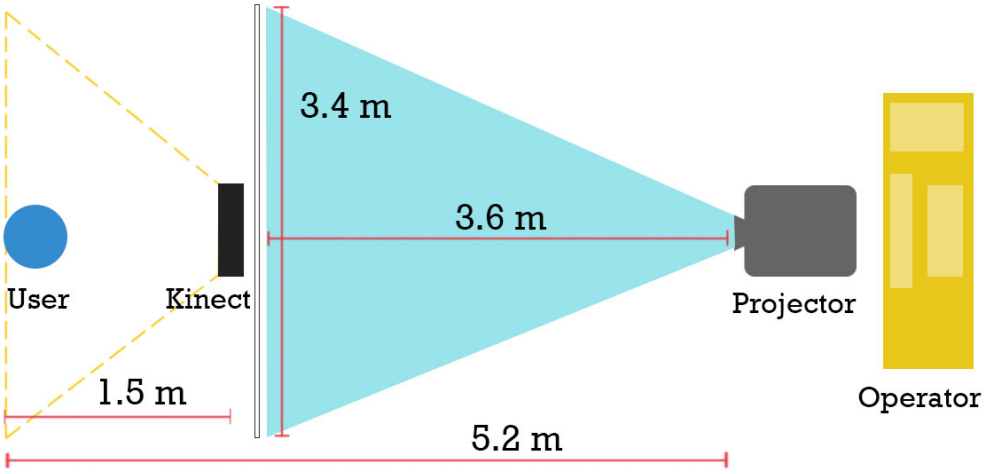

Figure 3.3: Setup Illustration Upper View

To let the user move around freely, a sufficient amount of space is needed as the area of experimenting with one's gesture. The user will face a big and wide canvas to project their visually represented gesture. Ideally, a four-side canvas that surrounds the user is preferred to enhance the term *environment* and to make the user more immersed in performing the experiment. However, as for the first experiment, a one-side canvas is used to measure the success before stepping on the next scale. Next, in order to track user's movement, a motion tracking system is needed to be placed right in front of the space that is utilized to perform the experiment. This motion tracking system will be discussed later on Chapter 4, Implementation. To project the visual representation of the user's gesture, a back projection mapping technique will be used. A projector will be set behind the canvas and project the image processed with a software in mirroring fashion to reflect the user's silhouette precisely on the same direction. This technique was chosen to prevent the image projected being blocked by the user, should the conservative, front projection mapping technique be used. Lastly, a small area for controlling the whole installation is not to be missed. Technically, it can be placed anywhere on the environment as long as it does not block the projected visual and disturb the flow of the experiment. But the ideal space would be on the back of the canvas and projector to let the operator see the image flow clearly.

3.1.2 Visual Development

Visual elements are also an essential key to stimulate one's mind since it highly correlates to visual reception of human. It is also a major part of the ambiance which is built by the whole environment to enhance the stimulation of the senses. The visual that is used as part of the composition of this project should be elements that people are familiar with, especially, colors and shapes. However, since this installation serves as a *painting* medium, abstract elements are more suitable in order for the user to create things without being limited by the shape, texture, or other visual elements. In other words, the visual element should not clearly resemble any object and even if it does, it should only symbolize an object based on merely its nature, characteristics, or flows. In this section, we will discuss about the exploration of the visual elements accordingly that will contribute to the project to gain its objective. The objective of this exploration is to create the most suitable visual elements to use in virtual painting and that can support the installation to stimulate the user's senses.

Generative Visual Composition

Generative means the ability to reproduce itself. In multimedia arts, generative visual is reproduced by a string of data or more. With the right tracking and capturing tools, this data may come from various external factors, such as movement, brightness, sound, temperature, etc. The data can also be affected from internal factors, such as manual data modification, or arranged programming. The data coming from external factors will appear as if it interacts with its data giver. For instance, if an installation turns its color into red when the surrounding temperature rises, and turns to blue when the surrounding temperature goes down, it will appear as if the installation is interacting with the temperature. The same goes to if a person behaves in certain way, such as waving their hands or making certain sound, an installation could change its visual, produce sound, or move in certain ways. Although this is caused merely by an order of data, tt will look like as if people interact with the installation and the installation responds by reacting back at them. This technique has been on the rise in the digital and multimedia world for quite a while due to its two-way interaction. It also adds to the surprise factor that is one of the essential keys in immersion. This technique was chosen as the base of developing the visual because it gives many potentials and freedom for the user to interact with.

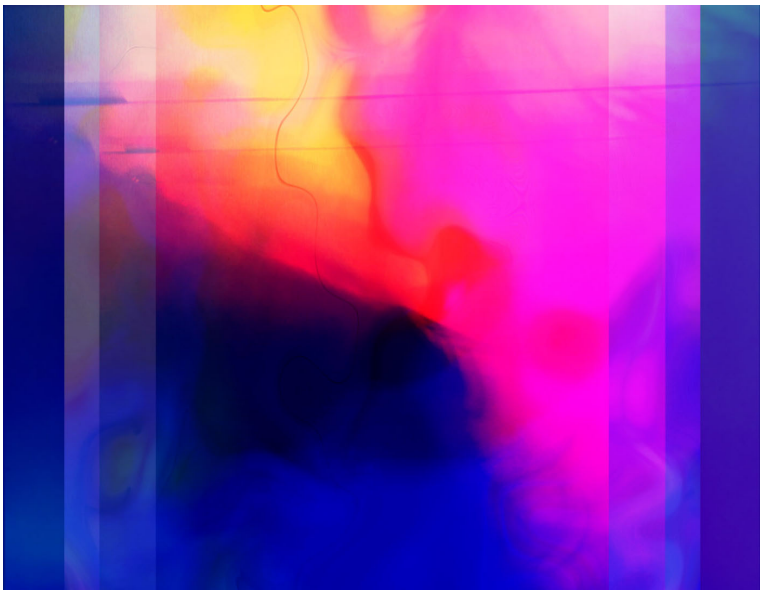

Figure 3.4: Visual Exploration 1

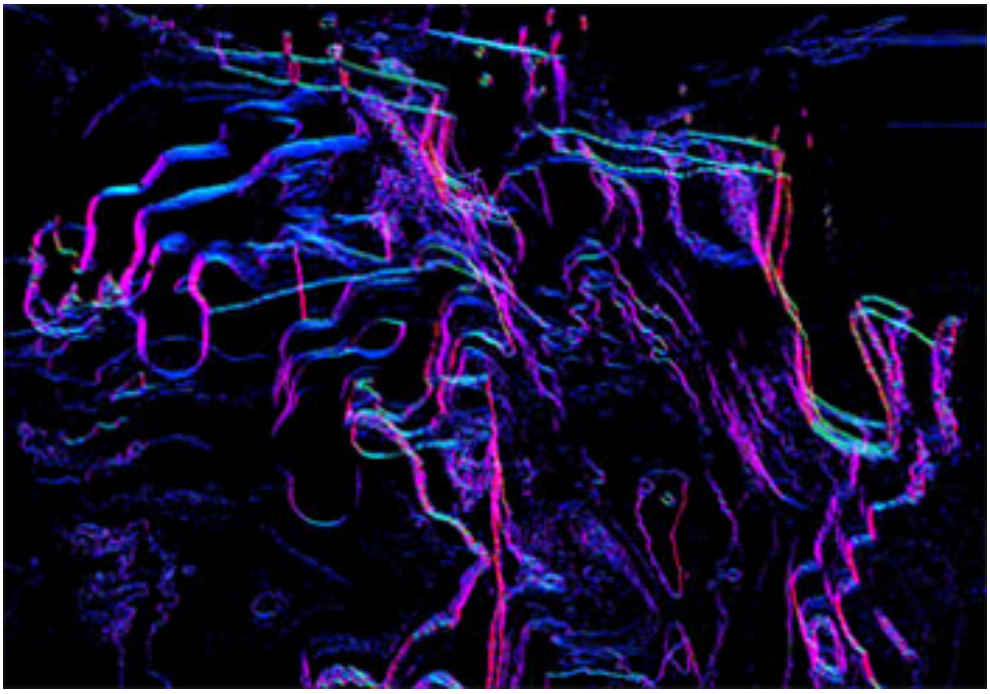

Figure 3.5: Visual Exploration 2

Figure 3.6: Visual Exploration 3

These samples of visual exploration are experimentation in order to find the most suitable visual elements as a basis of virtual painting. The author tried to find the closest shape that resembles what abstract painting is like generally by infusing colors and strokes with minimal shape and texture. This experimentation was made in Adobe After Effects CC with the help of TouchDesigner Visual Processing software.

Colors

The colors of choice to implement as part of the elements are the combination of primary and secondary colors. Primary colors are the main set of pigment and lights received by the color vision system in human and animals. For electronic displays and media, the colors red, green, and blue are well-known as primary colors. On the other hand, secondary colors, or additive colors by its other name, are pigments that are created simply by combining each of the primary colors to one another. The secondary colors consist of yellow, magenta, and cyan.

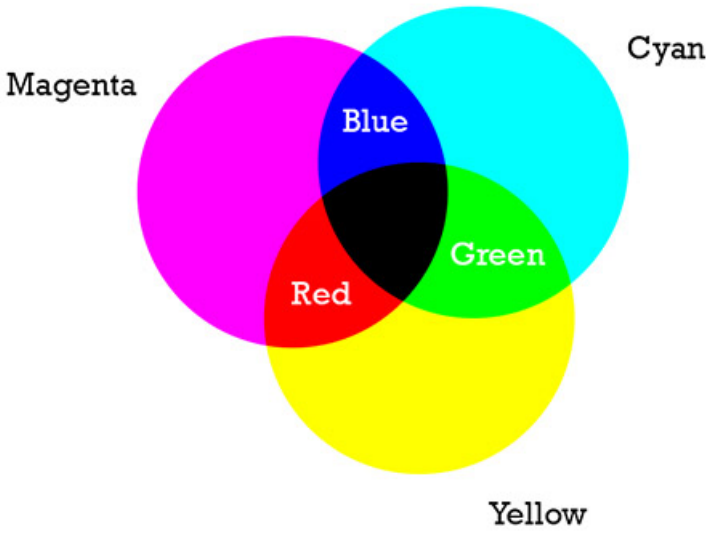

Figure 3.7: Primary and Secondary Colors

Fractal

Making an abstract and colorful visual elements will serve its purpose as a painting installation. However, it is not enough to engage with the folding fan. Since the folding fan is the unique point in this installation, it needs a special feature. When faced with a blank canvas and abstract visual, people would intuitively follow and understand that it's a medium to virtual painting. However, when equipped with folding fan, people would also suggest movements that can be made with the fan and expect the nature of the fan. One of the fan's certain nature, fluidity, should be utilized whenever a person uses a folding fan. In this case, it should be represented as visual elements. As discussed in Chapter 2, the fluid nature of the folding fan may affect the space around us. The unique gesture it makes can alter our perspective towards our surrounding. This trait will be represented by incorporating fractals into the visual composition.

According to Fractal Foundation, fractal is an infinite curve or geometrical figure that forms patterns that are self-similar across ranging scales [4]. They are created by repeating a simple process over and over in an ongoing feedback loop. These patterns are quite similar to humans since it can be found everywhere in the nature. For instance, trees, mountains, clouds, hurricanes, etc. Fractals can also be generated by computer through repetitive calculation of data that cause a never ending result. In this project, the author will incorporate a simple fractal pattern that can interact with the fan to answer the need of representing one of its nature; fluidity. Fractal pattern is a good example to represent fluidity because the samples can be found anywhere in nature and people are familiar with it, regardless if they have heard about the term or not. The author will create a simple geometrical pattern that linger around the user. When the fan is swung, the geometrical patterns will flutter away, as if being swept by wind casted by the swinging of the folding fan. This will resemble the gesture of leaves or flower petals being swept away by the wind. Therefore, people will be familiar with this fluid gesture when using folding fan. This type of interaction will also leave the impression as if the action of user transcends within dimension, from the reality into the virtual, digital space.

3.1.3 Audio Background

When talking about sensory stimulation, it is difficult to miss out on auditory reception. Although this element is not the focus of this project, but it also has

an important role for this environment to work. However, there is a limitation to how the audio should be. It should not suggest or stimulate user's mind into reacting in certain ways. For example, audio with exceptionally fast or low beats should be refrained, as it would suggest people into moving too dynamically or statically. The key in choosing the best audio for ambiance support in this project is relaxing but inspiring tune and without vocal sound. The existence of the audio background must be able to stimulate one's mind without suggesting to behave in specific manners. As a result, three sets of song were chosen with the consideration that the three of them are similar in term of the ambiance and nuance it gives. The first song is *Aquarium* by Nosaj Thing. The second one is *Clouds in My Puddle* by Limalo, followed by *Boatfriend*, also by Limalo.

Chapter 4
Implementation

4.1 Folding Fan and Interactive Multimedia Environment

The implementation of the design concept will require a folding fan and a set of multimedia environment that is generative and responsive to users. This experimental setup was attained through several prior attempts with some trial and errors beforehand. The experimental setup will consist of indoor area with three divided areas; painting space, back projection mapping area, and operator space. The apparatuses used to conduct the experiment are Kinect for Windows version 2 and Sony VPL-HW15, integrated together with TouchDesigner Visual Processing Software. The implementation of the visual sets created by the software will also be explained one by one and how it serves the objective of the design concept. A section of design iteration prior to conducting this experimental setup will also be described on the last section as well as why those are ineffective to this project.

As shown on the pictures below 4.1, the first area consists of space where users paint, dance, and interact with the installation. A large white fabric was used as the medium to interact, or in other word, as a canvas. The fabric chosen was Polyester 68% and Triacetate 32%. The maximum amount of Polyester was used in order for the projection to reflect with the maximum quality of image. Polyester fabric does not reflect additional bright light as glossy fabric does, but it also does not dim the projected image as matte fabric does. However, as for a rear projection mapping technique, spandex fabric with cotton mix is very recommended for its adequate transparency. Unfortunately, at the time, there was a consideration in the financial aspect and the fabric stock that limited the material. Consequently, polyester was used as the best replacement to spandex fabric.

Referring to the illustration 4.2, the width size of the fabric canvas is 3.4 meters. This size covers the width area of the projection with a slight remain of

Figure 4.1: Experimental Setup Area 1; Painting Space

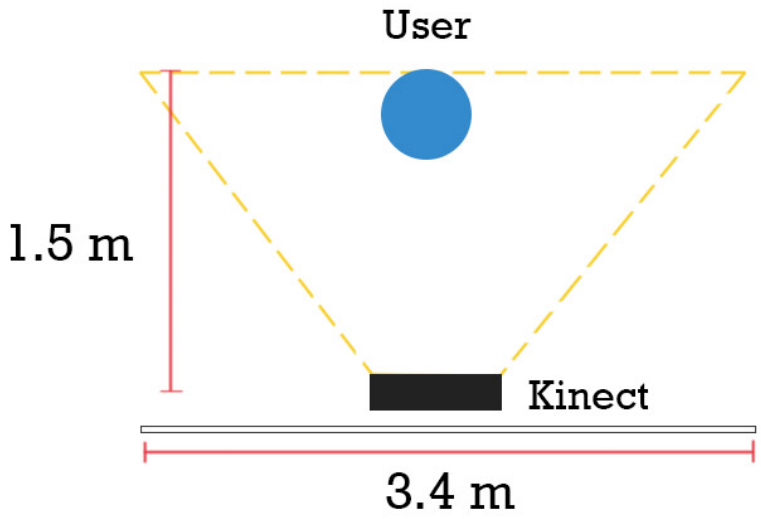

Figure 4.2: Painting Space Illustration

the left and right sides of the cloth unprojected. The distance from the Kinect motion tracker to the user will be 1.5 meters, which is the recommended distance to be able to interact with Kinect properly while freely moving to other directions.

Figure 4.3: Experimental Setup Area 2; Back Projection Mapping

The pictures above 4.3 show the area of the back projection mapping technique. This technique was selected instead of the regular front projection mapping to deliver the image projection without having the problem to be blocked by users in the painting space. As the illustration describes 4.4, the throw distance between the projector is 3.6 meters with the width area covered within that distance is approximately 3.4 meters. Initially, the projection mapping technique was expected to cover at least three sides of the canvas that surrounds the users; front, left, and right sides, to maximize the purpose of setting up a whole multimedia environment and to increase user's immersion. Unfortunately, that idea was not supported by the available facilities that the author could get since the idea would utilize one or two more projectors with the same quality and closest specifications.

The third area of the environmental setup consists of operation space 4.5. This area does not require a wide space as long as the operating PC or laptop may fit in the area. A table with sufficient size that can sustain the PC or laptop in control is recommended for convenience of operating the multimedia environment. During this project, the author used a PC to conduct and maintain the installation and a Macbook Pro laptop for audio control purpose and taking survey and feedbacks from users during the evaluation process. A JBL wireless

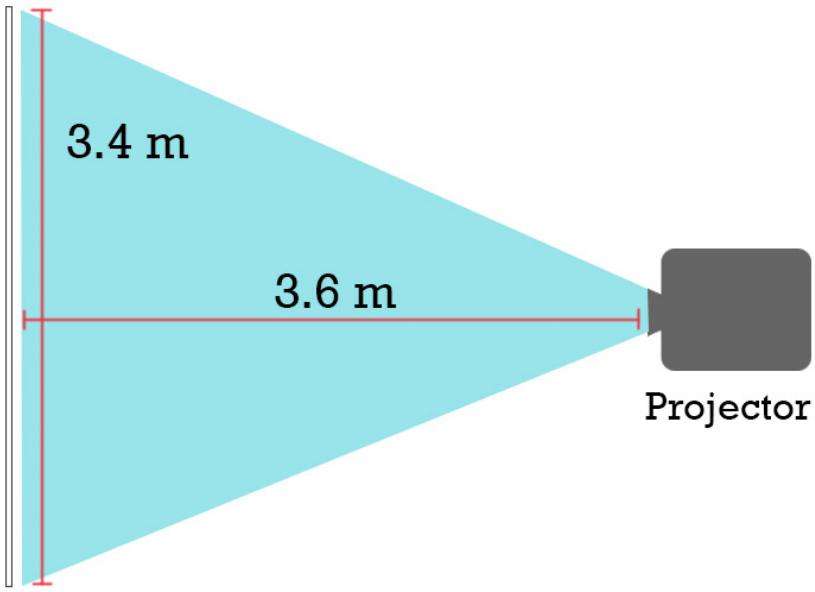

Figure 4.4: Back Projection Mapping Illustration

Figure 4.5: Experimental Setup Area 3; Operator Space

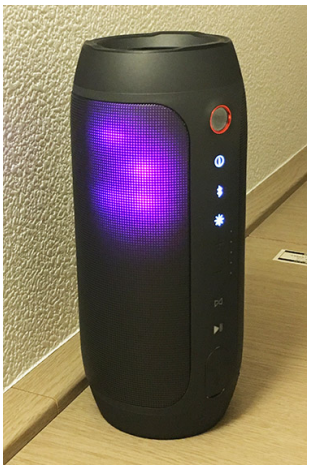

Figure 4.6: JBL Pulse 2

Table 4.1: JBL Pulse 2 Specifications

Specification	JBL Pulse 2
Signal-to-Noise-Ratio	>80dB
Frequency Response	85HZ - 20 kHz
Dimensions (H x W x D) in (mm)	84.2 x 194.4 x 84.2
Bluetooth Transmitter Frequency Range	2.402 -2.480GHz
Bluetooth Version	4.1
Weight (g)	775g

speaker with the model Pulse 2 was also used to provide audio background when the user used the installation 4.6. The table above shows the specification of the audio speaker which summarizes that this speaker has the best audio quality to deliver while also being portable and minimum in dimensions, and thus, the best choice for this project.

4.1.1 Method

This project was achieved by using Kinect for Windows v2 as the motion tracking sensor, combined with TouchDesigner as the software of visual processing. The motion data of the user which is captured by Kinect is sent into Touchdesigner Software and modified into generative visual compositions that can respond to users. The visual composition is eventually projected using a simple back projec-

tion mapping technique onto a wide piece of white fabric hung under a rigging system. The white fabric will act as a canvas that the users are given freedom to paint virtually with their movements.

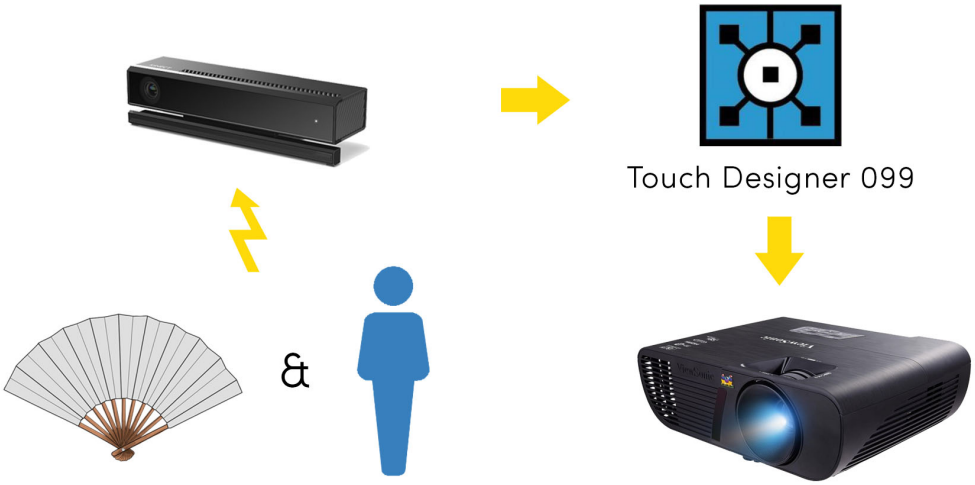

Figure 4.7: Technical Equipments

Kinect Motion Tracker

Firstly, in order to make the user and the installation interact with each other, a motion tracker is needed. There were a few technical options with available access at the time; Kinect and Optitrack. The author had tested and applied both of them into this project. While Optitrack is relatively new and advanced tracker, the author decided that Kinect is better suited for this project in term of feasibility and how it is more effective for public space situation. The experiment and result of using Optitrack will be covered in the next section. This section will highlight the utilization of Kinect Motion Tracker and how it supports the project.

Kinect is a renowned motion tracking sensor developed by Microsoft, originally introduced in November 2010 for broader gaming purpose. It is now a popular tool amongst many game or software developers and creative industries to create

Figure 4.8: Kinect for Windows v2

Table 4.2: Kinect for Windows Specifications Comparison

Specification	Version 1	Version 2
Depth Range	0.4 m - 4.0 m	0.4 m - 4.5 m
Color Stream	640 x 480	1920 x 1080
Depth Stream	320 x 240	512 x 424
Infrared Stream	None	512 x 424
Audio Stream	4-mic array	4-mic array
USB	2.0	3.0

motion-based applications, softwares, games, and installations. There were two options of Kinect for Windows available at the time, version 1 and version 2. After careful examination on the differences of the specification, the author decided to use the latest Kinect for Windows version 2 to get the motion tracking data. This version of Kinect is especially recommended compared to the older versions because of its enhanced technology. On the table shown above, the comparison of the specification will reveal a notable difference between version 1 and version 2 [9]. From the table, it is shown that the improvements include improvisation of the camera's field of view, immensely higher resolutions for the color camera, better depth camera, more joints and skeletons tracked, and 3.0 USB standard which allows faster connection. All of those mean that Kinect for Windows v2

will track more depth with higher resolution, wider coverage area, more motion capture data can be recorded, and faster response. Through all of these feature improvisations, the author believed that Kinect for Windows v2 will be sufficient to provide motion capture data for this project.

TouchDesigner Visual Processing

TouchDesigner is a visual processing platform made by Derirative which is equipped with various tools to create real-time projects that offer rich user experience. This developing software has a growing community and is commonly used to create interactive media systems, architectural projections, live music visuals, etc. With its simple interface and comprehensible features, this tool offers great convenience in rapid prototyping. Due to its easy and rapid prototyping feature, this software also gives the benefit of letting the user experiment with the content that results in various outputs. Furthermore, although it is a software to create an interactive system, it does not require a lot of coding, although basic knowledge of coding is recommended. That is to say, this software is user-friendly for people who have not learned in-depth programming beforehand.

Figure 4.9: TouchDesigner Interface

As explained in Chapter 3, the objectives of designing the visual are:

- to immerse user into the reactive, moving visual composition
- to let user maximize the exploration of their body movements

- to meet the expectation of user towards the folding fan

For this purpose, the author implemented three bases of visual using the software. Each of the visual was created individually than were later combined into one full composition.

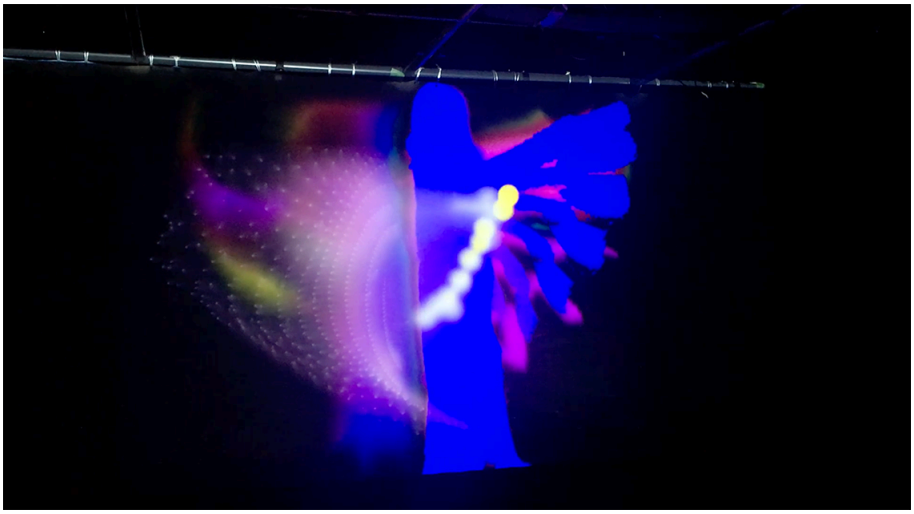

Figure 4.10: Visual Implementation 1; Motion Silhouette

The first set of code is to produce a colorful visual which is produced by the movement of the user. When the user moves their part of body, a colorful silhouette will appear after their movement, as if the motion of our bodies leave a bright, colorful trace. This visual is expected to encourage user to move around more and to further their exploration in body movement. The base color of the silhouette is blue and the color traces are colors ranging from primary colors (red, blue, green) to secondary colors (yellow, magenta, cyan).

The second visual code arranged is to make the folding fan work with the visual composition. This code serves the purpose of transforming the folding fan at the user's hand into a brush to virtually paint. By moving one's hand, it can cast a brush-like stroke as if we paint on the canvas with unlimited paint substance. This virtual stroke will fade away gradually within seconds to prevent the canvas being overcrowded with the strokes and leaving no space. By gradually fading away, the user is given freedom to move on from one artwork to another which lets them explore their creativity more. This visual supports the concept and objective of the project and also encourages the user to move with the folding fan and create things through the combination of hand and folding fan's movements.

Figure 4.11: Visual Implementation 2; Folding Fan Stroke

Figure 4.12: Visual Implementation 3; Particle Flow

The last visual set is the particle flowing around the user. It reacts by moving away when the user moves towards it. When the user swings the folding fan in the proximity of the particles, it will flow away, moving further from the user. The gesture of swinging folding fan appears as if the user produces wind with fanning movement, and that the particles flow away as if it is blown away by the wind created virtually by the user. This will make user more familiar with the expected movement of the fan generated into the visual composition. With this set of visual, it is expected to leave an impression to the user as if the wind created in reality by them transcends between dimensions and effecting the visual composition. This action of the particles is representational of that leaves fluttering or flower petals swaying away in the wind.

Projection Mapping

To setup a projection mapping installation, it is always better to pay attention to the quality and specifications of the projector that is going to be used. Some of the important terms in deciding if a projector is sufficient for a project are the brightness, resolution, throw distance, aspect ration, and image size. Since the experimental setup of this project is located indoor, the brightness of 1000 to 3000 lumens is adequate. Furthermore, this project also relies a lot with the quality of visuals because of the various contrasting colors and detailed particles it will produce, projector with high resolutions is preferable. Other consideration is the throw distance. This helps us plan better to determine the projector and object's surface setup location. For the setup purpose, the author tested two different projectors in advance to see which fit the setup requirement the best. The projectors are Sony BRAVIA VPL-HW15 and EPSON EMP-7950.

Table 4.3: Projectors comparison

Specification	Sony VPL-HW15	EPSON EMP-7950
Brightness (lumens)	1000	4000
Resolution (pixels)	1920x1080	1024x768
Aspect Ration	16:9	4:3
Throw Distance (m)	1.8 - 9.3	0.8 - 10.9
Image size (cm)	102-762	76.2-762

Seeing the table of comparison, there are several considerations that make each

of the projectors better than the other. Sony BRAVIA VPL-HW15 wins in terms of image resolution and aspect ration, which means the image projected will be able to appear wider with maximum quality of image. In the case of EPSON EMP-7950, its brightness notably exceeds Sony VPL-HW15. This means that the image projected will appear brighter and have more contrast, which is a great solution to projection mapping. However, the resolution and aspect ratio are particularly low and is not suitable for a medium to large sized installations. In theory, the Sony VPL-HW15 should be enough to conduct the experiment since the author was aiming for maximum potential of resolution and coverage area with a significant brightness. Nevertheless, the author decided to test both of them and came up with the result as shown in the pictures below.

Figure 4.13: Sony VPL-HW15 Projector Test

From the pictures, it is quite unusual that even though EPSON EMP7950 has way higher lumens than Sony VPL-HW15, the light projected still looks particularly dim. On the other side, the light coming out from Sony VPL-HW15 did wonder and significantly brighter than EPSON EMP7950. In term of area coverage, it is also obvious that Sony VPL-HW15 covered wider area as it has longer throw distance and wider aspect ration. The resolution and the strength of the colors are also better with this projector, resulting in contrasting colors and sharper images. While it looks peculiar that even though EPSON EMP7950 has three times the brightness but still produced dim and dull images, it is speculated that the projector's lens and lamp have aged, lowering its quality. For these find-

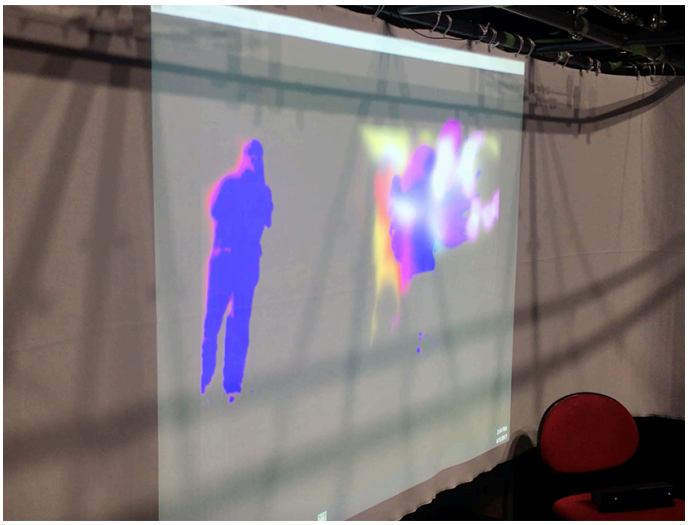

Figure 4.14: EPSON EMP7950 Projector Test

ings, it was decided that Sony VPL-HW15 would be the projector to sustain the projection mapping technique.

4.2 Design Iteration

Prior to establishing the current setup, the author attempted two technical methods in order to try to implement the concept into an environmental setup. These prototypes were eventually discontinued due to the ineffectiveness to the project. In this section, the methods and the reasons why it is ineffective will be discussed in hope that it may broaden the options and narrow down the consideration when choosing technical method in similar or future work.

4.2.1 Folding Fan Optitrack Prototype

For the initial step, the author decided to apply Optitrack sensors onto the folding fan as the motion tracking system. This method was expected to easily send the motion tracking data from the movement of the folding fan to the software as well as to produce more fluid visuals from the fan. The processing software of choice was VVVV.

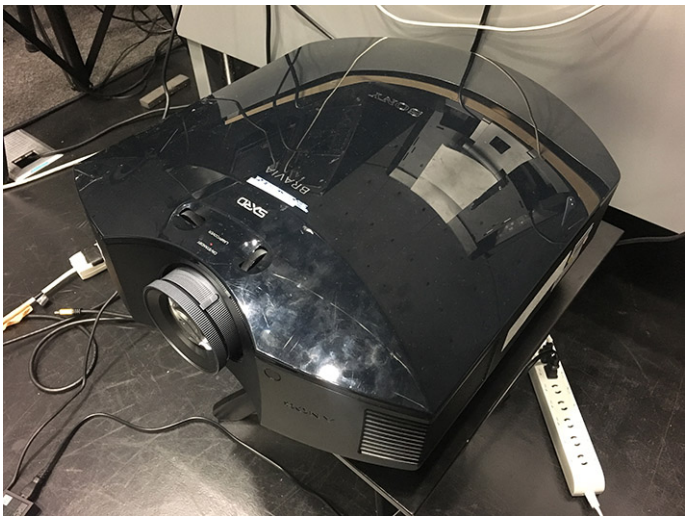

Figure 4.15: Sony BRAVIA VPL-HW15

Method

For the first prototype, six Optitrack Flex 3 were used as the camera trackers of the fan. At first, the author tried attaching Optitrack' s 6.4 mm Markers to the edge of the fan with the help of thin sticks to make the markers standing on the fan in stable and firm condition. With this method, the motion of the fan could be detected with the camera trackers steadily. Therefore, the author chose VVVV, a hybrid visual and text programming environment built for prototyping and development, as the software for the generative visual processing. VVVV is designed to facilitate the handling of large media environments with physical interfaces, real time motion graphics, and interactive audio-visual installations. For these reasons, the author considered that VVVV might be a good tool to help building the visual content in an interactive environment.

Result

This method required a careful arrangement and placements of the Optitrack trackers. The motion tracker also specifically needed a special wand for calibration purpose, which was not in possession of the author during that time. Furthermore, since the trackers are sensitive to movement, it may disturb the tracking of the markers. That is why the trackers need to be placed on higher and sturdier railings to keep the stability in check. Additionally, since the motion trackers completely

Figure 4.16: Folding Fan with Optitrack Motion Markers

Figure 4.17: Optitrack Prototype Setup

Figure 4.18: Testing Optitrack V120 Trio

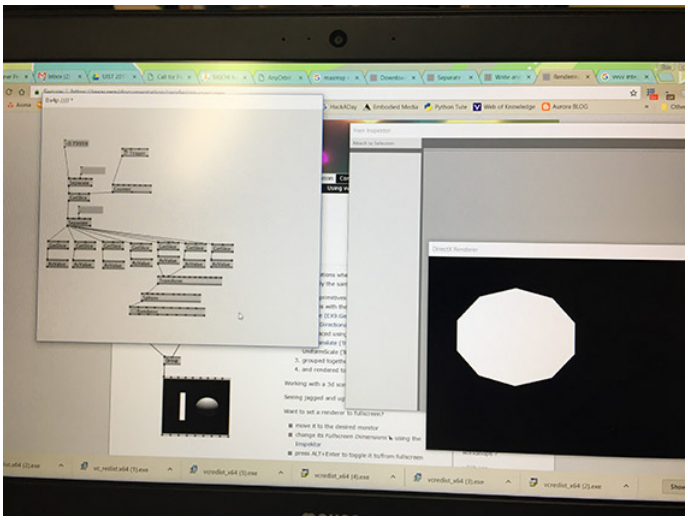

Figure 4.19: Getting Motion Tracking Data Using VVVV

rely on the visibility of the markers, once the markers are blocked by the gesture or body parts of user, it may not successfully track the markers, leading to the visuals not generated properly. Since this project especially expects the user to move dynamically, there would be a chance where the motion markers might be blocked by the movement or body parts of the user. For these reasons, the author decided that this sensor did not adequately suit the project.

As for the processing software, VVVV sufficiently translated the motion capture data from Optitrack Motive into a moving visual. However, VVVV required more experiments to modify and turn the visual into a growing and fluid visual that meets the author's expectation. As a result, this software is not very suitable for fast prototyping that can produce varieties of visual options.

4.2.2 Folding Fan OpenFrameworks Prototype

Seeing that the first prototyping did not result effectively, the author proceeded to test different method by using Kinect for Windows v2, a sensor developed by Microsoft to build interactive software and environment. Along with it, the software used to generate the interactive visuals was an open source C++ toolkit built for creative coding, called openFrameworks.

Method

Since Kinect is a tool that is used by many developers and there have been many examples of work produced by this sensor, along with openFrameworks which is a toolkit favored by many creative industries, this method was expected to be working more effectively with many options in building the prototype since it has numerous resources that the author can study over the internet. The method is by building a mock-up visual production application that would later connect with Kinect motion tracker and interact with users. By building a simple application with openFrameworks, this method was expected to give more freedom in experimenting with the production of the visual. The application building could be achieved by learning various codes from outsources on the internet.

Result

After several attempts of using the combination of Kinect and openFrameworks, the author found that this method might take longer time to complete. Since openFrameworks is based on C++ programming language, it is not the best tool

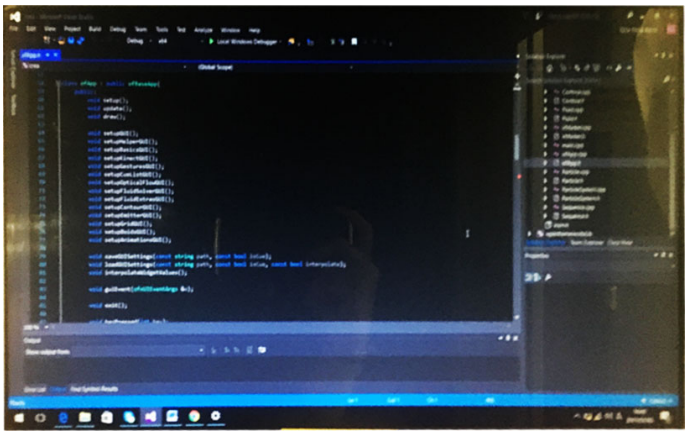

Figure 4.20: OpenFrameworks Prototype

to do rapid prototyping and needs time to do modifications to see the improved results. Furthermore, the codes have weakness in its practicality. It is complex in the maintenance and will take longer time to fix when there is bug or error, making it not very practical to execute on large scale, public event that is single-handedly operated. Additionally, since the author tried combining several resources collected from a number of related sites, not all resources may work properly with the hardware used at the moment. OpenFrameworks has many updates and, most of the time, the resources depend completely on the version of the software it used at the time it was built. Due to these reasons, the author decided to change the visual processing method into another software. Despite that, the author decided to keep the Kinect for Windows v2 as the motion tracking system since it served the purpose well with the objective of the experiment.

Chapter 5
Evaluation

In order to evaluate this project's design and impact to the users, qualitative data are measured. Surveys are used as one of the measures of collecting qualitative data. Other qualitative measure include a brief interview with the users to to get inputs and feedbacks. This section also explains the technical evaluation by analyzing and reviewing the outcome of the setup.

5.1 Method of Evaluation

The result of this project will be reached by analyzing and comparing the emotional effect and quality of the audiences with setup using folding fans and without using folding fan. Quantitative data is used as a way to compare the emotional impact that users have before and after trying out the installation, as well as using folding fan as a method to paint and without using the folding fan to paint. The motion data will result in the visual works the users produce individually. By analyzing the visual works along with measuring the qualitative data from the surveys taken by the users and holding a brief interview and review session, the project can be concluded. For this reason, two types of user test will be conducted; virtual painting using bare hands and using folding fans.

As the first step, the author had prepared an initial survey for the user to take before beginning the experiment. The initial survey consists of general questions such as self identity and the level of interest in trying out interactive multimedia installation that requires body movement that can be found in public space. This question was created to measure the level of interest in participating in an interactive installation of people around 25-33 years old. By collecting this data, the author will reach deeper understanding in the enthusiasm of participating in similar projects for the upcoming fashion exhibition mentioned in the Chapter 1.

Aside from the initial survey that gathers user's general identity, two kinds of

notable surveys are used here as the quantitative data collection method; PANAS-SF (Positive and Negative Affect Schedule) survey and NASA TLX (Task Load Index) survey. Positive and Negative Affect Schedule or PANAS-SF (Watson, Clark, and Tellegen, 1988) is a commonly used survey to measure emotionally positive and negative impact. The researchers came up with this method of evaluation by narrowing down a long list of emotions and tested it through multiple rounds of eliminations and analyzes. They chose the terms that have strong correlation of each of it but do not show much correlation to each other. Each positive and negative list of emotion has 10 terms, making it 20 questions in total, as shown as on the table below.

Table 5.1: Positive and Negative Affect Schedule PANAS-SF

Positive	Negative
Attentive	Hostile
Active	Irritable
Alert	Ashamed
Excited	Guilty
Enthusiastic	Distressed
Determined	Upset
Inspired	Scared
Proud	Afraid
Interested	Jittery
Strong	Nervous

NASA Task Load Index (TLX), on the other hand, is a survey developed by NASA's Human Performance Research Group. This method had been developed over three-year cycle that included around 40 laboratory simulations. [5] This survey measures the workload in term of mental and physical of a person in doing an experiment. NASA TLX is commonly used in many human factors researches and especially has been applied in variety of domains, such as aviation, healthcare, and other socio-technical domains. [2] It is divided into six scales.

- **Mental Demand**

  How much mental demand was required? Was the task easy or demanding?

- **Physical Demand**

  How much physical demand was required? Was the task easy or tiring?

- **Temporal Demand**

  How much time pressure did you feel while doing the task? Was the pace slow or fast?

- **Overall Performance**

  How successful were you in performing? How satisfied are you with your performance?

- **Frustation Level**

  How stressed were you while doing the task? Was the task relaxing or stressful?

- **Effort**

  How much effort (physically and mentally) did you put in order to achieve your performance?

The combination of the surveys will be used in every user in its own order. The order of the survey will consist of initial survey and PANAS-SF survey as the starting point before doing the experiment to gather data about how the user feels emotionally at the moment. Thus, the user is allowed to interact freely with the installation for around two to three minutes with a background music to support the ambiance and trigger user to explore their gesture and movement. Once it finishes, the user will be given a break for about one minute before completing another set of survey. The next survey they need to fill out is another PANAS-SF survey, followed with NASA-TLX survey. This serves the purpose of measuring the change of their emotional experience and to see how the workload of using the fan or bare hands has affected them.

On the last survey, one question that asks what the users reflect their performance with was added to gain an understanding of what usually motivate people to perform in interactive installation that requires free body movement. This particular question was based on a research conducted by Jodi Forlizzi, Carl DiSalvo, and Bruce Hanington called On the Relationship Between Emotion, Experience and the Design of New Products (2003). In this research, a set of similarly constructed question was asked to research's participants in order to understand people's attachment towards products. Participants were asked what kind of feelings and memories that triggered them when trying the products. This understanding will be useful when planning and designing new products. With the same

model, the author simplified the question into the sample below. By asking this question, the result is expected to contribute on how the author can improve the user's needs in future work or similar project.

During your performance, what did you link it with?

- Past memories
- Self-reflection
- Body movement exploration
- Area/space exploration
- Other

As the scheme below shows 5.1, User will be divided into two categories. The first category is user who uses folding fan as the medium of performing or virtual painting, while the second one is the opposite, which is user who does not use folding fan as a way to perform or paint. Though two categories are determined, the order of the surveys stays the same. However, since the one of the purposes of the evaluation is to measure and compare the data of user with folding fan and without folding fan, a user must undergo both experiments. In order to prevent a biased or planned answer, each experiment is given two-week interval break. User from the first category must take the second category experiment the next two weeks. Same with the user from second category, they must take the first category experiment in the upcoming two weeks. This 'break' is provided to minimize the bias that the users will have after doing their first experiment. This bias may effect their behavior in doing the second experiment. It means that after doing the first experiment and filling out the survey, they will likely get the idea of the objective of this experiment. As a result, they might suggest themselves into behaving in a way convenient for the experiment's objective, or even the opposite direction. Therefore, the fairly long time of break is given to let them 'forget' how their performance and emotional result were.

5.2 User Studies

The target user for this experiment will vary from 25 to 33 years old who are either working or studying in creative-related fields since they are expected to be familiar with visual-based environment and interactive technology. Through

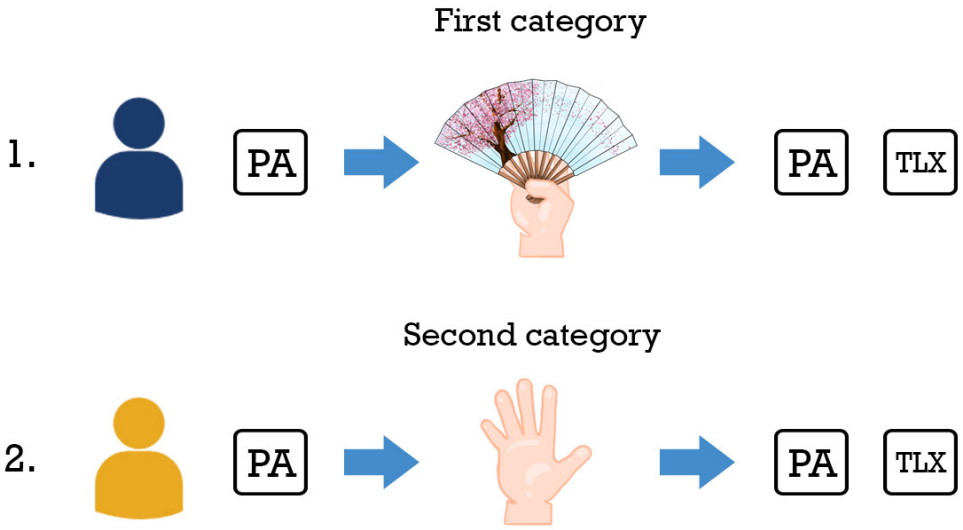

Figure 5.1: Evaluation Method Scheme

this scope of user too that this project's creativity exploration objective may be concluded. The users are selected based on their specific occupations in hope that they can represent other potential users.

According to the evaluation method, each user must undergo two sets of experiment. The first set of experiment took place on 13th and 15th of June 2017. The 13th of June was specially reserved for VINT-AGE collaborators to participate. The 15th of June was for people outside of VINT-AGE, which are students of Keio University Graduate School of Media Design and Keio University School of Design and Management with various academic backgrounds. The second set of experiment will be conducted on 3rd and 4th of July 2017 to give them two-week 'break' in between. All of the experiments are set on the same place, which is Media Studio of Keio Media Design, 3rd floor of Collaboration Complex, Hiyoshi, Kanagawa.

5.2.1 Pre-Test User Study

An initial user study was conducted in order to gather inputs and deepen the understanding of what users expect from the folding fan and the multimedia

installation. As this pre-test is an application of the final prototype, the objectives are to simulate the experimental plan and apply it into a real environmental setup, and also to get opinions from the users about possible improvements. The test was conducted on Monday, 5th of June 2017, with six participants, with occupations ranging from university students, fashion designer, public relation manager, and video director. Their ages ranged from 25 to 33 years old.

Figure 5.2: Initial Environmental Setup

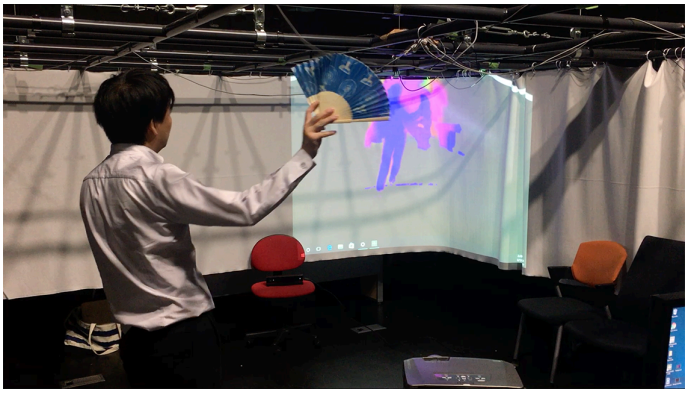

Figure 5.3: Pre Test User Study with VINT-AGE

5.2.2 Primary User Study

Primary user study is the main experiment and the implementation of the whole project. That means, the final output and execution of the design process should be performed. The objective is getting the qualitative data using the method of evaluation. In getting the data, a scope of users should be chosen. Below are the considerations in choosing the sample of users.

- Age ranging from 25 - 33 years old
- Working or studying in creativity-related field
- Have enough exposure on visual-based environment
- Familiar with interactive technology

The users selected will range from 25 to 33 years old, with occupation ranging from fashion designer, videographer, and university students who have studied about creative fields or have learned about creative-thinking or ideation. All of them are familiar with interactive technology as they are able to operate simple gadgets. These types of user samples were chosen in expectation that the result can represent other potential users too. The participants here are university students from Keio University Graduate School of Media Design and Keio University School of Design and Management, and also guests from this project's collaborator company, VINT-AGE.

Originally, around 18 people tried the experiment. However, only six people were qualified to sample their data because the six people underwent both experiments, from start to finish. The rest of 12 people did not go to their second experiment, mostly because of not being able to present themselves on the scheduled day due to their works or traveling.

5.3 Result

In this section, every result from the pre-test user study to primary user study will be discussed. At the last section, an evaluation for the technical setup will also be discussed.

Figure 5.4: Folding Fan User Study Experiment 1

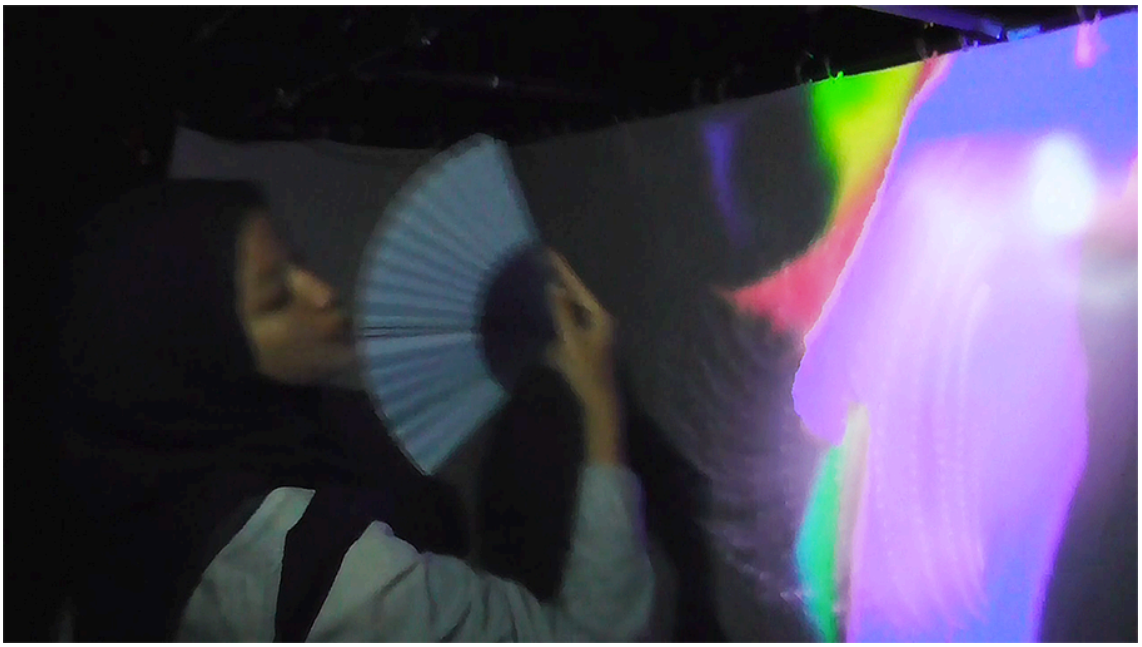

Figure 5.5: Folding Fan User Study Experiment 2

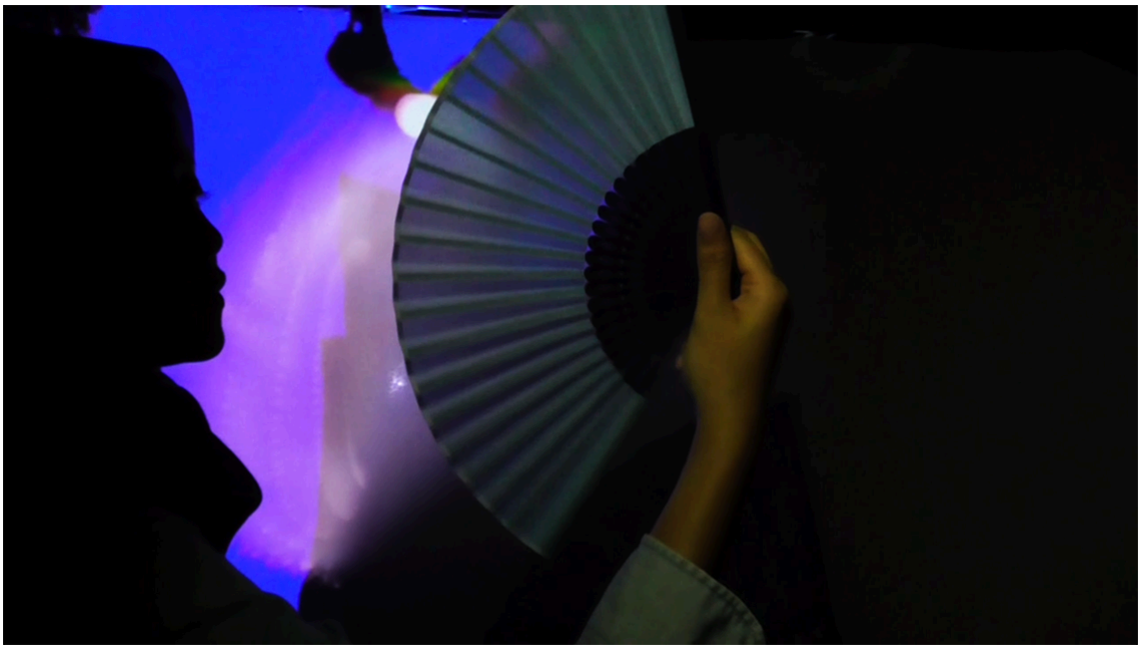

Figure 5.6: Folding Fan User Study Experiment 3

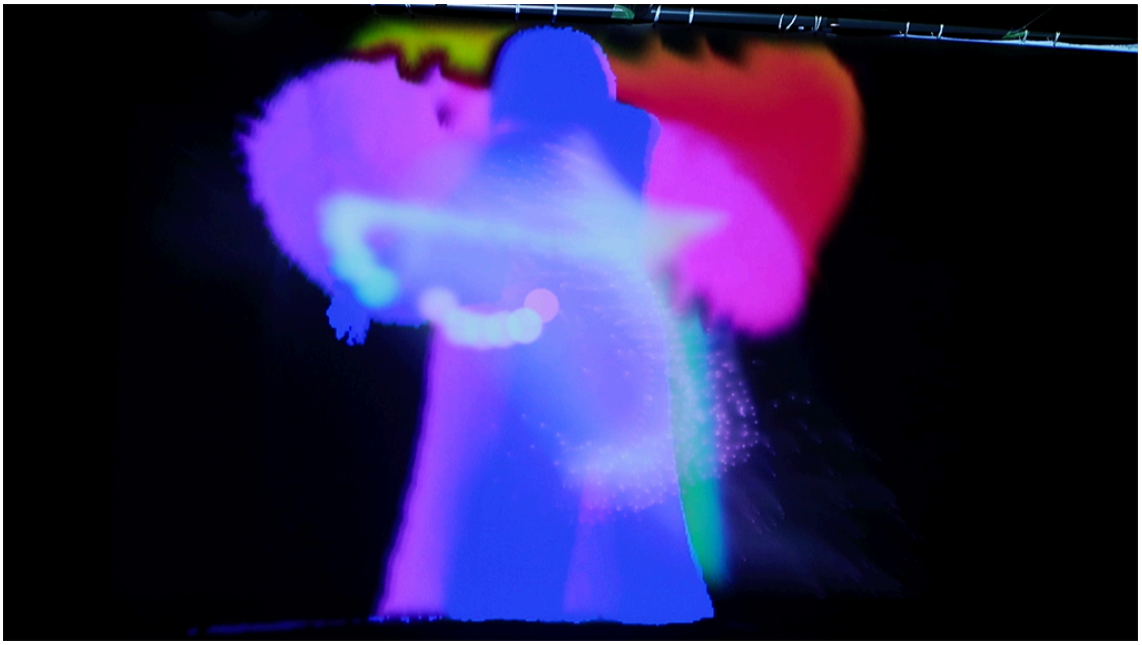

Figure 5.7: Folding Fan User Study Experiment 4

Figure 5.8: Folding Fan User Study Experiment 5

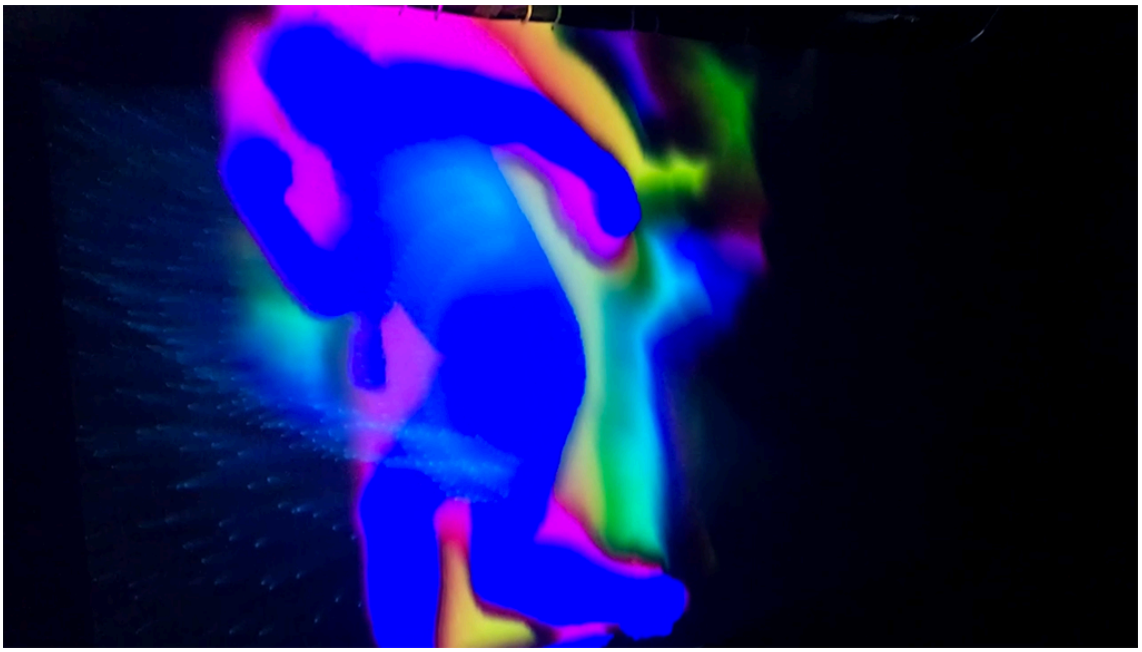

Figure 5.9: User Study Experiment - Without Folding Fan 1

Figure 5.10: User Study Experiment - Without Folding Fan 2

5.3.1 Pre-Test User Study Evaluation

Since the objective of the pre-test user study is to gather qualitative data, which is opinions from the perspective of the users, only qualitative data gathered from discussion with the participants was measured during this period. The method used in this test was a five to ten minutes of testing the installation each person and then proceeded into the discussion of potential improvisations.

Because most of the participants were VINT-AGE company collaborators, and all of them have been working in creative industries for a long time, most of the feedbacks gathered were about ways to improvise in term of the visual and the engagement between the visual and the folding fan and its gesture. Based on the discussion with invited guests from VINT-AGE company, it is recommended to incorporate different visual reactions from different ways that the folding fan is opened. During the discussion session, they had introduced the author to variation of holding folding fan during a dance performance. The three gestures as pictures shown below, might be an interesting key in Japanese cultural aspect and that it would be better to be utilized, as most of the visitors of the exhibition will be Japanese people and, more or less, they have the understanding in that culture.

Another feedback we discussed was that the incorporation of properties as decoration that is might be able to enhance the emotional stimulation more. For example, flowers or clouds properties as an element of decoration.

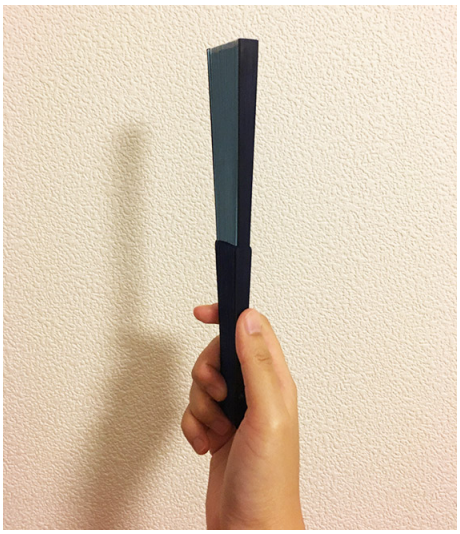

Figure 5.11: Holding Fan Gesture 1 - Close

5.3.2 Primary User Study Evaluation

Based on the method of evaluation, two sets of experiment are conducted. The first set of experiment took place on 13th of June 2017, where it was especially reserved for VINT-AGE collaborators to participate, and 15th of June 2017, for people outside the VINT-AGE company, which are students from Keio University Graduate School of Media Design and Keio University School of Design and Management. Each of the students have various academic backgrounds. The second set of experiment will take place on 3rd and 4th of July 2017 in order to give them a two-week interval 'break' to prevent biased or planned answers.

As explained on the Method of Evaluation, two kinds of survey will be used as a way to measure and compare the effect between performing with folding fan and without folding fan; PANAS-SF Survey and NASA TLX Survey. Each user will be required to fill PANAS-SF Survey twice of each experiment, before performing and after performing to record their emotional condition at the time. On the other hand, NASA TLX Survey will be filled after performing to record the load demand of the experiment. After that, each PANAS-SF Survey result

Figure 5.12: Holding Fan Gesture 2 - Mid-Open

Figure 5.13: Holding Fan Gesture 3 - Open

will be compared to each other of the same user by assigning a number of 1 to 5 of each answer. There will be two categories of result, positive and negative (refer to Table 5.2). Each category will be divided into sub-categories, Without Fan and With Fan. By subtracting the With Fan data with Without Fan data of each of the positive or negative category, a Change data is achieved. After the data from all users are counted, the total and average of the Change data can be summarized. Eventually, by subtracting the positive change with the negative change, the summarized point can be found.

Table 5.2: PANAS-SF Survey Data Evaluation

	+		-		Change		
	Without Fan	With Fan	Without Fan	With Fan	+	-	
User 1	280	300	120	110	20	-10	
User 2	240	330	150	170	90	20	
User 3	390	380	100	100	-10	0	
User 4	370	330	100	100	-40	0	
User 5	380	320	100	140	-60	40	
User 6	210	270	220	200	60	-20	
Total					60	30	30
Average					10	5	5

Seeing the set of data above on Table 5.2, a summarized point of positive 5 can be concluded. This point means that there is a rise in emotional quality of users when performing with folding fan.

The second set of survey that will be evaluated is NASA-TLX Survey. This survey was conducted in order to comprehend how much task load demand the users feel when performing with folding fan, and compare it to when they perform without the folding fan. Since the calculation of NASA-TLX Survey is quite complicated and required further study, the author tried to evaluate the data using an application created by NASA solely with the purpose of conducting NASA TLX Survey called 'NASA TLX'. The application provides quick calculation with data management and simple interface. Below are some of the screenshots of the application.

Firstly, the application lets us to identify the experiment with a experiment's

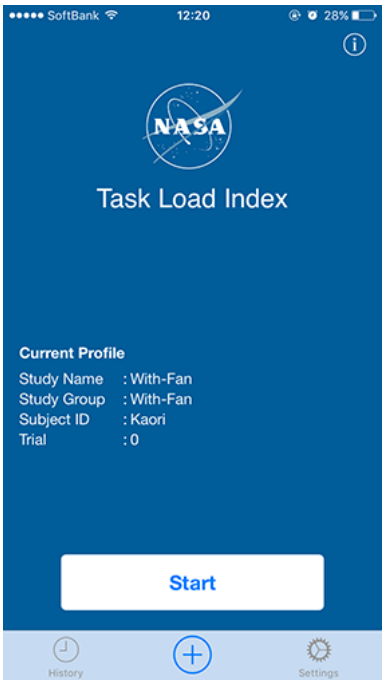

Figure 5.14: NASA TLX Application Interface 1

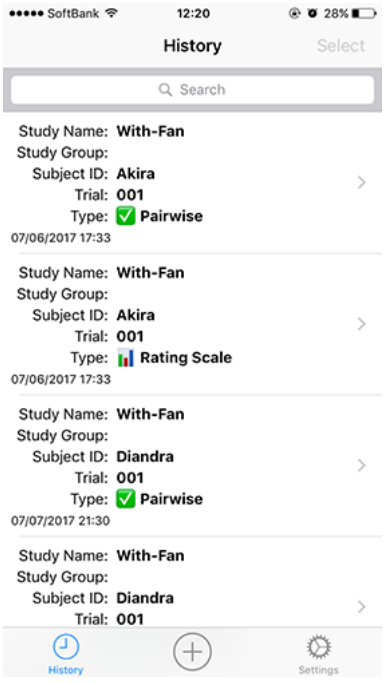

Figure 5.15: NASA TLX Application Interface 2

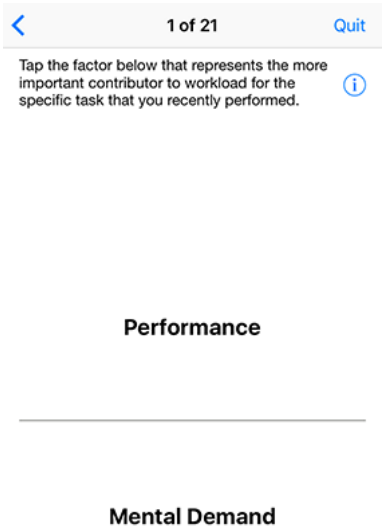

Figure 5.16: NASA TLX Application Interface 3

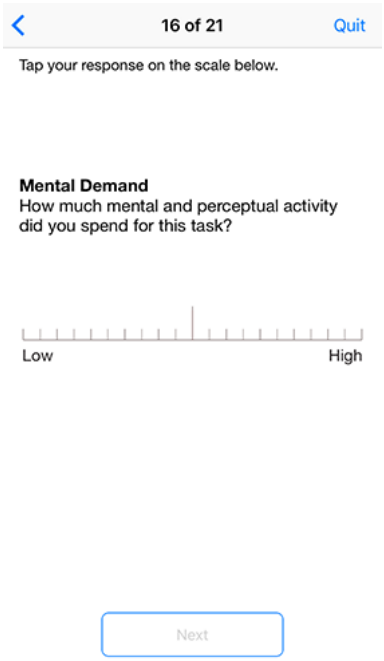

Figure 5.17: NASA TLX Application Interface 4

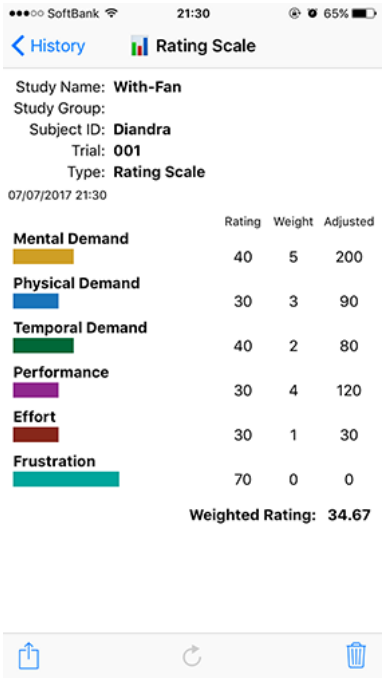

Figure 5.18: NASA TLX Application Interface 5

name, category, and participant's name for organization purpose. Secondly, we will be asked to rate our own experiment in term of the importance between each of the task load. This serves the purpose to let the application rate which task load holds priority in the experiment. Thus, we begin to input the data precisely as the data we have collected from the participants' survey. Lastly, the application will measure and calculate the data and summarize the weighted ratings for us as shown as Figure 5.18. From this summarized weighted ratings, the author gathered the results and measured in a separate table as shows below (refer to Table 5.3).

By subtracting the weighted ratings on With Fan column into the Without Fan column, the Change data can be achieved. However, contrary to PANAS-SF Survey, the positive point here means that more task load was required for the user when performing using the embodiment of folding fan. On the other hand, minus point means less task load for the user during their performance with folding fan. By averaging the overall result, a positive point of 9.16 was reached. This summarized that there is an increase of task load by 9.16 points whenever the user uses folding fan as a medium to perform. This means that

Table 5.3: NASA TLX Survey Data Evaluation

	Without Fan	With Fan	Change
User 1	8.67	11.63	2.96
User 2	34.67	33.33	-1.34
User 3	18.67	34.67	16
User 4	8.67	2.67	-6
User 5	6.67	47.33	40.66
User 6	18.67	21.33	2.66
Average	16	25.16	9.16

people feel more mental, physical, and temporal demand when performing with folding fan, compared to without using folding fan.

5.3.3 Other Findings

When analyzing the recorded documentation of each of the user, the author noticed that users that perform with folding fan had more dynamic movements compared to when they did not use folding fan. When performing with folding fan, the range of movement was notably wider. This means that they focused on the folding fan and how it can alter their movements too. Meanwhile, when there were not holding folding fan, they tended to have more static movements and only focused on the visual. From the pictures shown below, the same user with different experiments are shown. It can be concluded that the user's range of movement and gesture are different.

Another interesting finding discovered by analyzing the PANAS-SF Survey is that the most contrasting change of emotion people felt before doing the experiment until after doing the experiment is that the change of interest and excitement were significantly high. However, after experimenting with the installation, notable point decreases of alertness and attentiveness were also seen. This means that the overall installation especially effected their interest and excitement in positive way, but, on the other hand, lowered their attentiveness and alertness at the same time. An estimated cause of this decrease of those two points was that because of the exposure of abstract and contrasting visual in a dark area that tended to make them less focused on the surrounding.

Other finding that came from the user's feedback was that many participants

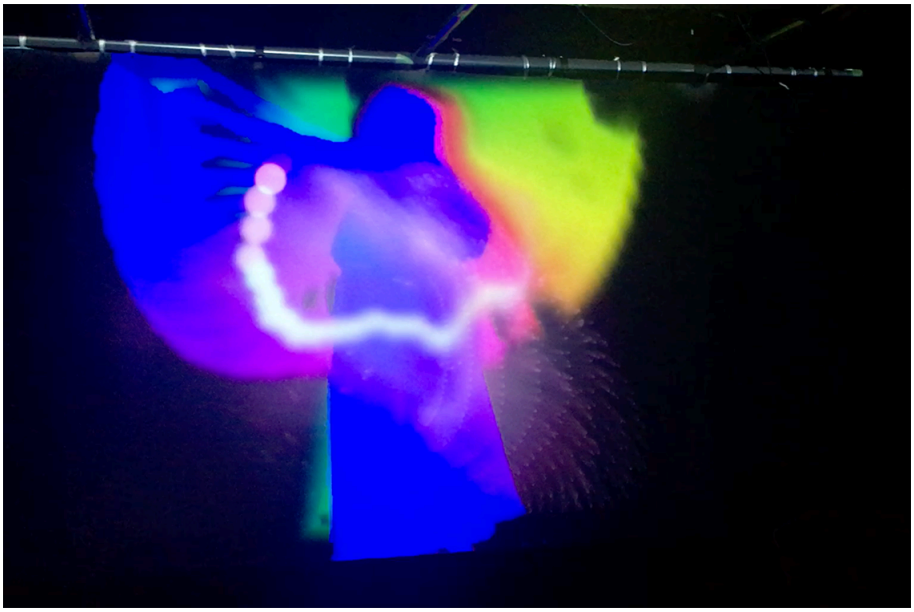

Figure 5.19: Movement Comparison - With Folding Fan

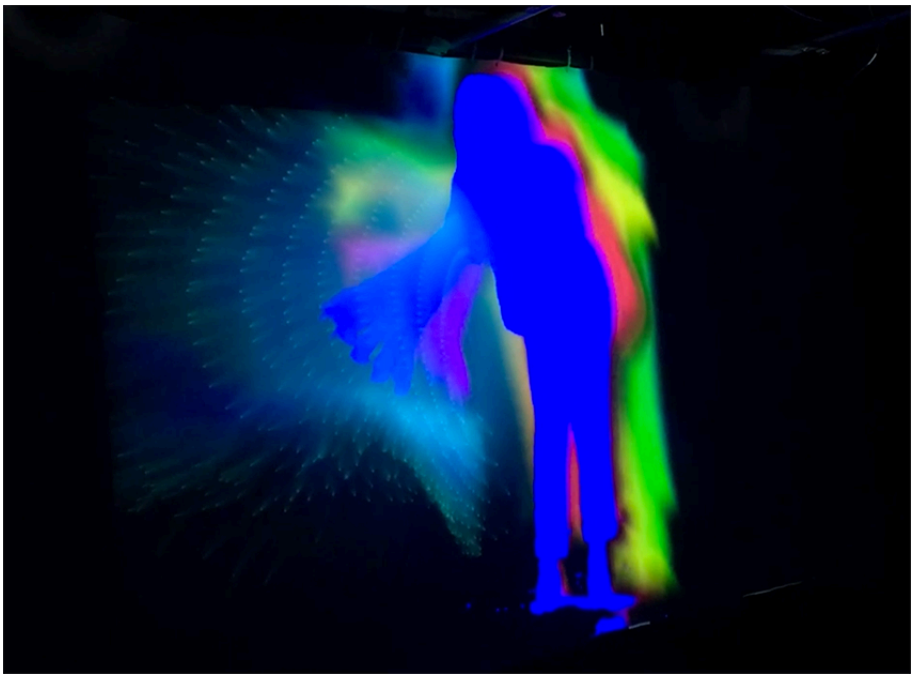

Figure 5.20: Movement Comparison - Without Folding Fan

felt more refreshed after experimenting with the installation. Mostly it was because they tried the experiment after a long class and tiring meeting. The exposure to the abstract visual along with the demand to move their body around and dance to the music somehow affected their energy in a positive way.

Other finding includes that in painting situation, Japanese people tend to make literal shapes when they are instructed to draw, even virtually. After some discussion with some Japanese users, it seems that this behavior resulted from how they were taught since kids. Japanese have strong senses of relation with shapes, seeing that even the Kanji words they use everyday originated from different kinds of shapes that more or less resemble the meaning of the words. They, too, were usually taught to picture things with literal objects. For example, since they were children, they were instructed to draw things like mountain, sun, or animals as how it is.

5.3.4 Technical Evaluation

A notable feedback coming from the users is how the painting space is too narrowed and limited user's movements. This problem resulted in not much freedom in user's mobility. The cause for this narrowed space is that to optimize the image quality of the projection, the projector needed more space in the environment compared to the painting space. The projector needed to be in the right distance to be able to maximize its throw distance while maintaining the quality of the image. Nevertheless, Sony VPL-HW15 delivered satisfying quality of image and that this specification or more is recommended to conduct similar project.

Additionally, another cause of the narrowed space was that Kinect Motion Tracker needed approximately a minimum of one meter distance from the user to track properly. This consumed more space for the painting space. As a result, the users had limited movement on the front-back direction, but normal range of movement on the right-left direction. On the other aspects, Kinect successfully did a good job in fast tracking the motion of users and delivering the motion data into the software. There did not seem to be a significant delay from the tracker. From this evaluation, it is supposed that Kinect will be suitable for future work in implementing this project into public event or for similar projects.

Chapter 6
Conclusion

Seeing the concluded data evaluated on the previous chapter, there is a slight improvement of the user's emotional quality when performing with folding fan in their possession. Also, by analyzing each of the recorded documentation video, there is a notable finding that users with folding fan have wider range of movement and more dynamic gesture, compared to when they did not hold the folding fan. From these facts, we can take a conclusion that the usage of folding fan might give them 'perspective' to explore their gesture more, resulting in the increase of emotional quality. However, the usage of folding fan also increased their mental and physical demand, since they had an object in their hands and they felt the responsibility to utilize the object for the experiment.

A lot of users also found the installation to be refreshing after as they tried it after doing some works. The installation altered their state of feeling pressured by work, classes, and meetings. The combination of the interactive visual, folding fan that triggered them to move more, and the relaxing audio. Some respondents also said that they expected more of the interaction between the visuals and how the fan is opened and held.

6.1 Limitations

From the evaluation discussed, it is implied that the technical setup gave limitations to the movement the users could make. The back projection mapping technique might have narrowed down the movement area of user since it took up quite more space than the rest of the area. This resulted in not much mobility freedom for the users to explore their movement. Another limitation which is found from conducting the user test was that users that have different cultural background from those that are familiar with folding fan in their culture may have limited gesture in exploring movement with folding fan. For example, in

Japanese culture, especially its traditional fan dance performance, there are three well-known steps in opening folding fan. Generally, Japanese people are familiar with this because the culture has been implanted since they were small. However, people from outside of Japan, especially those without folding fan influence in their culture, might only know several gestures that are widely-known, such as fanning or swinging.

6.2 Future Work

6.2.1 Improvement

A discussion about the potential improvements for this project pointed at how this installation can be enhanced in term of engagement between the visual and the users more. By gradually intensifying the visual elements through how dynamic the users' movements are, it is expected to improve user's engagement towards the installation more. The curiosity of the users to explore the growing visuals will let them exhibit their gesture to their potential. In term of visual improvement, as from the pre-test user study experiment mentioned, more visual reaction that responds with how the folding fan is opened and swung might become another strong point of this installation. Another possible improvement is from the technical side. Since the use of back projection mapping technique took up much space and as a result, narrowed down the performance area, it limited user's movement. There is a better idea to change the projection mapping method into other technical setup that does not take up a lot of space. An idea that has been planned is by replacing it with an LCD screen. This way, it may result in better and sharper visual, and a projection distance is not required. However, since LCD screen costs way more budget than projector, the space of the canvas might be limited and the idea will stick into a one-side canvas. Other suggested improvement is to search for another body extension and compare the effectiveness with folding fan. This other body extension should have its own unique trait and fluidity, with the same objective as folding fan in this project, which is an object that may alter the perspective of user towards the space around them and their gesture. Another suggestion of improvement is by proposing this idea to fan dance performers as they might welcome to this experimental multimedia performance. Also, they are more expertized in term of handling folding fans so there is a high change that they might offer many constructing inputs.

6.2.2 BeVintAge Fashion Show and Exhibition

As this project will be implemented on BeVintAge Fashion Show on 18th to 19th November 2017, this installation does not stop here. In fact, it is still ongoing by considering the inputs gained for improvement purpose. Since this project will be implemented into a public event situation, it is wise to consider more about the technical limitations to assure that things will work as how it is expected and to minimize the flaws found in this experiment. Furthermore, since most of the visitors are expected to be Japanese people, it would be good to match their expectations towards folding fans and the visual by creating more interaction and surprise elements regarding the combination of both. For instance, a special visual element appears when the folding fan is held in certain gesture. A finding discussed in the previous chapter where it mentioned that Japanese people have the tendencies to draw literal shapes when instructed also comes to this project's benefit, as this might be an installation that they will be more familiar with and that they are expected to gain quick understanding of what they have to do once faced with the installation. For the exhibition purpose, the author will hold more discussion session and attempt another test for improvement purpose.

Figure 6.1: VINT-AGE Poster

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Appendix

A Surveys

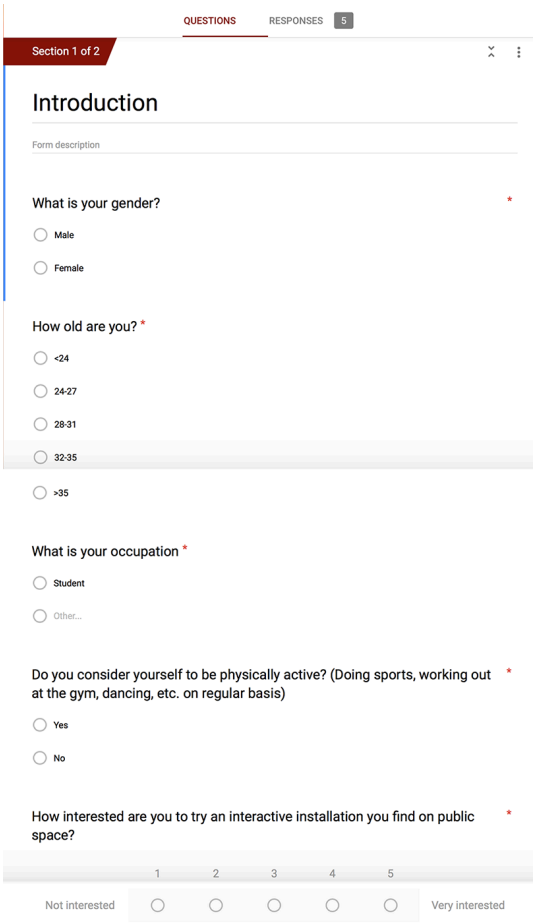
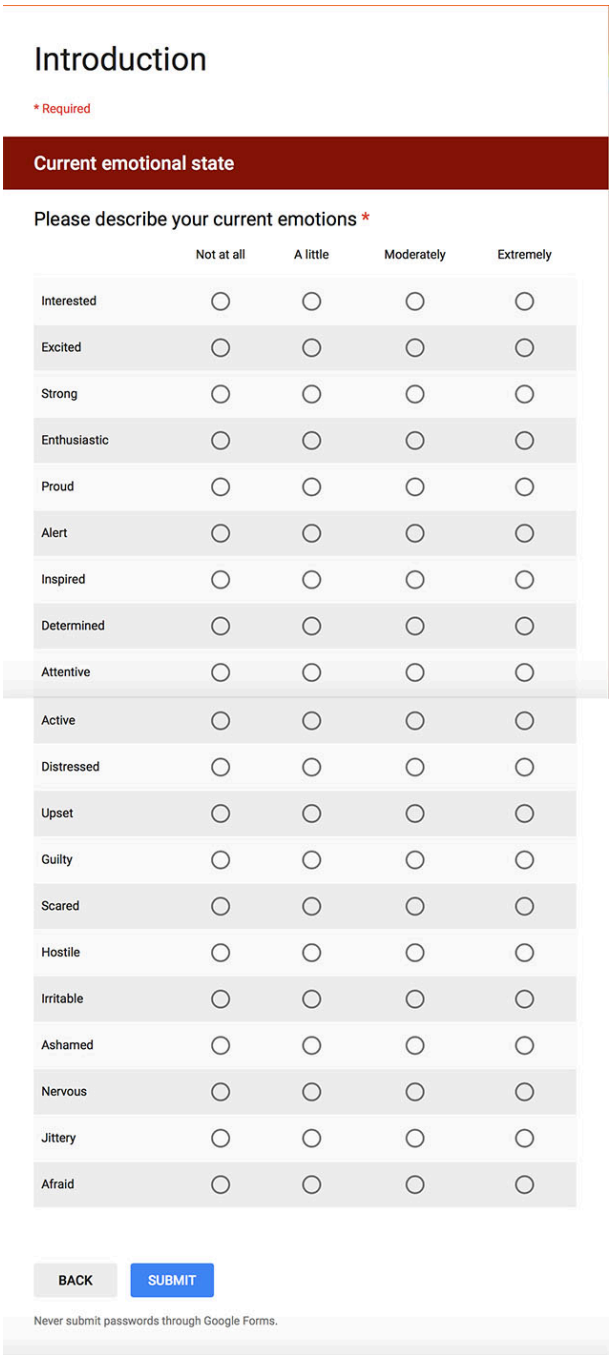


Figure A.1: Initial Survey



Introduction

* Required

Current emotional state

Please describe your current emotions *

	Not at all	A little	Moderately	Extremely
Interested	○	○	○	○
Excited	○	○	○	○
Strong	○	○	○	○
Enthusiastic	○	○	○	○
Proud	○	○	○	○
Alert	○	○	○	○
Inspired	○	○	○	○
Determined	○	○	○	○
Attentive	○	○	○	○
Active	○	○	○	○
Distressed	○	○	○	○
Upset	○	○	○	○
Guilty	○	○	○	○
Scared	○	○	○	○
Hostile	○	○	○	○
Irritable	○	○	○	○
Ashamed	○	○	○	○
Nervous	○	○	○	○
Jittery	○	○	○	○
Afraid	○	○	○	○

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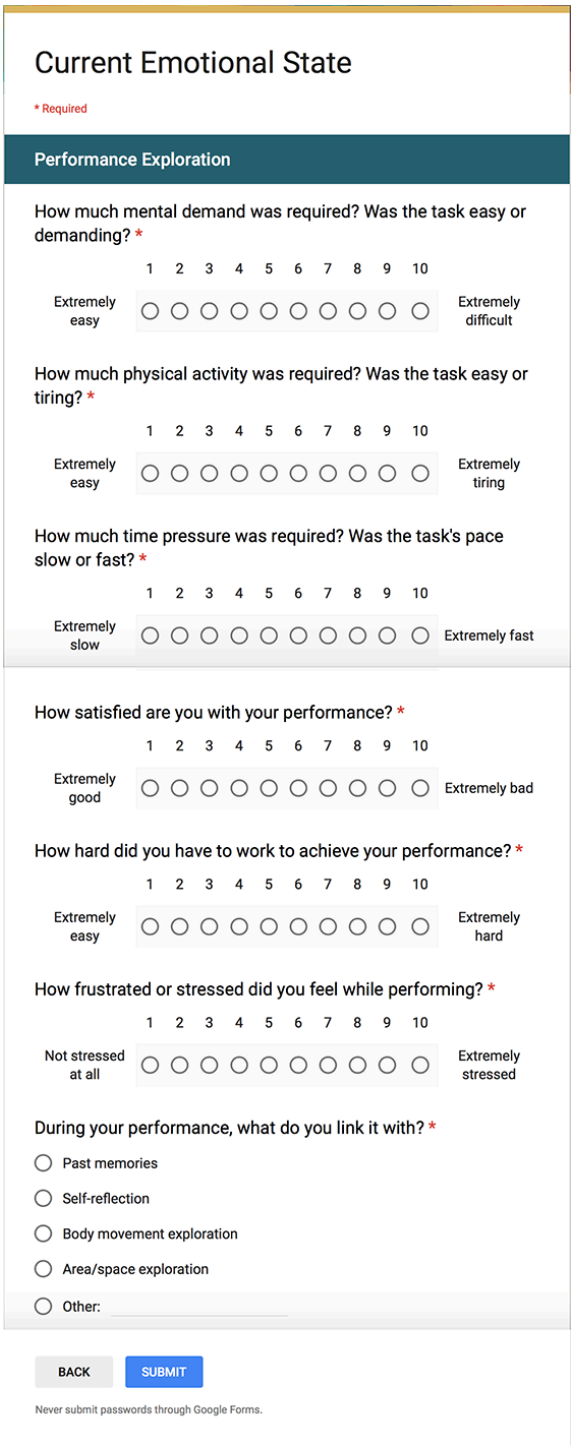
Figure A.2: PANAS Survey



Current Emotional State

* Required

Performance Exploration

How much mental demand was required? Was the task easy or demanding? *

1 2 3 4 5 6 7 8 9 10

Extremely easy ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Extremely difficult

How much physical activity was required? Was the task easy or tiring? *

1 2 3 4 5 6 7 8 9 10

Extremely easy ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Extremely tiring

How much time pressure was required? Was the task's pace slow or fast? *

1 2 3 4 5 6 7 8 9 10

Extremely slow ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Extremely fast

How satisfied are you with your performance? *

1 2 3 4 5 6 7 8 9 10

Extremely good ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Extremely bad

How hard did you have to work to achieve your performance? *

1 2 3 4 5 6 7 8 9 10

Extremely easy ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Extremely hard

How frustrated or stressed did you feel while performing? *

1 2 3 4 5 6 7 8 9 10

Not stressed at all ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Extremely stressed

During your performance, what do you link it with? *

- ○ Past memories
- ○ Self-reflection
- ○ Body movement exploration
- ○ Area/space exploration
- ○ Other:

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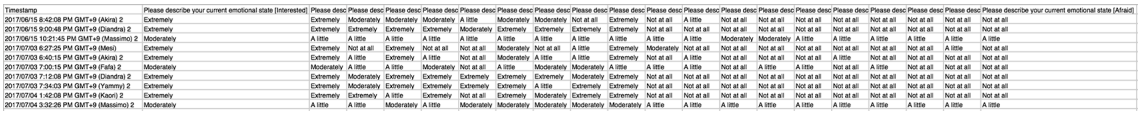
Figure A.3: NASA TLX Survey

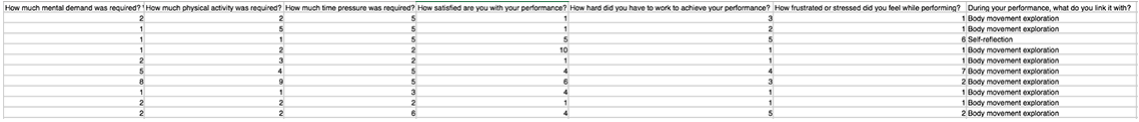
Timestamp	What is your gende	How old are	What is you	Do you com	How interes	Please describeyour current emotions	Please describe y	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please describe your current emotions [Afraid]
2017/06/15	Female (Yammy)	24-27	Student	No	4	A little	Moderately	Not at all	A little	Not at all	A little	Not at all	Moderately	A little	Moderately	Moderately	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/06/15	Male (Akira)	32-35	Student	Yes	5	Moderately	Moderately	Moderately	Moderately	A little	A little	A little	Moderately	Not at all	Extremely	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/06/15	Female (Diandra)	24-27	Student	No	5	Moderately	Extremely	Moderately	Extremely	A little	Not at all	A little	Moderately	Moderately	Moderately	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/06/15	Male (Massimo)	28-31	Student	Yes	3	Moderately	Moderately	A little	Moderately	A little	A little	Moderately	A little	A little	A little	Moderately	A little	A little	A little	A little	Moderately	Moderately	Moderately	Moderately
2017/06/16	Female (Fafa)	24-27	Student	No	5	Moderately	Moderately	Moderately	A little	A little	Moderately	Moderately	Moderately	Moderately	A little	Moderately	A little	A little	A little	Moderately	Moderately	Moderately	Moderately	Moderately
2017/07/03	Female (Mesi)	<24	Student	No	2	Extremely	Extremely	Not at all	A little	Not at all	Not at all	Not at all	Not at all	Not at all	A little	A little	Moderately	Not at all	Not at all	Not at all	Not at all	Not at all	A little	Not at all	Not at all
2017/07/03	Male (Akira) 2	32-35	Student	Yes	3	Not at all	A little	A little	Not at all	A little	Not at all	Not at all	Not at all	Not at all	A little	A little	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	A little
2017/07/03	Female (Fafa) 2	24-27	Student	No	4	Moderately	Moderately	A little	A little	A little	Not at all	A little	A little	Moderately	A little	A little	A little	A little	Not at all	A little	Not at all	Not at all	A little	Not at all	Not at all
2017/07/03	Female (Diandra) 2	24-27	Student	No	5	Extremely	Extremely	Moderately	Extremely	Moderately	A little	Moderately	Moderately	Extremely	Extremely	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/07/03	Female (Yammy) 2	24-27	Student	Yes	4	Moderately	A little	Not at all	A little	Moderately	Moderately	Moderately	A little	Moderately	A little	A little	Not at all	Not at all	Not at all	Not at all	Not at all	A little	Not at all	Not at all
2017/07/04	Female (Kaori) 2	28-31	dress design	No	5	Extremely	Extremely	Extremely	Moderately	Moderately	Not at all	Moderately	A little	A little	Moderately	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/07/04	Male (Massimo) 2	28-31	Student	Yes	4	Moderately	Moderately	Moderately	Moderately	Moderately	Moderately	Moderately	Moderately	Moderately	A little	Moderately	A little	A little	A little	A little	A little	A little	A little	A little

Figure A.4: PANAS-SF Survey Data 1



Timestamp	Please describe your current emotional state [Interested]	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please desc	Please describe your current emotional state [Afraid]
2017/06/15 8:42:08 PM GMT+9 (Akira) 2	Extremely	Extremely	Moderately	Moderately	Moderately	A little	Moderately	Moderately	Not at all	Extremely	Not at all	A little	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/06/15 9:00:48 PM GMT+9 (Diandra) 2	Extremely	Extremely	Extremely	Extremely	Extremely	Moderately	Extremely	Extremely	Extremely	Extremely	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/06/15 10:21:45 PM GMT+9 (Massimo) 2	Moderately	A little	A little	A little	A little	A little	A little	A little	A little	A little	A little	A little	A little	Moderately	Moderately	A little	A little	A little	A little	A little
2017/07/03 6:27:25 PM GMT+9 (Mesi)	Extremely	Extremely	Not at all	Extremely	Not at all	Not at all	Moderately	Not at all	A little	Extremely	Moderately	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	A little	Not at all
2017/07/03 6:40:15 PM GMT+9 (Akira) 2	Extremely	Extremely	A little	Extremely	A little	Not at all	Moderately	A little	A little	Extremely	Not at all	A little	Not at all	Not at all	Not at all	A little	Not at all	Not at all	Not at all	Not at all
2017/07/03 7:00:15 PM GMT+9 (Fafa) 2	Moderately	Moderately	A little	A little	Moderately	Not at all	A little	Moderately	Moderately	A little	A little	A little	Not at all	A little	A little	Not at all	A little	Not at all	Not at all	Not at all
2017/07/03 7:12:08 PM GMT+9 (Diandra) 2	Extremely	Extremely	Moderately	Extremely	Extremely	Extremely	Extremely	Extremely	Moderately	Extremely	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/07/03 7:34:03 PM GMT+9 (Yammy) 2	Extremely	Extremely	Moderately	Extremely	Extremely	Extremely	Extremely	A little	Extremely	Extremely	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/07/04 1:42:08 PM GMT+9 (Kaori) 2	Extremely	Extremely	Extremely	A little	Extremely	Not at all	Extremely	Moderately	Extremely	Extremely	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all	Not at all
2017/07/04 3:32:26 PM GMT+9 (Massimo) 2	Moderately	A little	A little	Moderately	A little	Moderately	Moderately	Moderately	Moderately	Moderately	A little	A little	A little	A little	A little	A little	A little	A little	A little	A little

Figure A.5: PANAS-SF Survey Data 2



How much mental demand was required?	How much physical activity was required?	How much time pressure was required?	How satisfied are you with your performance?	How hard did you have to work to achieve your performance?	How frustrated or stressed did you feel while performing?	During your performance, what do you link it with?
2	2	5	1	3	1	Body movement exploration
1	5	5	1	2	1	Body movement exploration
1	1	5	5	5	6	Self-reflection
1	2	2	10	1	1	Body movement exploration
2	3	2	1	1	1	Body movement exploration
5	4	5	4	4	7	Body movement exploration
8	9	5	6	3	2	Body movement exploration
1	1	3	4	1	1	Body movement exploration
2	2	2	1	1	1	Body movement exploration
2	2	6	4	5	2	Body movement exploration

Figure A.6: NASA TLX Survey Data

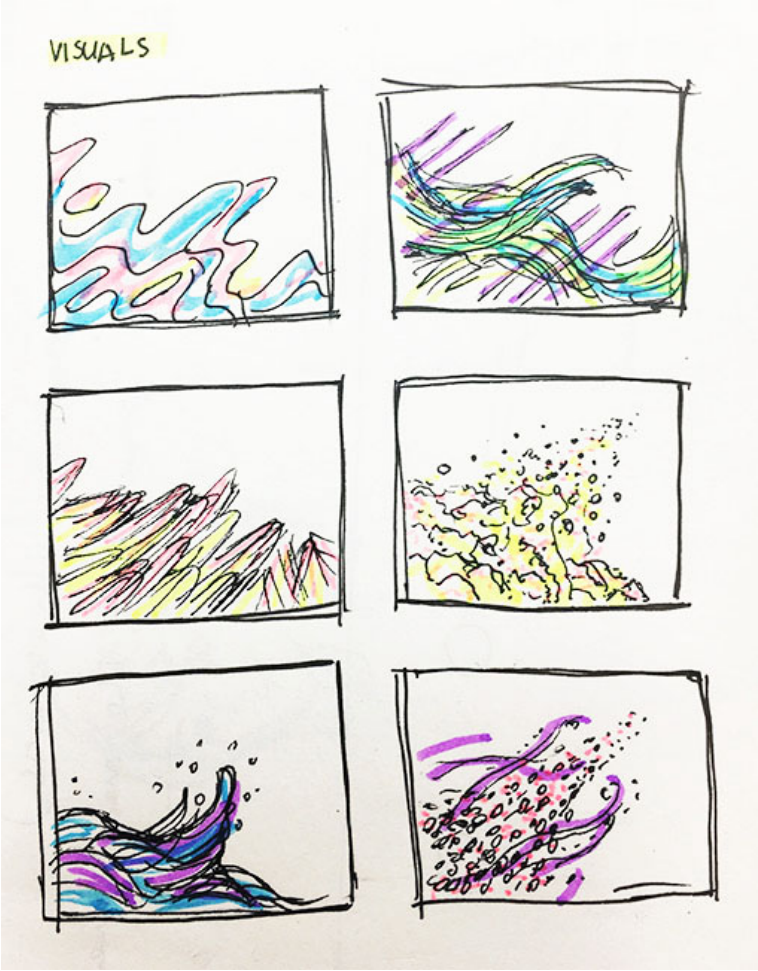


Figure A.7: Visual Sketch