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Master's Thesis
Academic Year 2019

Human Time Perception under Alternative Lighting System

Keio University
Graduate School of Media Design

CHIAHSUAN HU

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

CHIAHSUAN HU

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Associate Professor Roshan L Peiris	(Co-Reviewer)

Abstract of Master's Thesis of Academic Year 2019

Human Time Perception under Alternative Lighting System

Category: Design

Summary

Time perception is an experience or awareness of the passage of time and the perception of time is such a subjective experience that can be influence and manipulate by environmental stimulus easily.The most common stimulus for time perception may be light because of the solar cycle. This study focuses on how time perception can be change under different illumination environment and cause participants to immersion. This thesis is going to introduce several lighting system and lighting pattern, try to affect and control participants' time perception while their waiting time in daily life.

Keywords:

time perception, lighting system, waiting, space lighting design, subjective experience

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Chapter 1

Introduction

1.1. time and time perception

Time is the indefinite continued progress of existence and events in the past, present, and future regarded as a whole.[1]. As an established idea that we have been informed of from the very first day we come into this world, time play an important role in our everyday life and daily activities.

Light may have an important influence on time perception as the cycles of sun is the most obvious existence of time. Physiologically, light affect humans time perception in many ways. Not only play an important role on a "built-in clocks" in our brain as known as circadian rhythm, but also simply plays tricks on our visual system to come out with a temporal illusion of duration .The natural time signal for the circadian pattern is the change from darkness to light. [1]. (Figure 1.1)

Time has been shown to be perceived as passing faster than we predicted when we are highly concentrating on things besides time or, *immersed* in an activity, and vice versa [2]. As such, immersion is defined as when we are immersed in visualized information. This phenomenon is sometimes experienced when we are extremely focused on playing games or watching videos [3]

As such, the relationship between time perception and immersion is the key aspect in this research. Judging time duration accurately could be a challenging task as it requires a high level of attention and information processing by an individual. In addition, any distraction could lead to a greater error in estimating time accurately. The concept of attention when trying to estimate time involves "alertness, vigilance and selectivity" [4]. Research looking at the influence on time perception of exposure to such altered sensory environments indicates that the greater the environmental variation, the shorter is the time estimation obtained by the method of production; Hence, exposure to a monotonous sensory environment should result in a lengthening of time production [5, 6]. However,

1 Oxford University Press. 2011.
`https://www.lexico.com/en/definition/time`

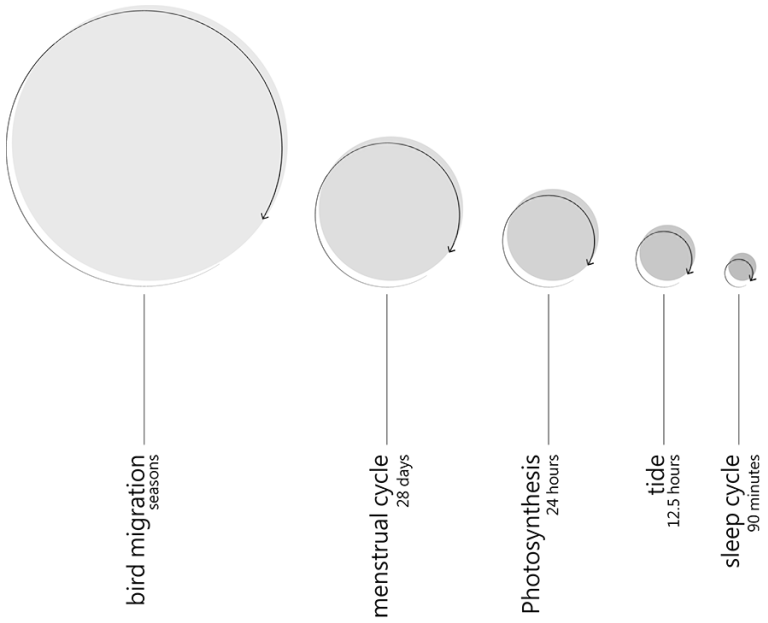


Figure 1.1 circadian rhythm

the clear relationship between time perception and immersion hasn't yet been investigated deeply [7]. (Figure 1.2)

Thus, in this work we observe the time perception of the participants as they are immersed in different environments with different distractions. Our work focuses on how time perception can be influenced under different illumination environments and cause participants to immersion. We conducted three experiments in order to evaluate this concept. The first experiment, participants were told to stay in a room for 90 seconds, within the condition of illumination changes every 30 seconds. Second experiment asked participants to walk back and forth between specific place in a room with a illumination moving with them in the second half of the experiment. Third experiment perform with 5 different lighting condition and participants were asked to do or not doing task in each condition.

That might be the reason why we sometimes feel boring and suffering while waiting for call in bank or hospital and do nothing. By any chance can we avoid such situation like that, life of ours can be much easier. In this work, we are aiming find a effective way that can influence peoples time perception is such situations.

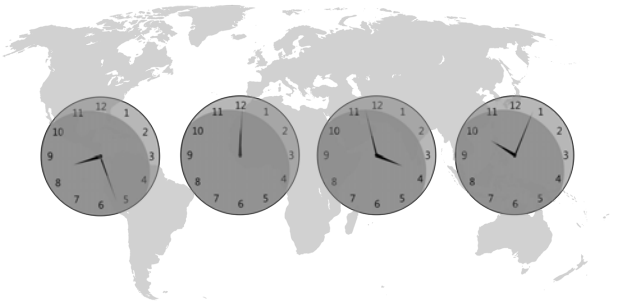


Figure 1.2 time zone

1.2. time perception with light

Time perception is an experience or awareness of the passage of time [3].Time is an established idea that we have been informed of from the very first day we come into this world and it is an important part of our daily activities. However, time perception, different from the rule of time, can be regarded as a subjective experience that can be influenced and manipulated by environmental stimuli. Research has looked at the influence of exposure to monotonous sensory environments on time perception, reporting that the greater the environmental variation, the shorter is the time estimation obtained by the method ofr production [8].

Chapter 2

Related Works

2.1. Time perception

Difference appear when human measure time by their own perception of a duration and order of priority. Due to the fact that time perception is a subjective sense, it is impossible for us to know another person's time perception directly. One's time perception most likely comes from external factor such as the length of day and night, solar term or solar elevation, and interior factor such as heartbeat of rhythm of breath. Research also shows that timing and perception of time affect by sex and age [9, 10].

The passage of time is invisible, inaudible and untouchable. By William Friedman, the sense of time could be two contrasted theories.First one called *The strength model*, which assert that if there is a trace of memory left behind, then human can judge the age of time from the strength of the trace. The other theory called *The inference model*, the time of one event can be known by deduce from the relations between other events whose time is known. [11]

2.2. Time perception under different situation

2.2.1 gaming

Time is a shared significant experience in humans [12]. The concept of attention when trying to estimate time involves "alertness, vigilance and selectivity" [**?**]. This therefore can mean that shared attention due to carrying out one or more tasks means lesser ability to judge time duration accurately. Thus playing a game and carrying out a secondary task should reduce the attention of a gamer to the judgment of the duration of time, more than a gamer that is just playing the same game without a secondary task. The complexity of the methods to investigate time perception whilst playing digital games makes it challenging to pick out what exactly is happening to a player's perception of time. However, [15] and [12]'s attempts at studying players' time estimation of how long they have

been playing in relation to their gaming experience suggest that although players generally underestimated time, there is not a significant difference between their time duration judgment and the correct time. This falls in agreement with the finding of [16], who were found that the higher the level of distraction from judging time duration which in this case is the video game the less time a subject will judge to have elapsed during an objective period.

Discussion

The results, however, do not support our hypothesis that participants have lower immersion scores and larger time differences in the experimental group. There was no different in immersion scores in both conditions. This could be participants with the secondary task treat the task as a part of the game. Answering arithmetic questions whilst playing games perhaps makes the whole activity become more engaging. What we could do in future study is to design a secondary task that require participants to pause the game at a single point and complete the task before they continue playing. This helps to produce a secondary task that is difficult to be included in the gameplay. Although there was no significant difference for time difference between conditions, the results suggest that participants in both conditions were underestimating time. They stopped playing before 7 minutes. This is because they could not focus all of their attention to estimate the time. Having to play the game distracts attention on the need to estimate time. And therefore, having a secondary task whilst playing the game reduces more attention on the need to estimate the time. That is why, participants in the experimental group are showing a larger underestimation of time compare to those in the control group. When you are distracted from monitoring the time, it contributes to the difficulty to measure time and influence participants to stop earlier before the correct time. Not only that, since attention is divided into several tasks, participants in the experimental group could not achieve high scores. Clearly, players need to invest a lot of attention to play the game and get a high score. When they were given a secondary task, they need to split their attention between the two. Their attention on the game was distracted. Therefore, they could not perform well in the game. Similar for time perception, the more attention that is invested to estimate the duration, the more accurate the estimation

of time [1]. However, in this work attention did not affecting immersion as predicted. Hence, our work suggests that there is dissociation between immersion and time perception. Given that attention is very essential for both, our work in progress shows attentions work differently in both notions. But as this is a work in progress, more investigation is needed to understand the relation between immersion and time perception in digital games.

2.2.2 waiting

2.3. Controllability of time perception

2.3.1 monochromatic environment

Light can elicit acute physiological and psychological responses in human beings. The magnitude of responses depends on the color temperatures, intensity, wavelength components and duration of light exposure (Noguchi and Sakaguchi, 1999; Katsuura et al., 2005). Recent studies have found an effect of the light wavelength on suppression and phase delay of the melatonin rhythm (Morita and Tokura, 1998; Brainard et al., 2001; Lockley et al., 2003, 2006; Hanifin et al., 2006). Likewise, some studies have found effects of monochromatic light on the central nervous system. However, the results are not all in agreement with each other. For example, there was a greater recovery in the alpha wave under red light than under blue light presentation (Ali, 1972). In contrast, one study showed that the alpha band power density was higher in blue light than in green light (Lockley et al., 2006).

(Figure 2.1)

(Effects of Monochromatic Light on Different Time Perception)

Figure 2.1 The experimental protocol

It has been verified that different light conditions could affect cortical activity. Therefore, the time sense might be affected by lighting conditions. A previous study (Katsuura et al., 2007) described activation in the central nervous system

based on the evidence of P300 event-related potential. The latency of P300 under red light exposure was shorter than that under blue light exposure, according to the results of time-production tests lasting 180 s. The powers of the red light and blue light exposure were unified by the illuminance. In this study, we aligned the measurement unit of monochromatic light exposure with illuminance (red, green and blue I conditions) and irradiance (red and blue II conditions) to verify the differences between the two types of unit. We examined the time sense using a 180-s time task and a 600-s time task. We recorded the physiological indices of the activities of the central nervous system by EEG, P300 and the activities of the autonomic nervous system by finger PPG. During the experiment, the subject sat quietly on a chair for 30 min under baseline conditions. Thirty minutes later, the fluorescent lamps were turned off, and then the monochromatic lights were turned on and stayed on until the experiment ended.

Discussion

Color generally is categorized as being either warm (e.g., red, orange, yellow) or cool (e.g., blue, green). Studies have shown that warm colors are psychologically and physiologically arousing and sometimes stressful, whereas cool colors are relaxing and tend to decrease feelings of stress (e.g., Bellizzi et al. 1983). These effects have been found to persist over 10- to 15-minute time periods (e.g., Jacobs and Suess 1975). Moreover, it has been observed that the passage of time tends to be overestimated in a room painted with warm colors and underestimated in a cool-colored room (National Aeronautics and Space Administration, Johnson Spacecraft Center 1976). In the present study, we got the same results that the red or warm color could make the time sense run faster than the time sense with cool color conditions. We found in both 180-s task Tp1 and Tp2 that red light condition was significantly shorter than the green, blue I and blue II conditions. This result showed that the 180-s production time intervals feel faster-passing in the red light condition than in the other color conditions. Katsuura et al. (2005) found the same result that the subjective time sense runs faster in the red light condition than in the blue light condition. However, an interesting finding in the present study was that this effect was attenuated in the 600-s time estimation task, because the time sense in the red light condition came to show a marginally

significant difference from the other color conditions. The alteration of significance between the 180-s time task and the 600-s time task may show that the red light condition has an acceleration effect on the time sense, but that it also has a timing characteristic that may be more effective in the short term in our brain, and alter to be normal with time.

2.3.2 Ganzfeld

Research looking at the influence on time perception of exposure to such altered sensory environments indicates that the greater the environmental variation, the shorter is the time estimation obtained by the method of production; Hence, exposure to a monotonous sensory environment should result in a lengthening of time production (TP; Glicksohn, 1992, 1996). The notion that exposure to a monotonous sensory environment could elicit reports indicating aberrant subjective experience and altered time perception is the impetus for the present report. Research has looked at the influence of exposure to such environments on time perception, reporting that the greater the environmental variation, the shorter is the time estimation obtained by the method of production. Most conditions for creating an altered sensory environment, however, have not facilitated an immersive experience, one that directly impacts both time perception and subjective experience. (Figure 2.2)

Exposure to an altered sensory environment, such as that entailing what Marcusson-Clavertz et al. (2012) have termed a sensory homogenization procedure, has a marked impact on subjective experience.A more convenient solution to creating a Ganzfeld is to employ halved ping-pong balls covering the eyes, coupled with exposure to red-colored stimulation, as pioneered by Hochberg et al. (1951) this being the technique that we employed in previous research (Glicksohn, 1991, 1992; see also Wackermann et al., 2002, 2008). Yet, as Avant (1965, p. 249) correctly asserted, It is highly likely that this technique produces a different field from that produced by a larger stimulus field at a greater distance from the eyes. All such Ganzfeld techniques entail pattern reduction, monotony, homogeneity and perceptual deprivation (Suedfeld, 1980, pp. 89).

Their TP task requires the participant to produce a target duration (P) by signaling when that duration (T) is thought to have elapsed.

FIGURE 1 | Whole-Body Perceptual Deprivation (WBPD). The person in the photo has volunteered to be photographed for the illustration of the WBPD paradigm, and did not take part in the current research.

Figure 2.2 Ganzfeld

A reviewer of this paper has astutely commented that in employing two different WBPD chambers, we might have impacted on TP, because the second chamber was smaller in size relative to the first. We further note that one group of 16 participants (S1S16) repeated the TP task within the larger chamber, at the end of the session, while the second group of 16 participants (P1P16) repeated the task after exiting the smaller chamber. There is a scanty literature that bears on the possible effect of the WBPD chamber size on temporal experience.

For the experiment, not all their participants exhibit the hypothesized lengthening effect; some, in fact, exhibited shorter TP following WBPD. We find that for those participants whose data exhibited linearity in the loglog plot of produced duration to target duration, it was the intercept of this function which was the locus of the effect for WBPD, much as was reported in a previous study (Glicksohn, 1996) employing both altered sensory environments (including Ganzfeld) and TP (using the same target durations). While an increase in the intercept might be due to the repetition of the task, and not necessarily due to exposure to an altered sensory environment (Glicksohn, 1996, p. 368), here we note a marked decrease in intercept due to exposure to WBPD, for those participants who remained in the chamber. For those exiting the chamber, on the other hand, there was practically no decrease in intercept due to WBPD.

Illumination type

Lighting system play a important role in every public space such as train station and hospital. Follow the stander of Public lighting system, the design is aim to control human's subjective sense of time. Starting our everyday life, traffic light or subway might be the very first thing we have to wait for. When we are in a hurry to get to next destination, wait for the light turns to green seems to take a hundred years.

Chapter 3

Concept Design

3.1. Design over view

When considering about what time is it, we often try to find a clock, which is the most accepted way of time visualization. However, regardless of whether round clock or digital clock both provide the information of time, which really isn't the visualized flow of time. In olden days, water clock and hourglass were a form that try to express the flow of time and calculate time physically by the alternative actual object.
The main purpose of this thesis is to visualize the flow of time,give out an experience that cause participants to become immersed in a time perception experience create by changing the form of light and make human feel time pass faster in those waiting time that can not be avoid in daily life, like wait in line in a bank or hospital, even though waiting for the traffic lights. The experiment below helps to find an effective way to manipulate the sense of duration of the participants.

3.2. Hypothesis

The hypothesis for this thesis is that different forms of light change humans perception of space and time.

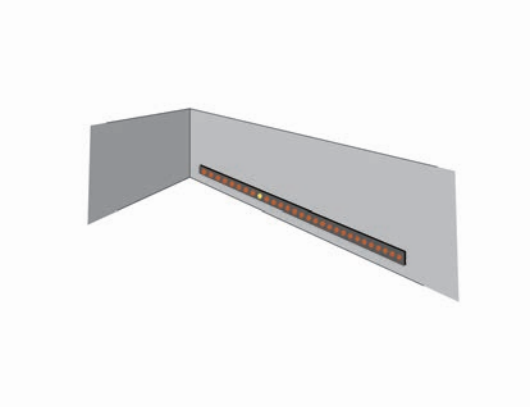
(Figure 3.1) (Figure 3.2) (Figure 3.3)

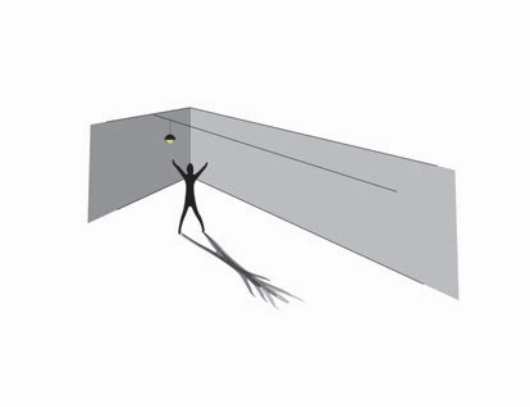
3.3. Prototypes

3.3.1 test-1

Hypothesis

The hypothesis of this experiment is that it si possible to change human's time and space perception by changing lighting condition.





This study was conducted as a preliminary study with the main objective of observing the effects of different lighting conditions in a static room environment. We explored three different lighting conditions: light off; light on; and light rotating above their head. (Figure 3.4)

(Experiment 1 : participant seat in a dark room with one light above)

Figure 3.4 Experiment 1

In the study procedure, the participants were asked to sit on a chair in the middle of a dark room with only one light above the chair. The lighting level of this condition was changed according to the experimental condition. Each condition lasted 30seconds each. The participants were not informed about the content and purpose of this prototype before they finish the experiment. Following the experiment, the participants completed a questionnaire and we conducted an informal interview with the participants to discuss the perception of time under each condition and other observations.

In total 7 participants (3 females, 4males) aged 22-28, took part in the study. The participants were recruited from the author's institute. Once the participant sat on the chair in the room, the experiment was commenced: for example, started from a fully dark environment and 30 seconds later, the room was illuminated with

white light above participant. After another 30 second, the light started rotating till the end of the experiment.

Results

All participants completed a questionnaire and an informal interview after completing the experiment. The questionnaire included questions regarding the perception of time under different conditions. From the questionnaire and the interviews, we observed that five of the participants felt that the third condition in which the light was rotating above their head, was the shortest condition of the experiment relative to the other conditions. Next, the participants identified that the second part, in which the light was switch on (without any movements) was shorter than the first condition in which the light was completely switched off. I.e., the participants perceived the time passing slower when they were in a completely dark environment. However, one participant mentioned that all conditions were perceived as the same duration while another mentioned that the second condition was longer than the first condition in contrast the other five participants. one participant mentioned that the third condition (light rotating above the head) is the shortest but the first part was short than the second one and another one believes each part have the same length.

(Figure 3.5) (Figure 3.6) (Figure 3.7)

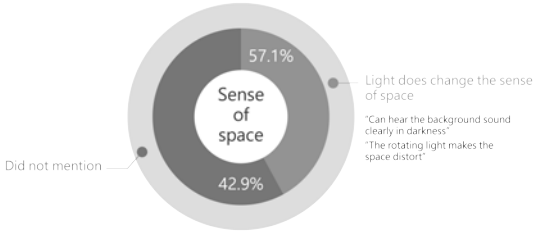


Figure 3.5 Sense of Space

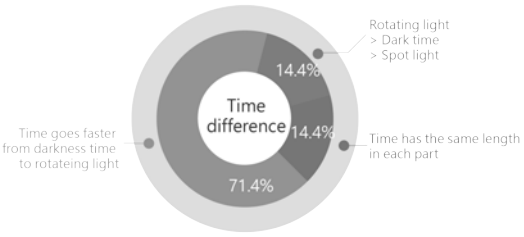


Figure 3.6 Time Difference

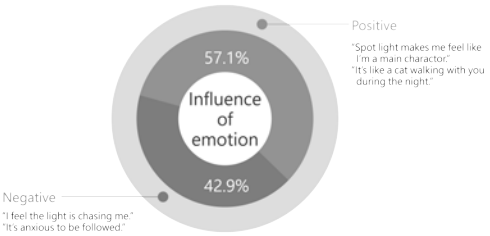


Figure 3.7 Influence of emotion

Discussion

Although not statistically proven, through our observations, we identify that the participants had different perceptions of time under the different lighting conditions. In addition, participants also mentioned of other influences besides time perception about the illumination. Five of the participants claim that their emotion was slightly effected whilst the light was rotating above their head. They reported "I feel like I was in danger."; "It was exciting and just like dancing in a disco"; "It was a creepy experience."

3.3.2 test-2

Hypothesis

The moving speed of light be influence on participant's speed of walk.

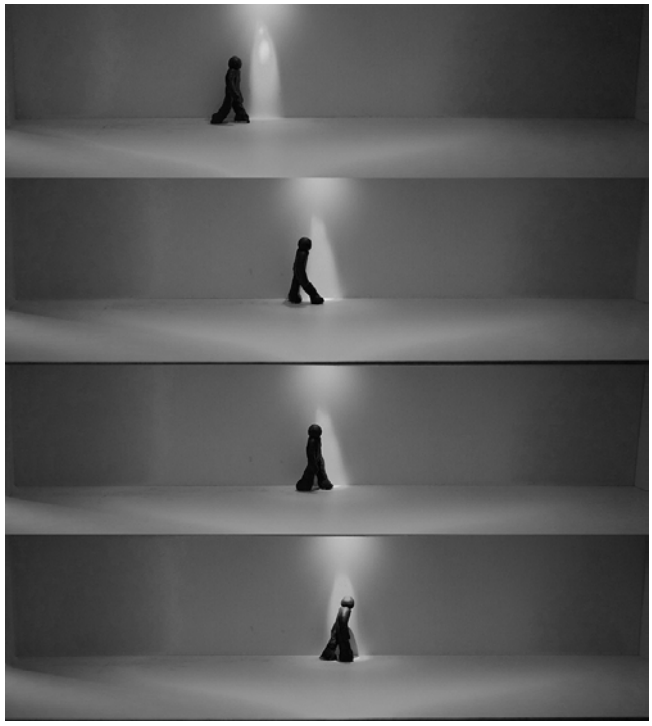
(Credit: Li-Yang Yu)

Figure 3.8 Subway passage

The preliminary results of Experiment 1 observed that the time perception could be influenced by the movement of a lighting illumination. Thus, the aim of the second experiment is to observe the effects of moving illumination on the perception of time during daily behaviors such as walking. (Figure 3.8)(Figure 3.9) (Figure 3.10) (Figure **??**)

(Credit: Li-Yang Yu)

Figure 3.9 Subway passage



(Experiment 2 : Ideal model for experiment 2 made by clay)

Figure 3.10 Experiment 2-1

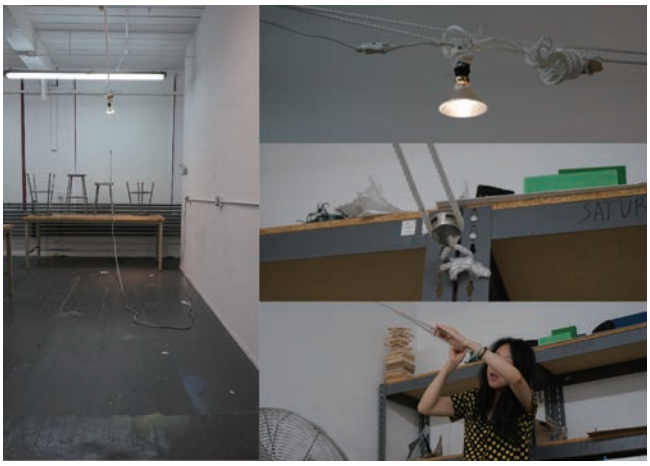


Figure 3.11 Setup photos for experiment 2

The experiment was setup in a room within a 15m space. Two locations of the room (15m apart) were marked as 'A' and 'B'. A movable lighting illumination was hoisted at a 2m height. This lighting illumination was movable within the points A and B through a pulley system. This experiment consisted of two conditions: walking with a static background illumination; walking with the moving lighting illumination. Participants were asked to walk from A to B at their usual speed. In the first condition, the static illumination was lit while they walked from A to B. In the second condition, participants were asked to walk from from B to A while the movable lighting illumination followed the participant. The speed of the light's movement was matched to the participant's walking speed. We hypothesized that the participant's perception of time would be different when walking with a moving illumination, and the moving speed of light be influence on participant's speed of walking.(Figure 3.12)(Figure 3.13)

In total 15 participants (7 females, 8 males) aged 22-28 took part in this experiment. All participants were recruited from the author's institution. Prior to the experiment, the participants completed a questionnaire about their walking experience at a subway station that was a part of their daily routine. At the end of the session, the participant underwent a brief interview and completed the a questionnaire about the experience in the process of this experiment. In addition, we measured the time that the participants took to complete the route between

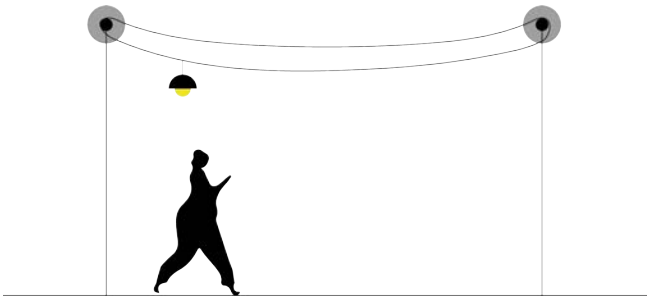


Figure 3.12 System of experiment 3

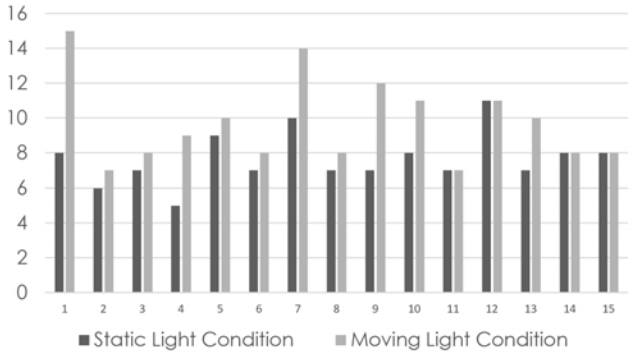
(Experiment 2 : Top-Walking under the static lighting illumination condition, Bottom-Walking with the moving lighting illumination)

Figure 3.13 Experiment 2-2

points A and B in both conditions.

Results

The overall walking times for both conditions are depicted in Figure. The average time under the static lighting illumination was 7.67s (SD 1.5) and 9.73s (SD 2.43) for the movable lighting illumination condition. In contrast to the previous study, in a walking situation, overall, the results shows that 12 of participants took longer time to walk from B to A whilst the illumination moving than walking in an environment with a static lighting illumination. Although this is observed in the results, further analysis with a paired T-test showed no significance in the result which could be due to the differences in the individual walking speeds. As such, although the conclusion of our preliminary experiment observed that the perceived duration was shorter when the was illumination moving, the result was in contrast in a real world walking scenario. In addition, it should be noted that the experiment 1 primarily focused on the perception of time while the above result observes the physical measurement of time for walking between two point. (Figure 3.14) On the contrary, our informal interviews revealed that less than half



(Timing results of Walking between points A and B under the different conditions)

Figure 3.14 results of experiment 2

of the participants (six participants) believed that the duration was shorter when they walked from B to A (movable lighting illumination condition). 23% of them, on perceived the duration as longer for the movable lighting illumination condition

than the static lighting illumination condition. Another 13% of the participants indicated that both duration felt the same. As such, although the average data indicates (not statistically proven) that the participants took more time walking with the moving illumination, many participants perceived the contrary. In addition, during discussions some participants mentioned that this could be due to the shaking of the movable lighting illumination or due to its lower brightness compared to the static lighting illumination. We intend to address these limitations in our future work.

Discussion

The result does not really support the hypothesis that moving speed of light be influence on participant's speed of walk, even approaching the same since there still some participants didn't be affected by the movement of illumination. Although most of the data says the participants took more time walking with the moving illumination, some of them didn't notice the fact that they actually took longer time. The physically reason participants walked slower might because the illumination was shaking when moving and not bright enough for them to walk smoothly. Hence, there are possibility that some slight inaccuracy exists in this experiment. But as this work in progress, there are still some relationship between altered stimulus and time perception.

3.3.3 test-3

Hypothesis

The hypothesis of this experiment is that participants judge time more accurately when they are not engaged in a task.

In the third experiment, we look back the first and the second experiment, discuss about the relationship between the *controllability* of subjective experience of time and the alternation of illumination. Furthermore, the motivation behind the experiment is to observe the effect of *immersion* (with a task) on the perception of time. As such, the hypothesis of this experiment is that participants judge time more accurately when they are not engaged in a task. The result of this experiment will be obtained through comparing the data amount 3 different test.

The experiment consists of two main variables: Lighting Condition and Task. The given task was to copy an article by hand writing. The Brightness Conversion condition refers to changing the light's brightness between 80% and 10% after 30s intervals. This resulted in a total of 5 test conditions as indicated in Table 3.1. Light off-with Task condition was not considered as the participants would not be able to complete the task in the dark.

The study took place in a lighting-controllable room that consisted of a desk and a chair with the materials for the task. In addition, the participants were given a smart phone which displayed a button. As the goal, the participants were asked to estimate the passing of five minutes under the different conditions and press a button to stop the session. As the experimental data, we recorded the time at which the button was pressed and, the number of copied words for the conditions 2 and 4.

In total 5 participants (4 females, 1 males) aged 23-27 took part in this experiment. All participants were recruited from the author's institution.

Discussion

cite time perception

Table 3.1 Approach of Experiment 3

Lighting condition	Test A (w/o task)	Test B (with task)
I. Light on	1	2
II. Brightness conversion	3	4
III. Light off	5	/

Table 3 shows the length of time participants sense about the target duration (5 minutes). As per our hypothesis, the mean perceived time while engaged in a task (conditions 2 & 4) was 438.76s (SD 86.66) while without a task (conditions 1, 3 & 5) was 384.06s (SD 57.1). As such, in the without task conditions, the participants estimated the time closer to the goal of 300s (5 minutes). However, even though participants were asked not to count in any session, we observed that majority of them tried to estimate time through various ways such as singing songs or walking around the room when not doing task and count the letters they

write when doing task. In addition, we observed that the task in this experiment became a reference for few participants to judge the duration. Figure **??** indicates the average word count for 2 & 4 conditions. Perhaps it is because people tend to stop writing or reading while finish a full sentences. It is possible to have the next experiment in a opposite way : ask participants to finish the task and estimate how long they took, rather than ask them stop doing the task at a specific duration. (Figure 3.15)

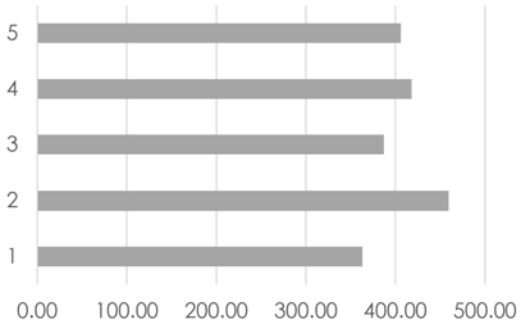


Figure 3.15 Experiment 3 - average seconds

3.3.4 final design over view

This work presents a preliminary out look into the perception of time with different lighting illumination conditions. In the first and second experiments we attempted to test the difference of subjective experience about time with different illumination conditions while the participants were static and mobile. Experiment 1 manipulated the illumination while participant was still, and experiment 2 had the participants and illumination moving at the same time. In the third experiments, we explored the participants perception of time under different lighting illumination conditions *and* while participants were *immersed* in a task. As such, all experiments provided interesting relationships between perception of time with different lighting illumination and immersion conditions. However, our results are limited in its analysis due to its preliminary work in progress nature and the limited number of users. As such, in our future works, we intend to futher look deeper into the relationship between lighting illumination, immersion and the perception

of time with more detailed studies. The experience of immersion may not only come from having a great amount of stimulate from environment at the same time, but also emerge when . The highest of engagement is a requirement to attain total immersion. The way illumination has been used in previous experiment only gave participants stimulus for their sense of duration, but without any occurrence that participants have to execute. For the future experiment, more illumination-related task will be require to participants, and the project is going to find more active way of illumination.

Chapter 4

Time Illusion

4.1. Experience Design

The final design aim to control participant's time perception and make participants fell time pass fasteror slower to them with three different type of illumination system. All the participants were asked to answer a questionnaire before they start to have the designed experience and at the end of each section of experience. Before the enter the waiting room, all the participants were asked to consider about what they spend the most time to wait for in their everyday life. If the answer is waiting for a train or subway, they will be ask to image the train they are waiting for will be coming in for 3 minutes. When they sense the duration arrive to 3 minutes, participants will stop the timer which given to them before they enter the room, and go out the room as if they are getting on a train.

4.2. Setting

The waiting experience room were setting in a meeting room in Kyousei-kan, a building at Hiyoshi campus of KEIO university. The room were sized to 2.5m*5m. Totally 15 meters LED tapes, 450 of LED lights have been used. The led tape was WS2812B non water proof LED strip. Voltage goes to 5V and Power is 9W/M. All the LED All the LED tapes were pasted on the ceiling around the whole room. The height of ceiling is 3 meters. All test subject were asked to have a sit in the middle of the room, which have only one chair but nothing else inside. Test subject were given a timer that the screen have been covered, provide them from knowing the time. They were asked to start timing when the LED light are all on, and stop the timer and left the room when they sense 3 minutes have passed. Three different lighting pattern were tested on each test subject.

4.3. final design prototype

4.3.1 Participants, Questionnaire Previous Investigation

In total 5 participants (2 females, 3 males) aged 24-31 (mean = 27.2) - all from Graduate school of media design, KEIO university took part in three tests of our final design prototype. All of them answer the questionnaire before the test start and by the end of each test section. The questionnaire before the all tests start is about their personal information and What do they do the most while waiting for subway or train. This question aim to make participants get into the groove more smoothly - they were ask to image that they are waiting for a train that will come after 3 minutes. All of our participants answered that they always listen to the music or focus on their phone when waiting for a train. The questions participants have to answer after each section include:

1) "How did this light experience make the time pass for you?"
   Option for this question is a linear scale from 1linear scale from 1 to 9, and participant were to choose 5 in they see no difference between normal waiting experience and this test.

2) "Did you try to count for 3 minutes? If yes or maybe, how?"
   The option for this question is yes, no and maybe.

3) "How do you feel in this waiting experience?"
   - Exciting, - Interesting, - Relaxed, - Concentrated,
   - Anxious, - Moody, - Boring, - Stressful
   8 kind of emotional reaction are list in the questionnaire and participants have to score how they feel of each emotion from 0 to 5.

4.3.2 pretest

Before the final test of the prototype, 3 different pattern of rotating LEDs have been tested. First pattern is to light the LED up one by one every 0.35 seconds and extinguished the LED one by one every 0.35 seconds after all of the 450 LEDs have been light up (Figure 4.1). The second lighting pattern of pretest is keep the LEDs moving to the right one beside like they are chasing each other (Figure 4.2).

The third one, also will be the one that used in the final test, is keep 10 LEDs running around (Figure 4.3). There was three test subject participated pretest and they were only asked to timing for 3 minutes only by their sense of time. In the pretest all of three participants mentioned that it is very boring because of the monotonous moving of LEDs even if all three test are in different pattern. This is the reason that we choose only pattern that have been use in pretest and change the two thers.

Figure 4.1 surrounding lighting pattern

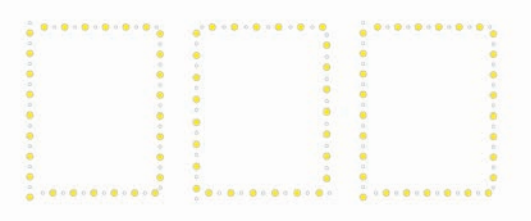


Figure 4.2 chasing lighting pattern

Figure 4.3 running lighting pattern

Figure 4.4 Final prototype test process

4.3.3 test 1

This test offer a LED lighting condition that 450 LEDs fade in within every 0.35s and fade out within every 0.35s. All the LEDS acting at the same time(Figure 4.5)
.

The first question for our participants is "How did the breathing light experience make the time pass for you?". According to the chart below (Figure 4.6), 60% of participants feel time pass faster to them in this experience, 20% indicated that they see no difference and another 20% says they feel time pass slower.

When it comes to how our participants spend their in this experiment, 60% of them claim that they didn't try to count for 3 minutes. 20% of them are not sure that they count or not, and another 20%, which means on of them, said that she count from 1 to 180 in heart(Figure 4.7).

We have more positive emotional reactions than negative in this test. Relax got 16 points, which is the highest score out of 8 emotional reactions. Second one is Concentrate within 10 points. Exciting and Interesting both ranked at the Third by 8 points(Figure 4.8).

Figure 4.5 breathing lighting pattern

4.3.4 test 2

The running pattern have been used in pretest before, which is to keep 10 LEDs running around the room (Figure 4.9).

80% of participants indicate that they feel time pass faster in this test, and on the contrary, 20% sense no different between this test and their daily waiting experience.(Figure 4.10)

Also 80% of participants indicated they didn't count for 3 minutes and only timing by their own sense of time.(Figure 4.11)

We still reward more positive emotions than negative ones in this test, but the overall score of negative emotional reactions getting higher obviously. (Figure 4.12)

4.3.5 test 3

The lighting pattern we used in the third test is the twinkle pattern that let 450 LEDs flashed randomly.(Figure 4.13)

We have 80% of participants indicated that they feel time pass faster in this test and 20% indicated that they feel slower.(Figure 4.14)

None of our participants indicated they count for this three minutes with the twinkling lighting pattern firmly. (Figure 4.15)

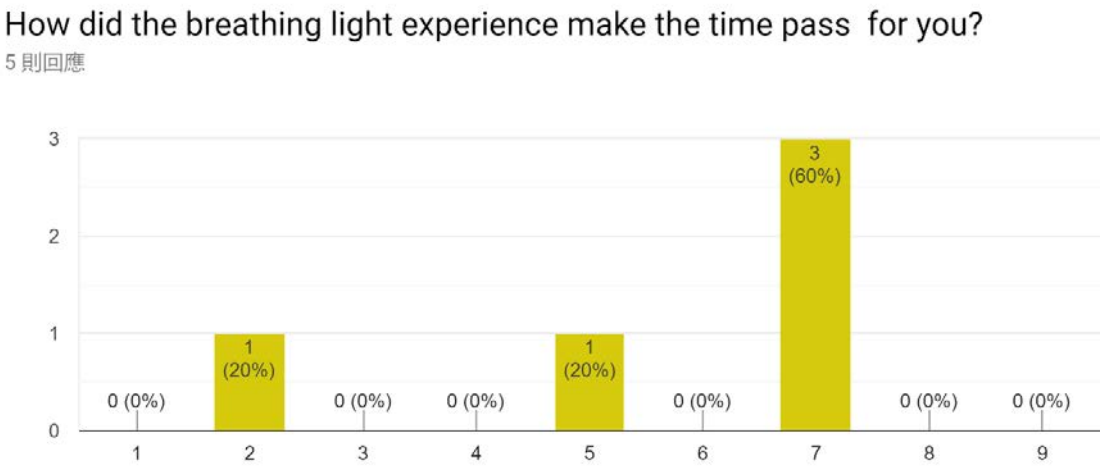


Figure 4.6 Time passing in breathing light experience

The third test with twinkle lighting pattern received the lowest overall score for all the negative emotional reactions. In addition, the points of relax are the highest - 16 points, which is the same score with the first test of breath lighting pattern. (Figure 4.16)

4.3.6 discussion

timing

Within these three tests of the final prototype, we are going to discuss about how this lighting pattern really affect participantss time perception. Compare their timing result and how they sense time passing (by answering the question about how do you feel time pass faster or slower in this experience.). The timing result for average and each participants(A, B, C, D, E) and the overall result follows below. For the time perception graph, the red line for score 5 means the normal time passing speed for our participants.

1. Participant A
   The result for A is shows that breath and running pattern keep she stay in

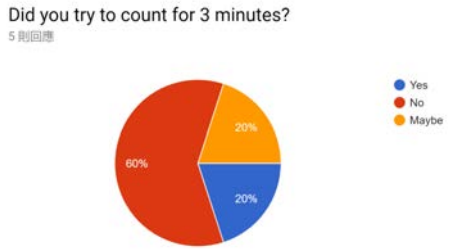


Figure 4.7 Counting Tendency in breathing light experience

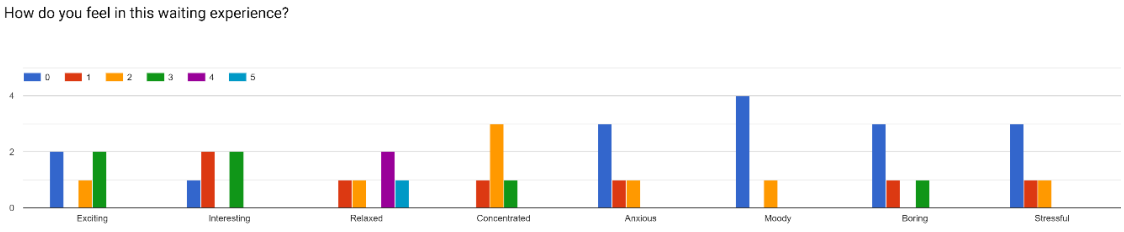


Figure 4.8 Emotional reaction of breathing light experience

the room longer than plain time, and twinkle made it shorter. The answer from her reveals that because of the twinkle lighting system made her feel time goes faster, she leave the room earlier than the target duration. Though she indicated that she didn't see any different between plain time and both breath and running lighting pattern, this to lighting system still kept her in the room longer than plain test. (Figure 4.17)

2. Participant B
   For B, the graph provides some interesting data regarding that participant B consider all of 3 tests make time goes faster. However, the timing result from B depicts that only the twinkle lighting pattern made him stay longer at theroom than the duration he spent in plain test. He scored the twinkle lighting pattern for 8 out of 9, and also did he mention that he didn't try to count for 3 minutes, only sense the time by his own subjective preception. (Figure 4.18)

Figure 4.9 running lighting pattern

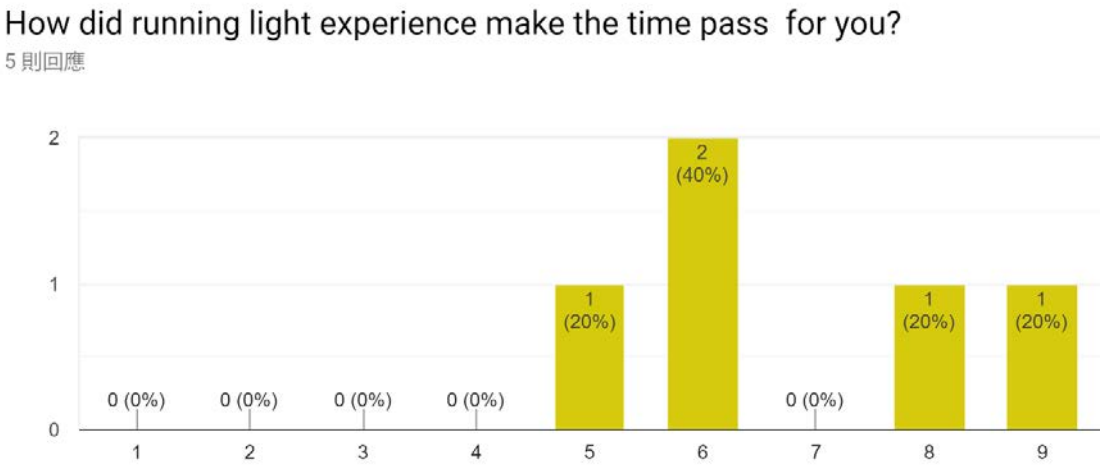


Figure 4.10 Time passing in running light experience

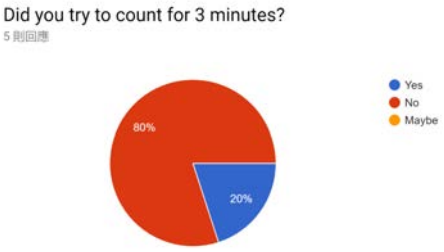


Figure 4.11 Counting Tendency in running light experience

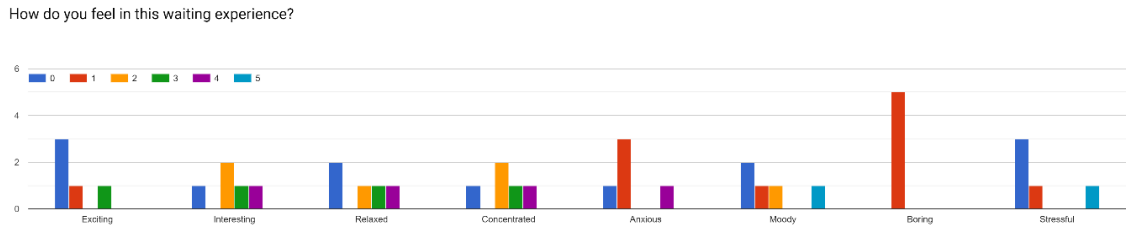


Figure 4.12 Emotional reaction of running light experience

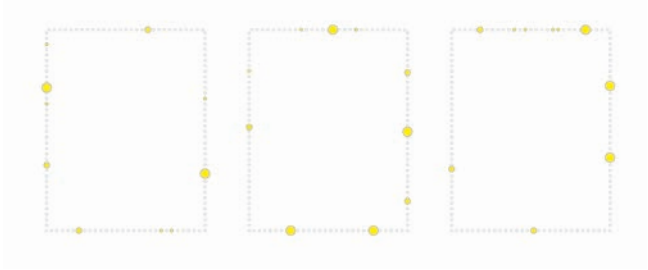


Figure 4.13 twinkling lighting pattern

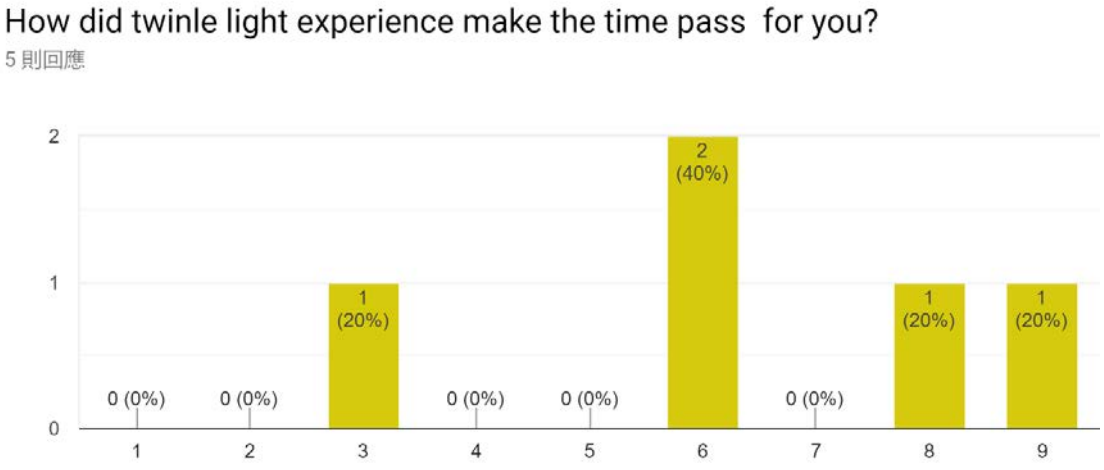


Figure 4.14 Time passing in twinkle light experience

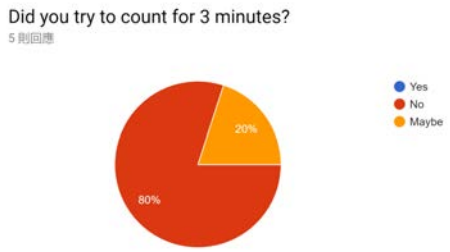


Figure 4.15 Counting Tendency in twinkle light experience

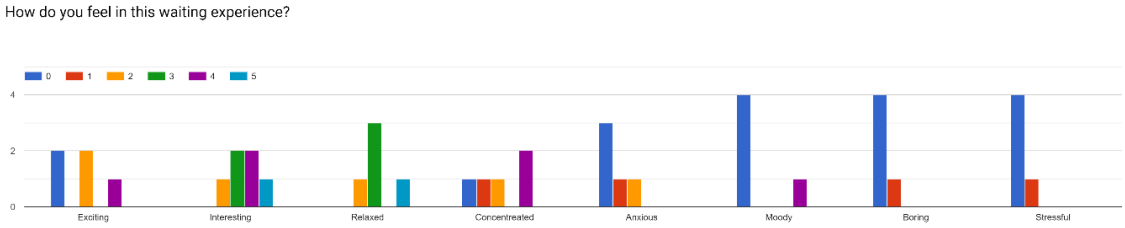


Figure 4.16 Emotional reaction of twinkling light experience

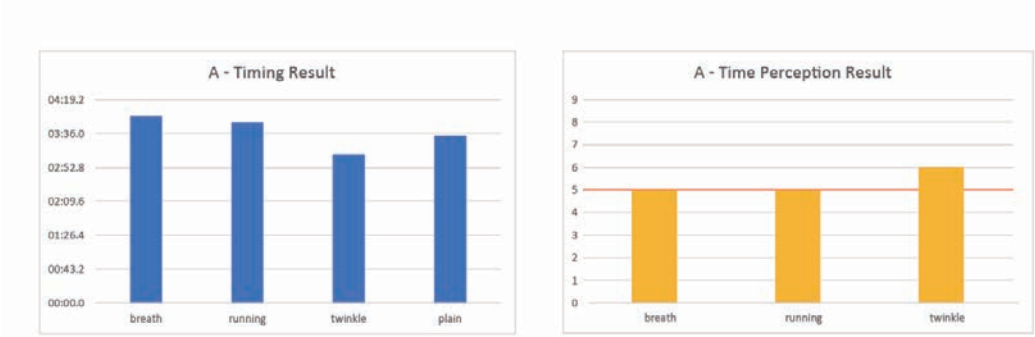


Figure 4.17 Timing and Time Perception result of participant A

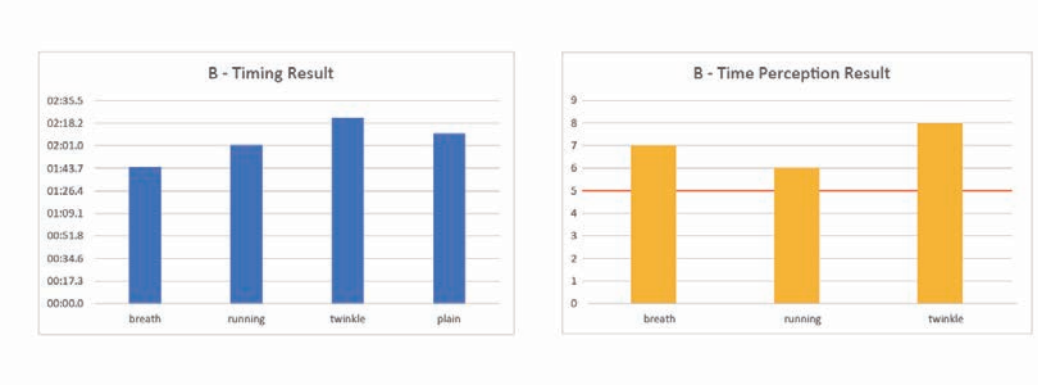


Figure 4.18 Timing and Time Perception result of participant B

3. Participant C

   As can be seen from the graph, great discrepancies have taken place in the time perception result of participant C. Running lighting pattern is the only lighting system that made him feel time pass faster. He spent his time in the room with both breath and and twinkle lighting pattern longer than plain test, which shows the same meaning from his time perception result - he sense time goes slower because he actually have a longer duration in the room with these two lighting pattern. There is a possibility that his perception of time have been affected by the breath lighting pattern. (Figure 4.19)

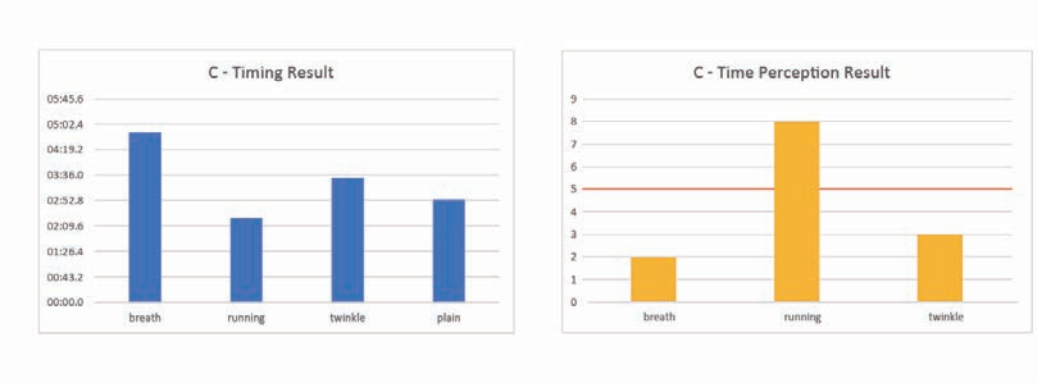


Figure 4.19 Timing and Time Perception result of participant C

4. Participant D

   According to the graph, participant D consider all of 3 tests make time goes faster, yet there is only one lighting pattern make he timing the duration longer than plain test. The running pattern made him stay in the room for over 5 minutes, nearly 2 minutes longer than the plain test. Besides, he scored both the running pattern -which really made him stay longer in the room - and the twinkle pattern - which have the shortest result for duration - for 9, the highest score in this question.

   (Figure 4.20)

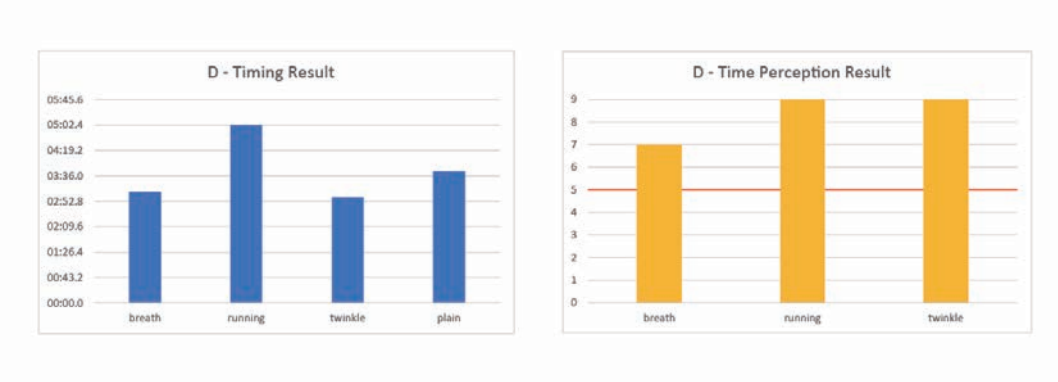


Figure 4.20 Timing and Time Perception result of participant D

5. Participant E

   According to the graph, participant E consider all of 3 tests make time goes faster. The graph of her timing result also shows that she stay in the room longer with all lighting system than plain test.

   (Figure 4.21)

6. discussion

   The total timing result shows that every pattern of our light system keep participants stay in room longer than under stable illumination. Also the time perception result shows that the alternative lighting system makes they

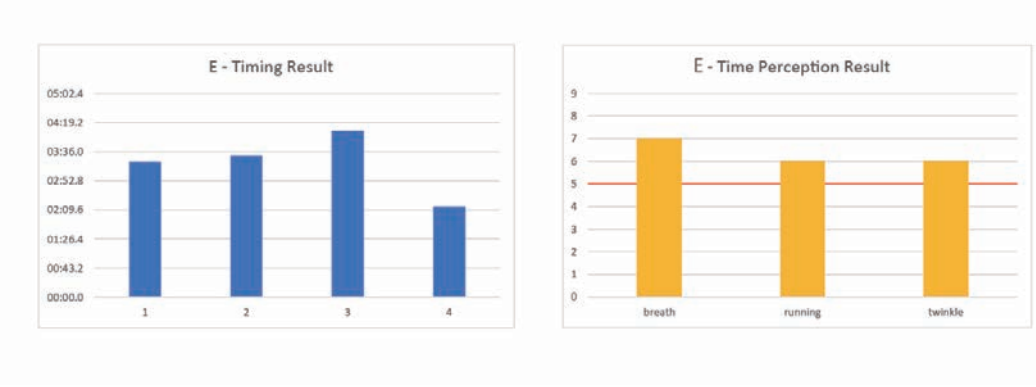


Figure 4.21 Timing and Time Perception result of participant E

feel time goes faster.However, two graph shows difference when it comes to physical and subjective time perception. Timing result shows that breathing pattern kept 60% of our participants in the room for the longest time, running pattern goes the second and twinkling pattern made participants stop the timer in the shortest time. On the contrary, time perception result shows that running pattern, which keep the liner movement in a stable speed, make participants feel time goes the fastest, and breathing pattern make time goes the slowest.

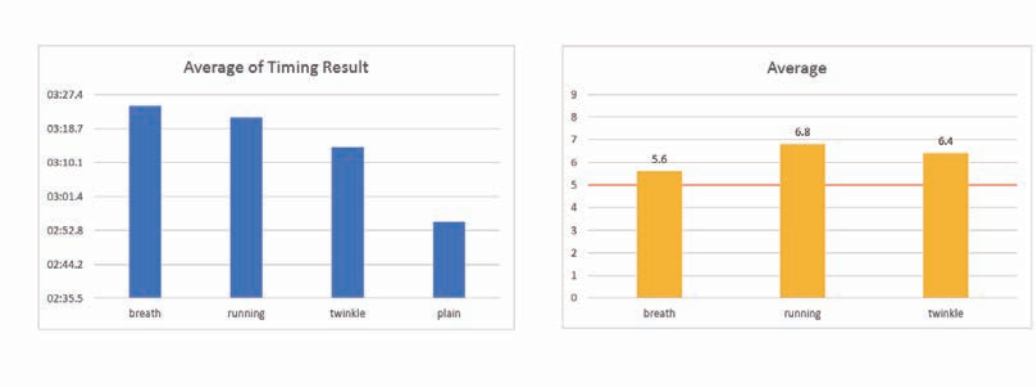


Figure 4.22 Timing and Time Perception result for Average

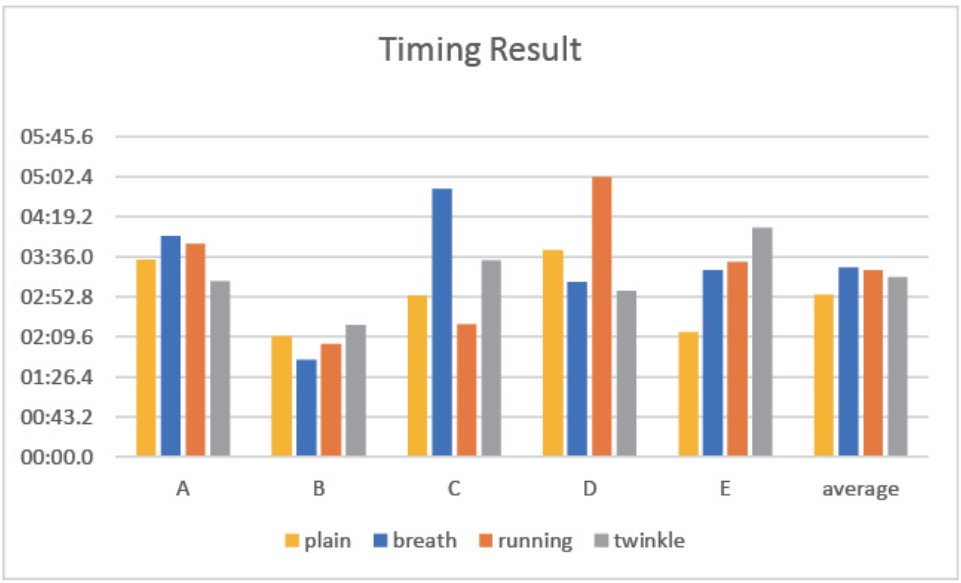


Figure 4.23 Timing Result Over View

perception.jpg

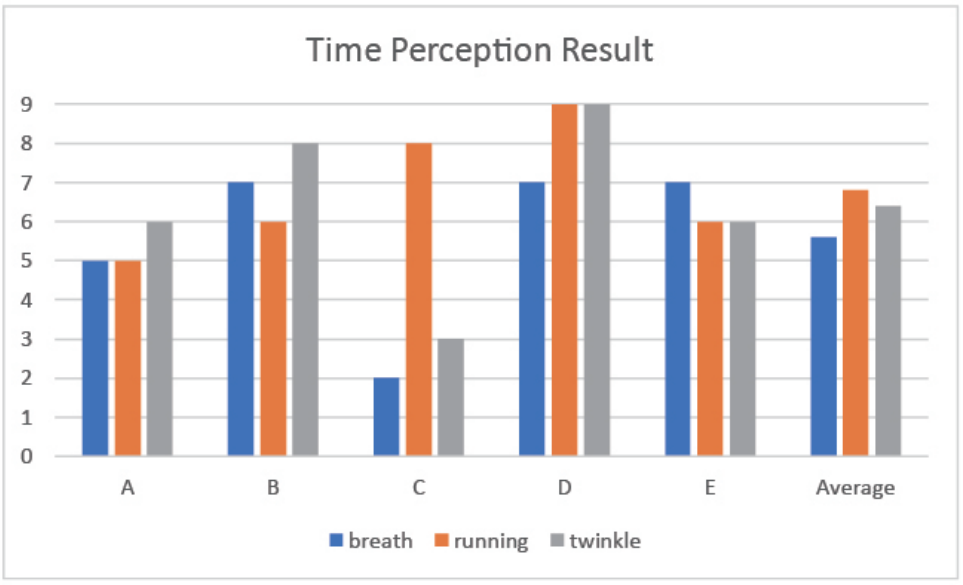


Figure 4.24 Time Perception Result Over View

emotional reactions

Rection.jpg

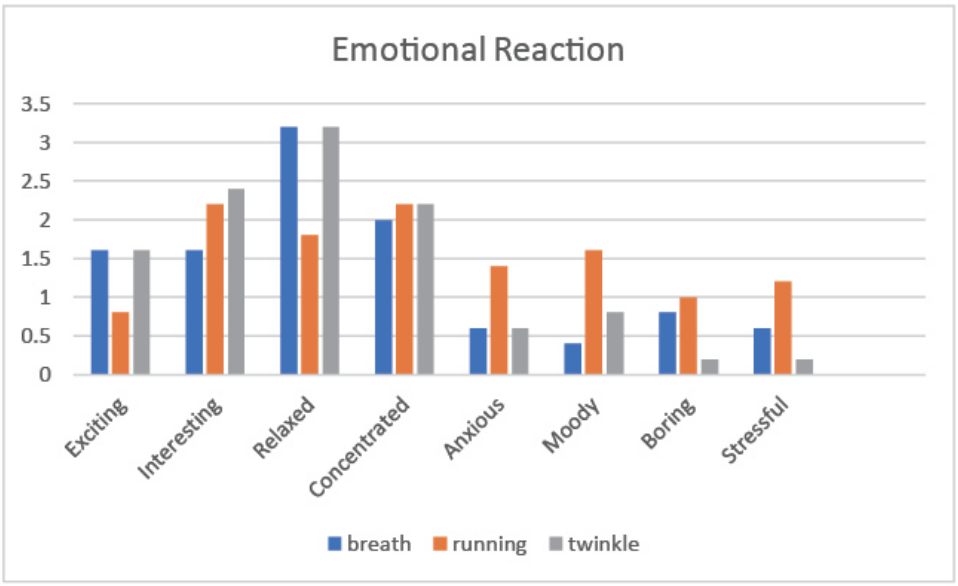


Figure 4.25 Emotional Result Over View

Chapter 5

Conclusion

5.1. Conclusion

This project introduce several kind of alternative lighting system to change human's time perception when waiting by provide different kind of illumination or different type of lighting pattern from same illumination. In chapter 1, a overview was given that time is a concept we have been given that can not be change and time perception a subjective experience about our own sense. Thus, how can control the subject part to make human feel more comfortable when they are waiting for something in their daily life.

Next, chapter 2 introduce the definition of time perception in multifaceted approach. Specific waiting situation that make people stay in a limited space also be mention in chapter 2. We also study about what kind of effort have been done to change human's time perception.

Chapter 3 describe the concept of this thesis, and record 3 different kind of prototype tried to control time perception in different and by multiway. After summary all the data from these test, we found that moving or rotating the illumination may change participant's not only sense of time but also sense of space at the same time, which can effect their time perception more directly, we came out with the final prototype.

Chapter 4 dove into a fixed lighting system with different lighting pattern. Done both actual timing and subjective time perception to analysis how the prototype work for effect participants on tine perception and emotion.

In conclusion, our final prototype and all the prototype that have been test in chapter 3 shows the potential to change human's time perception when waiting. Limitation to this lighting system leave several avenues for future works to be explored. Firstly, a top side lighting system with stable illumination may be very more effective than the setting we've done in the final prototype in chapter 4, but device and place of test prohibited further examination in this thesis. Secondly. Not every data we get can prove the original hypothesis that a moving illumination can change human's time perception. Their is still plural participant claim

that the prototype doesn't work on them by any way. Thirdly, future works can explore the relationship between the frequency of changes for light pattern and the variation of emotion, It is going to be a important part to influence time perception. I hope the research can provide a strong framework for the development of such study in the future.

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