Enhancing board gameplay experience with light based timers

YAJIE DU
KTH Royal Institute of Technology

School of Information and Communication Technology

Enhancing board gameplay experience with light based timers

Yajie DU
Abstract

In this thesis we will present a study on using lighting to enhance the gameplay of modern board games as a gameplay element - timer. Based on the research on the usage of the timers in various social board games, we categorize the timers into 3 types: the turn-taking timer, the reminder timer and the warning timer. For designing and developing the light based timers, we frame the design space and propose 4 types of timers to be our design object: the turn-taking timer, the reminder timer, the warning timer and the combination timer of warning and reminding timer. We designed different light effects for each type of timer, evaluated and redesigned these light effects by pilot test and controlled experiments. We summarized the findings on how the light effect affect people and created a guideline for designing the light effect for timers based on the findings. Finally, we conclude this thesis by discussing the findings and outlining future work.
Referat

Contents

1 Introduction 3
1.1 Background ....................................................... 4
1.2 Problem ............................................................ 4
1.3 Purpose ............................................................. 5
1.4 Goal ................................................................. 6
1.5 Method ............................................................. 6
1.6 Delimitation ....................................................... 7
1.7 Outline ............................................................. 7

2 Related work 9
2.1 Pervasive game .................................................. 10
2.2 Modern digital board game ....................................... 10
2.3 Light enhanced user experience ................................ 11
2.4 Light enhanced social board game ............................... 11
2.5 Exploration of light modalities in board games ............... 12

3 Design and developing of lighting based timers 15
3.1 Method ............................................................. 16
3.2 Timer research .................................................. 16
    3.2.1 Usage of timers ............................................... 16
    3.2.2 Physical and digital timers ................................. 18
3.3 Category of timers ................................................ 19
3.4 Light effect design for timers .................................... 20
    3.4.1 Exploration of light characteristics ....................... 20
    3.4.2 Reminder timer ............................................... 21
    3.4.3 Warning timer ............................................... 22
    3.4.4 Combination of reminder and warning timer ............ 25
    3.4.5 Turn-taking timer .......................................... 26
3.5 Developing of timers ............................................. 27
    3.5.1 Light setup .................................................. 27
    3.5.2 Technologies exploration ................................. 29

4 Evaluation of lighting based timers 31
4.1 Method ............................................................. 32
    4.1.1 Evaluation .................................................. 32
    4.1.2 Analysis ..................................................... 32
Contents

4.2 Pilot test .............................................. 34
4.3 Controlled experiments ......................... 34
    4.3.1 Conditions .................................. 35
    4.3.2 Structure .................................... 38
4.4 Results ............................................. 38
    4.4.1 Turn-taking timer .............................. 39
    4.4.2 Ambient light vs Spot light ................. 40
    4.4.3 Warning timer ................................ 40
    4.4.4 Reminder timer ................................ 41
    4.4.5 Combination timer .............................. 41
    4.4.6 Questionnaire results ....................... 41

5 Discussion ........................................... 43

6 Redesign and guidelines ......................... 47
    6.1 Redesign ......................................... 48
    6.2 Commercial application ......................... 49
    6.3 Guideline ....................................... 50
    6.4 Examples ........................................ 53

7 Conclusions ......................................... 55
    7.1 Key findings ................................... 56
    7.2 Future work .................................... 57
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Chronos chess timer</td>
<td>18</td>
</tr>
<tr>
<td>3.2</td>
<td>DGT Cube 6-Player Game Timer</td>
<td>18</td>
</tr>
<tr>
<td>3.3</td>
<td>Schematic representation of the human eye, source: (Phillips Lighting, 2014)</td>
<td>20</td>
</tr>
<tr>
<td>3.4</td>
<td>Reminder timer with color changing light effect</td>
<td>22</td>
</tr>
<tr>
<td>3.5</td>
<td>Reminder timer with highlighting light effect</td>
<td>23</td>
</tr>
<tr>
<td>3.6</td>
<td>Various ways of brightness changing</td>
<td>23</td>
</tr>
<tr>
<td>3.7</td>
<td>Bomb timer with explosion light effect</td>
<td>24</td>
</tr>
<tr>
<td>3.8</td>
<td>Warning timer with the light effect of flashing faster and faster</td>
<td>24</td>
</tr>
<tr>
<td>3.9</td>
<td>Warning timer with the light effect of sudden flashing</td>
<td>25</td>
</tr>
<tr>
<td>3.10</td>
<td>Combination light effect of warning timer and reminder timer</td>
<td>25</td>
</tr>
<tr>
<td>3.11</td>
<td>Combination timer with two types of light</td>
<td>26</td>
</tr>
<tr>
<td>3.12</td>
<td>An example of turn-taking timer</td>
<td>27</td>
</tr>
<tr>
<td>3.13</td>
<td>Philips Hue Iris</td>
<td>28</td>
</tr>
<tr>
<td>3.14</td>
<td>Philips Hue Lightstrip</td>
<td>28</td>
</tr>
<tr>
<td>3.15</td>
<td>Philips Hue Go</td>
<td>28</td>
</tr>
<tr>
<td>4.1</td>
<td>Normal room light effect in the formal experiment</td>
<td>35</td>
</tr>
<tr>
<td>4.2</td>
<td>Light effect of condition 3 and condition 4</td>
<td>36</td>
</tr>
<tr>
<td>4.3</td>
<td>Light effect of condition 5</td>
<td>36</td>
</tr>
<tr>
<td>4.4</td>
<td>Table light effect in the formal experiment</td>
<td>37</td>
</tr>
<tr>
<td>4.5</td>
<td>Ambient light effect in the formal experiment</td>
<td>37</td>
</tr>
<tr>
<td>4.6</td>
<td>Sensory immersion of the players when playing social board games with lighting enhanced timers</td>
<td>42</td>
</tr>
<tr>
<td>4.7</td>
<td>Time pressure of the players when playing social board games with lighting enhanced timers</td>
<td>42</td>
</tr>
<tr>
<td>6.1</td>
<td>Brightness changing trends</td>
<td>48</td>
</tr>
<tr>
<td>6.2</td>
<td>A mobile application of light based timer</td>
<td>50</td>
</tr>
</tbody>
</table>
List of Tables

4.1 Order of the conditions on the gameplay . . . . . . . . . . . . . . . . 38
Chapter 1

Introduction

The first chapter introduces the topic of light extended board games. We start by introducing the domain of social board games and smart lighting where our topic takes place. Then we explain why we think the combination of board games and lighting could be beneficial. Finally, we propose our research questions and introduce the method we aim to use to tackle these questions.
1 Introduction

1.1 Background

Traditional board game is a social activity. Players gather around a table and collaboratively create a shared, engaging, and entertaining experience, in which their actions are conveyed through tangible interactions with physical objects[21]. The popularity of board games keeps increasing these years. From 2013 to 2015, board game purchases rise by between 25% and 40% annually[3]. There are thousands of new board games releasing every year, and the top ones sell millions of copies.

The increasing maturity of technologies open up new possibilities for board game design. The Internet of Things (IOT) is the new way forward in the technological inventions. IOT has made its presence felt in diversified industry, not only it has helped sectors like healthcare, education, agriculture etc. to expand and grow but has also amplified gaming industry. IOT has fueled technological innovation in gaming and has changed the way we used to play, now the games are more interactive, use artificial intelligence and with sensors and physical gaming take your playing experience to next level. This kind of pervasive game combines the advantages of both traditional physical board games and digital games, strengthening direct interaction between the players while offering a computer logic that keeps track of the game[5].

This thesis work was carried out at the Experience Research department at Philips Lighting Research in Eindhoven. The goal was to find a potential area of research in light enhanced social board games where there is opportunity for innovation by combining products with Philips Hue lights. We choose the gameplay element with a focus on the timers.

1.2 Problem

According to global business intelligence company, ON World’s research, smart lighting is one of the most active segment of the Internet of Things [4]. In 2012 Philips released the Hue light product which is a personal wireless lighting system. It allows users to control the light with their smart phones remotely and offers the spectrum of 16 million colors. Digitally controllable LED light sources enable almost limitless lighting output possibilities, such as dynamic and colored light[3], which enables the role of lighting go far beyond simple illumination. Philips Hue’s open API provides a new platform for diverse new innovations related to light.

Philips hue connected light bulbs have already been used in computer games and TV sets to create an immersive experience. There have been some cases where light plays
a decorative role in board games, while using light to enhance the gameplay experience of board games is still a rarely explored fields.

Board games match people’s needs for real social interaction and the tangible interaction contributes an enjoyable user experience to board games. However, there are also some flaws that influence the user experience. For instance, long player turns can make people feel boring and it is a burden for players to remember and keep track of the game rules and so on.

In this research, we focus on investigating how can we use digitally controllable LED light to bring the traditional board game to a new level by enhancing the game experience in aspect of immersion, flow, etc. To answer the question of how can light enhance the board gameplay experience, it is necessary to know the board game elements and explore what roles that light could play in a board game.

In Balint’s work[28], he studies the elements that a board game consists of and categorizes the possible roles that light could play in board game as follows. (1) ambience support for decorative purpose; (2) gameplay elements such as thematic indications, thematic timer, challenge caused by special light condition and so on; (3) game tools that players can interact with. In this study, we explore the second role - light as a gameplay element. As timer is a quite common gameplay element in board games, we choose timer to be our study object and the research question is:

**How can lighting based timers enhance the social board gameplay experience?**

To address this question, firstly it is essential to learn the different usages of timers in board games. Then we can design different light effects for different types of timers. Thus, the sub-questions could be:

1. How the timer is used in board games?
2. What light effects are there that can be used to indicate the passing of time?
3. How do the different light effects affect people?
4. What light effects should be designed for a certain timer based on its usage?

**1.3 Purpose**

The purpose with this thesis is to explore how light can be used as a gameplay element to enhance the social board gameplay experience.
1.4 Goal

The goal of the work is to reveal the effect of different types of lighting based timers on the gameplay experience of social board game, which can be a guideline or reference for other designers who work on light extended board games.

1.5 Method

To achieve these goals, a background research is conducted to explore light modalities in board games. This exploration focuses on information about the current commercial board games market, related work in this area as well as the innovative application of light. Based on this exploration, we have a general idea of how the modern board games works, and how light is used in current social board games as well as in other similar fields, which is the inspiration to explore the way that light could be used to enhance the social board gameplay experience.

Based on the gathered information, several ideas of integrating light as a gameplay element into a certain board game come up. As timer is indeed a quite common element that makes up the board game, we choose timer to be our study object for the further exploration.

After determining the study object, a research about timer is conducted in order to have a knowledge of in what way timer is used in different board games. A simple classification of the timer usages is created based on the information collected from the timer research. Several light extended timers with different light effects are designed and implemented for each timer type.

Before the final formal controlled experiments to evaluate the design, a pilot test is carried out in order to choose several timers with better effect for the final formal experiment. After the pilot test, five lighting based timers are redesigned and selected to be evaluated in the formal experiments according to the participants’ feedback. Qualitative and quantitative data are collected during and after the experiments. The main methods for collecting data in this project are questionnaires, focus groups interviews, audio recording and direct observations. Mathematics and statistics are used to process and analyze the data. Then we summarize the results and make the conclusion.

At the end, based on the results, we redesign the timer, come up with a commercial application of the lighting based timers and provide a guideline of designing and developing light extended timers for social board games.
1.6 Delimitation

In chapter 3, we frame the design space and propose 4 types of timers to be our design object: the turn-taking timer, the reminder timer, the warning timer and the combination timer of warning and reminding timer. And we present several timer modalities and devices, such as countdown timer and DGT Cube 6-Player Game Timer that are used for accurately timing in chess game. Since there is less requirement to make the board game players perceive the accurately timing second by second in real life, the timer that is used in the chess game for accurately timing is not considered in this project.

1.7 Outline

In Chapter 1, the topic of light extended board games is introduced. We start by introducing the domain of social board games and smart lighting where our topic takes place. Then we explain why we think the combination of board games and lighting could be beneficial. Finally, we propose our research questions and introduce the method we aim to use to tackle these questions.

In Chapter 2, the state of the art research that relates to this project is introduced. We outline the fields of pervasive games, the application of smart light, light enhanced board game, as these fall the closest to our research topic. Then we explore the the possible ways that light could be used as a gameplay element in board games.

In Chapter 3, we introduce the method and process of design and development of the lighting based timers. We introduce the research of timer, categorize the timers based on the research. Several light effects are designed for each type of timer. At the end, we introduce the development of the light timers, which includes the light setup and technology exploration.

In Chapter 4, the evaluation process is introduced. The light timers were evaluated with 3 groups of 5 players under 6 conditions each. The method used for the evaluation and analysis of the results is presented. After that we go into the details of the different conditions and report their results.

In Chapter 5, the results and their implications is discussed.

In Chapter 6, the light effect are redesigned based on the results and a guideline of designing the light effect for timers in social board games is provided. Examples about designing for the light timers based on the guideline are given. At the end, an example of a commercial application of the lighting enhanced timer for board games is presented.
In Chapter 7, a conclusion of this project is made and potential future works are listed.
Chapter 2

Related work

In this chapter we introduce the state of the art research that relates to our project. We outline the fields of pervasive games, the application of smart light, light enhanced board game, as these fall the closest to our research topic. Then we explore the possible ways that light could be used as a gameplay element in board games.


2 Related work

2.1 Pervasive game

A pervasive game is a video game where the gaming experience is extended out in the real world\[18\] or where the fictive world in which the game takes place blends with the physical world\[5\]. Pervasive or hybrid games bridge the physical and virtual worlds by integrating the physical context such as players, locations and real-world parameters into the game experience. This kind of game combines the best of both worlds by accentuating the direct interaction between players while presenting a computer logic that keeps track of the game, which is similar to one of the goals of this project: uniting the advantages of computer games with the social advantages of board games.

2.2 Modern digital board game

Although the light extended board games is still a rather unexplored field, there has been some interesting research about board games extended by digital technology. In the work of Al Mahmud et al.\[2\], a digital tabletop game is designed and developed by project visuals on a table, which was used as the board of the game. As with the normal board games, the game was controlled by tangible pawns. The results of their evaluation showed that the player not only enjoys playing the digital game, but also enjoys the immersive experience created by the interactive visual effects which is provided by the projection.

In the work of Wallace et al.\[21\], they explored whether the addition of automation enhances or detracts from the game experience. The gameplay of the board game Pandemic was compared across different levels of automation. The results of the study reveals that automating routine activities like shuffling cards and moving pawns decreased players’ effort. The automation changes the game flow. Players consulted the rulebook less often in the high automation interface. While game automation can provide advantages to players, it can also negatively impact enjoyment, game state awareness, and flexibility in game play. The authors interpret this result as the design considerations in adapting board games to the digital platform.

The state of art of the modern digital board games gives us inspiration when exploring the light enhanced board games. For example, the turn-taking timer is designed to be an automation system in chapter 3 and shows a excellent performance in the experiments (in chapter 4).
2.3 Light enhanced user experience

Knowing how the light enhances user experience in other fields can inspire the design part for this project. Light is surrounding humans everywhere and is needed to function in daily life. Light not only has an effect on visibility, health and well-being, but also arouses emotional reactions and creates certain atmospheres. As a result of the technology development, the function of light today has gone beyond its basic usage of illuminating an area when there is insufficient daylight. Furthermore, nowadays, there are millions of different colored lights that are attainable for us to create numerous light effects for various usages.

Previous research [8, 22] has shown that music and movies enhanced by dynamic light effects provide more enjoyable and immersive experience. Ambient lighting system has also been used in television sets to generates dynamic light effects around the television set that correspond to the video content, which brings about an extension of the displayed colors, offering a larger perceptual view as well as a higher sensation of presence[19].

Light has also been used to enhance the video games. In the work of Brett et al.[14], a proof-of-concept system called IllumiRoom is presented for augmenting the physical environment surrounding a television with projected visualizations to enhance traditional gaming experiences. Besides, the Philips Hue wireless lighting system creates the opportunity to not only control customize your lighting with an app, but also to create immersive new gaming opportunities when combined with an Xbox One.

2.4 Light enhanced social board game

There are some commercial board games out on the market that use light in some way or have digital components. One example for that is the Operation game. Players have to use their hand-eye coordination skills to remove plastic ailments with a pair of tweezers without touching the edge of the cavity opening. In case of touching, they get a feedback in a form of light and sound.

Apart from acting as a feedback, light is also used in some board games for decoration purpose. One interesting example is the Terrain Tech Power Grid. “Our technology will allow you to use light and animation throughout your entire miniature board game terrain without wires or batteries! Now you can have cinema quality lighting and even

---


---
animated game pieces. Animated? Yes! We even make wireless motorized terrain props, and a lighted base that will light up your miniatures and make them compatible with our wireless power.”

In Balint’s work [28], a study on using lighting to enhance the gameplay of modern board games is presented. The author explored the possible roles that light could play in board games and proposed three types of roles that lighting could play in board games to enhance the gameplay experience:

- Ambiance support for decorative purposes. For example, creating thematic atmosphere, interactive light effects.
- Gameplay elements. Gameplay elements here includes thematic timers, thematic indications, randomly triggered gameplay elements, challenge caused by special light condition.
- Game tools such as lighting objects that players can interact with.

A light extended board game prototype is designed in order to evaluate several ambiance support and gameplay element role concepts. The test verified that the light enhances players experience when used in the board game while some ambiance support also distracted players. Thematic indications enhance sensory immersion, and randomly triggered elements can make the game more exciting by causing surprise and uncertainty, while reducing player effort.

2.5 Exploration of light modalities in board games

According to Balint’s work, we focus on the role of gameplay elements that light could play in the board game. Then we explore multiple ways that light could be used as gameplay elements in board games.

The color you see for an object depends on the mix of light frequencies that reach your eye. That mix, in turn, depends on two things: the frequencies that the object absorbs, and the frequencies in the original light source. Therefore, differences in light sources causes colors change when you change the light source. This phenomenon gives us inspirations that we can take advantage of this feature of light to create new dimension for the board games. With the help of light, some objects or some area on the board can change between visible status and invisible status. In this way, light plays as randomly triggered gameplay elements and challenge caused by special light condition (light roles proposed in Balint’s work), revealing clues, setting or removing obstacle on the board, making the fast track on the board visible and so on.

Dice and spinner are gameplay elements that are frequently used in board games to formulate random numbers or colors and trigger some events. This is a potential area
to be enhanced by light. Through mapping different colored lights to the correspond events, light can be used to trigger random events in the board game. In some board chess games, the board is partitioned by different colors, and light can be used here to replace the colored dice or spinner to decide which colored area the player can go to.

Timer is also a frequently used gameplay element in board games for time control. Timer speeds up the game process to some extent as well as creates some tension to the players. The timer in board games could be enhanced by using light to visualize the phases of timers such as the start, the passage of time and the end of the timer. And the rules of the board games are often connected with timers. Thus, light enhanced timers can provide a great potential area to create new games with new mechanics. In this project, we choose timer to be our study object. In addition, studying how the light effect could be used to indicate time and how the light effect affects people will also contribute to explore other roles of light, such as the ambient light design.
In this chapter we introduce the method and process of design and development of the lighting based timers. We start by explaining the method of acquiring our information, then briefly introducing the design and development process. After this we introduce the research of timer, summarize the usage of timer in board games and categorize the timers based on the research. Then, several light effects are designed for each type of timer based on their characteristics. We close this chapter by introducing the development of the light timers, which includes the light setup and technology exploration.
3 Design and developing of lighting based timers

3.1 Method

Board game aficionados are quite active on the Internet, in some forums and social media. Therefore, a key source of collecting information about board games is the discussions and opinions on these forums. The website BoardGameGeek\(^1\) is one of these forums, which is a popular international community with more than 1,000,000 users, as of February 18, 2015. Its database holds reviews, articles, session reports, images, videos, and files for over 84,000 different games and expansions, and over 23,000 game designers \(^23\). Apart from the academic sources, BoardGameGeek is the main source of access to research information for this project.

The design and development process follows an iterative design process, which is a cyclic process of designing, implementing, testing, evaluating and refining the process. Iterative design is commonly used in the development of human computer interfaces. This allows designers to identify any usability issues that may arise in the user interface before it is put into wide use. Thus, when properly applied, iterative design can make the significant cost savings possible as well as ensure a process or product is the best solution possible \(^17\).

In this project, we frame the design space for lighting based timers by outlining the domain of timers used in board games and categorizing the usage of timers in different board games. 13 lighting based timers in total are designed and implemented during the first stage.

3.2 Timer research

3.2.1 Usage of timers

Timer is quite a common element used in the board games, which is usually used for timed tasks, time control during the gameplay and also connected with the rules of the board games. “Egg timer” (also known as countdown timers) are usually used in the board game, which have to be launched and paid attention to by the players. By enhancing the social board games digitally, the timers can be automatic and the light effects can be used to visualize different phases such as preparation of the task, starting the task, passing of time and the end of the task. To provide more insight into timer usage, we study on how the timer is used not only in the board game but also in other related field that timer is frequently used such as computer video game, TV show and so on.

Reminder timer

\(^1\)BoardGameGeek - http://www.boardgamegeek.com
3.2 Timer research

When the timer is used for timed tasks, it is common to see that players are indicated how much time has left for them to finish the task. For example, in the TV game show, when a one-minute countdown timer is launched, the host or hostess always reminds the players in the middle of the timer as well as the last 10 seconds to help the players manage their time to finish the task. The similar scenario also appears in the gameplay of board games and computer games.

We name this kind timer the *Reminder timer*, which gives the players an indication that something is going to happen and how much time is left for the task. The *Reminder timer* provides subtle time-pressure to encourage the player to manage their time wisely and not procrastinate too much.

**Warning timer**

On the contrary, compared with the *Reminder timer*, a *Warning timer* is not entirely the polar opposite, but it is close. The *Warning timer* is usually used for a short duration time, attempting to create tension, panic, and excitement all in one frantic warning. If the *Reminder timer* says “The bomb is going to explode in one minute”, the equivalent information expressed in terms of a *Warning timer* could be “Hurry up! The bomb is exploding! Go Go!”.

The *Warning timer* puts a considerable time-pressure on the players to make the players react quickly to finish the task as well as create much more fun by making people feel tense and excited.

**Time control**

Timers are also usually used for time control in board games as a support for the rules. A time control is a mechanism in the tournament play of almost all two-player board games so that each round of the match can finish in a timely way and the tournament can proceed [26]. Time controls are typically enforced by means of a game clock.

The right method to use a game clock to regular games varies considerably. Few of them are listed as follows.

- **Sudden death.** This is the simplest method. Every player is assigned a fixed amount of time for the whole game. A player loses the game when his main time expires.

- **Hourglass.** This method is similar to how an hourglass works: sand from one side empties and fills into the other side. While player 1 is making a move, his time is decreasing and the player 2’s time is increasing. But the sum of the two players’ time always keeps the same. The game is over when one of the players runs out of time.
• **Overtime formats.** Here there are two domains that consist of the game time: the main time and the over time. Reaching a fixed number of moves can trigger the gain of bonus time.

**Turn-taking control**

Since social board game is an activity for multiple players, turn-taking is an essential part of the game. Usually, players take turns to decide and take a move. To speed up the game process and create some tension for players, each player is assigned a fix amount of time. When one player’s time runs out, the next player’s timer will start seamlessly.

### 3.2.2 Physical and digital timers

In section 3.2.1, the current usage of timer in different board games is researched and introduced, and we have an overview of the functions that timer performs in board games. Apart from the functions of timers, in order to have a deeper understanding of the timer usage and derive inspiration from them, a research on physical and digital timers used for board games is performed.

**Egg Timer and Sand Timer**

These timers are very common devices used in board games, with the basic functions of measuring the passage of time.

**Chronos Chess Timers**

As shown in Figure 3.1, the Chronos chess timer has become a standard in the chess games and is the very best chess clock being sold today. There are two buttons for the two players to control the timer and the passage of time is shown on the LEDs screen.

![Figure 3.1: Chronos chess timer](image1)

![Figure 3.2: DGT Cube 6-Player Game Timer](image2)
3.3 Category of timers

DGT Cube 6-Player Game Timer

The DGT Cube 6-Player Game Timer[^1] is a commercial product of the company Digital Game Technology (DGT), which is a six sided game timer suitable for any table top game or board game with up to six players. As shown in Figure 3.2, the DGT Cube provides each player their own clock on one of the six sides to keep track of his or her time. This timer has five different timing options such as counting down the allotted time per game or counting down the time per move.

A motion sensor embedded in the device ensures that only the clock facing upwards is running. Just by simply turning another side up and the next player’s clock will start to run automatically. To pause all the clocks, players need to place the cube in its base and interrupt the game.

Mobile application of timer

As mobile phone has become a daily necessities for people, there are a lot of mobile applications of timers published on the app store. For example, an application called Turn Timer allows players to quickly and easily limit the time players take for their turn in games. Turn Timer will make a short beep at 1 minute, 30 seconds and 15 seconds remaining and beep for every second remaining in the last 10 seconds so players always know how long they have without having to look at the screen.

3.3 Category of timers

Based on the above research on how timer is used in current board games, we have learned that some timers are used mainly for reminding users the passage of time while some timers create much more pressure, tension and also a lot of fun for players. Normally, timers works in conjunction with the game rules such as turn-taking, gaining bonus time and so on.

To facilitate the later design and development of lighting based timers, a classification of the general usage of board game timers is created according to the research in section 3.2. The types of timers that are chosen as the design objects in this project are as follows:

- **Reminder timer.** This kind of timer indicates players the passage of time in due time and assist the player to manage their time wisely and not dawdle.

- **Warning timer.** The Warning timer attempts to create tension, panic, and excitement during the gameplay as well as produce a lot of fun for players.

• **Turn-taking timer.** The *Turn-taking timer* works as a part of the social board game mechanics. Each player is assigned an amount of time to make a move or decision. When the active player’s turn is over, the next player’s timer will start automatically.

### 3.4 Light effect design for timers

Based on the research on timers usage in board game, we categorize this usage into three types of timers for the subsequent research: the reminder timer, the warning timer and the turn-taking timer. In this section, various light effects are designed for the characteristics of these three types of timers.

#### 3.4.1 Exploration of light characteristics

The human eye is able to perceive light, which is an electromagnetic radiation of a wavelength between approximately 380 and 780nm [6]. Light entering the human eye is projected on the rod and cone cells of the retina [15]. Rod cells support vision at low light levels while cone cells support color vision and vision at normal light level. Three types of cone cells exist, which are sensitive for short, medium and long wavelengths. These cones support the vision of red, green and blue colors in the visible spectrum, which is called trichromatic color vision [27]. By combining the signals of the three cones, a variety of colors can be perceived by the human visual system.

![Figure 3.3: Schematic representation of the human eye, source: (Phillips Lighting, 2014)](image)

Color can be expressed in three visual characteristics: (1) brightness or lightness, (2) saturation and (3) hue [16, 10]. Brightness can be defined as the perceived amount of light, making a distinction between bright and dim light. Saturation refers to the
3.4 Light effect design for timers

visual sensation according to which the perceived color appears to be more or less chromatic. Hue, the last characteristic, distinguishes between colors by name, e.g. red, blue, green, yellow and so on, related to the dominant wavelength of the visible spectrum.

All the colors that we can perceive can be described by using the terms red, yellow, green, blue, and their combinations \[1, 12\]. Color researchers consider red, yellow, green, and blue to be basic colors \[4\]. Light also has an effect on humans’ emotions. The shorter wavelengths (which we call “blue”) tend to make us calm, whereas longer wavelengths (yellow, orange and red) make us more alert. The most saturated red color makes people more tense, compared with the other colors.

Another essential characteristic of dynamic light is the flash of the light. With different flash frequencies, light can be used to represent various signals. Flashing once can mean a signal that something happens while flashing very fast can represent entering into a danger state.

For the subsequent design of light effect for timers in board game, we summarize the basic characteristic of dynamic light as follows:

- Color changes
- Brightness changes
- Saturation changes
- Flash frequencies

Designing the light effect for timers can be taken as designing the visualization of different phases of the timer, including the preparation for the task, start of the timer, passage of time and the end of the task. In the next three sections (section 3.4.2, section 3.4.3 and section 3.4.4), we will respectively design corresponding light effects for the reminder timer, warning timer and turn-taking timer based on their features as well as the light characteristics.

3.4.2 Reminder timer

As we have mentioned in section 3.3, the reminder timer indicates players the passage of time in due time and assists the player to manage their time wisely and not dawdle. Thus, the light effect for the reminder timer ought to remind the players at the right time with a quite noticeable signal. There are two ways of reminding the players of time-passing during the gameplay. One is reminding the players the passage of time roughly, letting them know which status they are in. The other way is to remind the players the specific time that has passed or left for them.
To have a better understanding of the light effect, we arrange a meeting with Sekulovski [7], who is a research scientist of Philips Lighting working on the light perception fields, to discuss about designing light effect for different types of timers. From the discussion, we learn that colors with names like red and yellow is more noticeable compared with brightness and saturation. In addition, from the aspect of dynamic effect, the light flash shows a more noticeable effect than gradual change.

For reminding time passing roughly, color changing is used here to indicating the passing of time. The light changes gradually from green to yellow, orange and finally ends in red, indicating that the left time changes from sufficient to inadequate. Different color represents different status during the timed task. And this color design is connected to people's cognition in daily life, as color red usually represents danger and stop while green means safety.

As for indicating the passage of time specifically, for example reminding players every 10 seconds in a 30-seconds timer, light flash is used here to highlight every 10 seconds.

To present the light effect in a more intuitive way, we illustrate the ideas with figures 3.4 and 3.5.

![Figure 3.4: Reminder timer with color changing light effect](image)

### 3.4.3 Warning timer

Warning timer aims at creating tension and excitement in the gameplay. As the most saturated red is perceived as most tense, we use color red for the light effect design of the warning timer. Brightness changing and flash frequency changing are used here to indicate the passing of time.

**Brightness changing**
3.4 Light effect design for timers

Figure 3.5: Reminder timer with highlighting light effect

We list 8 possible ways of brightness changing to show the passing of time as shown in Figure 3.6.

Since the light effect (a) and (b) are similar with (c) and (d), while the light effect (c) and (d) are more noticeable than (a), (b). At the end, we remove the light effect (a) and (b), and choose the last 6 ways of brightness changing for later implementation and pilot test.
**Bomb timer**

As the Bomb timer is used in the context of the corresponding board games to create a tense and panic atmosphere, we also design the light effect for the bomb timer to simulate the explosion effect, as shown in Figure 3.7.

![Figure 3.7: Bomb timer with explosion light effect](image)

**Flash frequency changing**

Flash is a noticeable light effect. Here we use flash frequency of light to indicate the passing of time. People always feel okay at the beginning of the timing while feel tense, worried and eager to finish the task when they are running out of time. Thus, as shown in Figure 3.8, the light effect we designed here is flashing faster and faster to make people more and more tense.

![Figure 3.8: Warning timer with the light effect of flashing faster and faster](image)

Another light effect designed is shown in Figure 3.9. The light timer won’t flash until the last few seconds come, suddenly frightening the player.
3.4 Light effect design for timers

3.4.4 Combination of reminder and warning timer

We have discussed about the light effect design of the reminder timer and warning timer in section 3.4.2 and 3.4.3, and it is also interesting to know what the effect could be if we combine the reminder feature and warning feature in one timer. In Figure 3.10, an example of the light effect design for a combination timer is presented.

The light flashes regularly in blue color and highlight every x seconds in half saturated red color for the main phases. At the end several seconds, the light flashes in most saturated red to give the warning signal.

Figure 3.11 shows another combination timer that uses two types of light: the ambient light displays the reminder light effect while the Hue Go shows the warning light effect at the same time.
3.4.5 Turn-taking timer

Turn taking is an essential part of social board games. All the players take turns to do some task or make a decision. However, when the amount of players rises, it is common that some players lost track of the turn and have to ask other players whose turn it is, which kind of interrupts the gameplay. To reduce the memory burden for players and enhance the flow of the gameplay, we think of using lighting based timer to tackle this problem.

Color names are used here to identify different players as “ID color”. Players just need to remember their own color. When the timer light flashes in their “ID color”, it means that this is his or her turn to make a move. The next player’s timer will start automatically when the previous player’s time is up. Players can also end their turn by flipping their phones or pressing a button to end their turn and start the next player’s timer automatically. To indicate next player his or her turn is coming, when one turn is over, the light won’t change to the next color directly, but will change to white color and then to the next color gradually. In this way, players can have a little preparation for their coming turn.

As shown in figure 3.12, we give an example of how this kind of lighting based timer works in social board games. There are three players who are assigned “ID colors” red, yellow and green separately. Firstly, the light timer flashes in red, and the “red” player takes his turn to make a move. When “red” player’s time is up, the light timer
3.5 Developing of timers

In the previous chapter (Section 3.4) we designed different lighting based timers for different types of timer. In this section we are going to present the light setup which is used for visualizing the light effect for each timers we designed. In addition, the technology exploration is also going to be introduced here.

3.5.1 Light setup

In chapter 3, we discussed and designed different light effects for different kinds of timers. Now we need to apply these light effects to the lamps for further study. Philips has launched various kinds of Philips Hue lamps on its products line. It is also interesting to explore how different types of lamps can influence people’s perception with the light effect we designed. Generally, the light can be divided into two categories based on their illuminated area: (1) spot light that illuminates the board like a table in board game, and (2) ambient light which colors the whole room.

Three lights are chosen to be used for further study. We use two lights: Philips Hue Iris (Figure 3.13) and Philips Hue Lightstrip (Figure 3.14) to present the light effect of ambient light, as these two kinds of lights have better performance in coloring the whole room. Philips Hue Go (Figure 3.15) is used to be placed on the table as a spot light.
3 Design and developing of lighting based timers

Figure 3.13: Philips Hue Iris

Figure 3.14: Philips Hue Lightstrip

Figure 3.15: Philips Hue Go
3.5 Developing of timers

3.5.2 Technologies exploration

In order to control the Hue light remotely, we did a research on the technologies that could be used in this project. Here we introduce three tools or platforms for connecting to the Hue light as they offer lightweight and friendly development process.

1. IFTTT Maker Channel[^3]

IFTTT is an abbreviation of “If This Then That”, a free web-based service that allows users to create chains of simple conditional statements, called “recipes”, which are triggered based on changes to other web services such as Gmail and Facebook[^24]. The Maker Channel allows users to connect IFTTT to their personal projects. With Maker, you can connect a “recipe” to any device or service that can make or receive a web request.

2. Philips hue SDKs[^4]

Philips hue developer program provides Philips hue API, hue SDKs for iOS and android and other 3rd party libraries, tools and software.


Evothings Studio is a mobile application enabler for the industrial Internet of Things (IoT). With built-in support for connected things and libraries for common IoT technologies, users can develop real mobile apps for the app stores in JavaScript.

We tested the IFTTT method, but found there is a delay between “triggers” and “actions”. As for the Philips hue SDKs, we can only choose one kind of platforms to develop, iOS or Android SDKs. Finally, in this project, we choose the Evothings Studio to be our development tool due to its rapid workflow and cross-platform publishing. Since it’s based on the web technology, when you have finalized the development, you can build apps for Android and iOS from one code base and publish to the app store. Therefore, there will be no limitation to the mobile device system that the players should use when playing in the social games with light enhanced timers.

[^3]: IFTTT Maker Channel - https://ifttt.com/maker
[^5]: Evothings Studio - https://evothings.com
Chapter 4

Evaluation of lighting based timers

The previous chapter discussed the design and development of the light extended timer. The light timers designed were evaluated with 3 groups of 5 players playing the game on 6 conditions each. In this chapter we explain the method we used for the evaluation and analysis of the results. After that we go into the details of the different conditions and report their results.
4 Evaluation of lighting based timers

4.1 Method

4.1.1 Evaluation

In chapter 3, we have discussed the characteristics of the light and designed various light effects for different types of timers. In order to pick up some light effects with better performance and optimize them for the formal experiment, a pilot test was conducted to collect people’s feedback of all the light effects. In the pilot test, we invited five people to observe all the light effects and play some small social games using the lighting based timers. A focus group discussion was held after the pilot test and qualitative data was collected during the discussion. At the end, five lighting based timers were selected and redesigned for the further formal test.

The method chosen for the formal test was similar to the one which was used to evaluate a digital tabletop game for senior citizens in Al Mahmud’s work [2]. Within subject test were conducted for 3 groups of 5 players (15 participants in total). All the participants were interns at Philips Research and Development Center, aged 22 to 27, 4 female and 11 males. In addition, the 5 players in each group know each other well, in this way we avoid the interference that may be caused by the unfamiliarity between players in one group.

Each group participated in the board game play with 6 conditions, which including the 5 conditions with different lighting based timers and one condition that uses a normal egg timer instead.

To evaluate the effect of the different lighting based timers on the gameplay experience, both of quantitative and qualitative data was collected. For collecting qualitative data, the core module of Ijsselsteijn’s Game Experience Questionnaire [13] was used. Since the sample size of the experiments was rather small, the results of the questionnaire are quantitatively weak. Using this questionnaire was mainly to reveal indications that show difference between playing the games with the different conditions. To complement the results of quantitative questionnaire with qualitative data, we also used the observation method and took notes on the gameplay. What’s more, a group focus discussion was conducted at the end of the experiment, where participants reported their experiences. For the group focus discussion we used audio recording to collect information.

4.1.2 Analysis

Qualitative data analysis

Qualitative data consist of words and observations, not numbers. As with all data, analysis and interpretation are required to bring order and understanding. This
4.1 Method

requires creativity, discipline and a systematic approach [20]. For the qualitative data analysis, we went through all the notes we taken through the observation on the gameplay and the audio recording of the group discussion several times. We selected the information which is useful and related to our research questions. After that, this effective information was clustered and categorized by different categories of lighting based timers. Then we analyzed the structured selected qualitative data and summarized the findings.

Quantitative data analysis

The quantitative data was collected from the Game Experience Questionnaire results. The Game Experience Questionnaire [13] consists of three modules that included several dimensions of user experience: core module, social presence module and post-game module. After tapping into the details in each module, we chose the core module as it related to our research questions most. The core module of the Game Experience Questionnaire contains 6 dimensions of game user experience:

- Competence
- Sensory and imaginative immersion
- Tension/Annoyance
- Challenge
- Negative affect
- Positive affect

There are 4 to 6 questions in each dimension that together give a score for the corresponding dimension. As we mentioned before, the sample size of this experiment was not big enough. Thus, the quantitative data we collected only provides indications. The scores of each participant in each condition have been summarized in a spreadsheet. Significance of the differences between the different conditions was determined through ANOVA (Analysis of Variance). But there was no significance produced on the above 6 dimensions of Game Experience Questionnaire, which might be caused by the small samples and the Game Experience Questionnaire where there are some questions designed for video games. Then we just calculated the average value of the 6 dimensions and took the results as a suggestion to see if the qualitative results are in sync with the questionnaire results.
4.2 Pilot test

In the pilot test, we invited 5 participants aged from 22 to 27 to observe all the light effect designed and play some small social games with all the light timers we designed and implemented in chapter 3. After the gameplay, a focus group discussion was held, where participants reported their experience and comments on these timers. The notes were taken during the discussion to record the key information, which is summarized as follows:

1. Flash light effect makes three players feel tense.
2. The light effect of Hue Go is more noticeable, reported by two players and is aesthetically pleasing for four players.
3. Brightness increasing makes one participant feel that time pass quickly compared with brightness decreasing. And two other participants reported that brightness increasing effect aroused their initiative.
4. For the lamp Hue LightStrip, three participants think the light effect with the most saturated color is better than the half saturated one.
5. Four participants reported that the light timers make them think really fast and create tense.
6. Three participants didn’t notice the time passing with the lighting timers very well until the timer was close to the end.
7. For the light effect displayed on two kinds of lights at the same time, four participants complained that it was kind of confusing when two lamp displayed different light effect at the same time.

4.3 Controlled experiments

Based on the feedback from the pilot test, we selected several light effects with better reviews and redesigned them (in section 4.3.1) for the formal controlled experiments.

In this section, we evaluated the 5 redesigned light timers through the social board game “I have never ever”. “I have never ever” is a popular social board game among young people, which is often played during parties. The verbal game is started with the players getting into a circle, and each player have 5 life points which is represented by five fingers. Then, the first player says a simple statement starting with “Never have I ever”. Anyone who has done the action in their lives that the first player has done, will lose one finger. Play then continues around the circle, and the next person makes a statement.
4.3 Controlled experiments

In this experiment, each player was given 10 seconds to say the statement. And we used normal phone timers and the 5 light enhanced timers to time the 10 seconds for each player’s turn.

4.3.1 Conditions

This session had 6 conditions including 5 conditions with various redesigned light timers and one condition without any light effects but with the normal room lighting. The 6 conditions are explained as follows:

1. Condition 1: Play the game using normal phone timers with normal room lighting. (Figure 4.1)

![Figure 4.1: Normal room light effect in the formal experiment](image)

2. Condition 2: Turn-taking timer. (in section 3.4.5)

3. Condition 3: A combination of warning and reminder timer. The light brightness increases to the max value with blue color every 5 seconds and also highlights in red color every 5 seconds. When the light flashes quickly, the time is up. (Figure 4.2)

4. Condition 4: The light effect of condition 4 is the same as condition 3, but uses ambient light which are presented by Philips Hue Iris lamp and the Hue LightStrip.
5. Condition 5: Reminder timer. The light changes its color gradually from green to yellow, orange, then to red and flashes quickly when time is up (Figure 3.4).

6. Condition 6: Warning timer. The light flashes faster and faster and the brightness of the light keeps increasing with the passing of time. (Figure 4.3)

Here we need to indicate that condition 2, 3, 5, 6 used the Philips Hue Go (Figure 4.4) while condition 4 used the Philips Hue Iris lamp and the Hue LightStrip lamp to support ambient light (Figure 4.5).
4.3 Controlled experiments

Figure 4.4: Table light effect in the formal experiment

Figure 4.5: Ambient light effect in the formal experiment
4.3.2 Structure

We divided the participants into 3 groups and ensured that participants from a same group know each other. In the beginning of the sessions, the participants got a short introduction of this project. After that, the rules of the game and the structure of the experiment was introduced to them. Before the formal gameplay, the participants started with a tutorial game to get familiar with the game process. After the tutorial, the participants played again the game six times with the 6 conditions. After playing under each condition, they were asked to fill out the questionnaire we prepared. In the end of the experiment, a focus group discussion took place, where the participants reported their experience and gave comments and suggestions. The order of playing the games with different conditions was random in order to eliminate the order effect. Table 4.1 indicates these orders.

<table>
<thead>
<tr>
<th>Session</th>
<th>Players</th>
<th>Condition orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Group 1: p1, p2, p3, p4, p5(^1)</td>
<td>Condition 3, 2, 6, 1, 5, 4</td>
</tr>
<tr>
<td>2</td>
<td>Group 2: p6, p7, p8, p9, p10</td>
<td>Condition 5, 1, 4, 2, 6, 3</td>
</tr>
<tr>
<td>3</td>
<td>Group 3: p11, p12, p13, p14, p15</td>
<td>Condition 1, 3, 5, 4, 6, 2</td>
</tr>
</tbody>
</table>

Table 4.1: Order of the conditions on the gameplay

4.4 Results

The sessions went without any problems, most of the participants had a lot of fun playing the games with light timers. Overall, the majority of the participants love the light timers idea and gave positive feedback. Although some participants reported that sometimes the light effect kind of distracted their attention, they still thought it created a lot of fun as well as tension and excitement.

“The light kind of messes up your concentration but also makes the game more immersive. It’s harder to play it with light, but also really fun to play with light as it creates more time pressure” [p11]

“The Light effect is really good for gaming, I enjoy it very much, and the buzzer is really annoying.” [p13]

The light effect works well in putting time pressure as well as excitement for the players.

“When the light starts to changing, I feel I am eager to say something quickly. It forces me to think and act really fast.” [p8]

\(^1\)Player IDs are indicated by ‘p’ and a number. For example player one is p1
For some players, it was hard to notice the light effect changing details in the whole duration of the timer when it was their turn. But they always kept an eye on the light during other players’ turn and had fun to frighten the player when the time is about to up.

“Actually I didn’t notice the light for several seconds when I was talking or thinking really hard what to say, but I noticed the light when time was about to up.” [p3]

“Yeah, I agree. I cannot focus on the light when I am thinking hard but I have to say I watched the light change when it’s others’ turn. And it is fun to bully the talking person when the time is about to up, like "Hurry! Hurry! The time is up!".” [p1]

It should be noted that not everyone loves the tension atmosphere, which should be taken into consideration for the further usage of the light timers.

“I really love the idea of using light to time for players, which makes me feel tense and excited, and more active!” [p4]

“I have to say that I hate the feeling being stressed out.” [p10]

Above is the general feedback of all the lighting based timers, in the next few sections (section 4.4.1, 4.4.2, 4.4.3, 4.4.4 and section 4.4.5) we clustered and analyzed the qualitative data in different specific fields.

### 4.4.1 Turn-taking timer

The turn-taking timer got the most positive feedback, the majority of the participants thought this is the most impressive one during the gameplay, as it makes it easy to follow the turn taking. In addition, they like the light effect design for switching “ID colors”. And they also gave some suggestions about the light effect design for turn-taking timers.

“I love the one with traffic light (turn-taking timer) most. I just need to watch the light and know when it is my turn.” [p15]

“I think maybe it is gonna be more fun if the turn-taking timer switches the color in a random order. You will never know when is your turn.” [p12]

“I suppose that the turn-taking timer with the ambient light would work really well. Because it is easier to know the color change and you don’t have to look at the table” [p3]

Some players suggested that the discussion part should be considered for the turn-taking timer, as discussion is an essential and the most fun part for some board games but the turn-taking timer is running continuously and automatically.
“With a white color in the middle (in switching colors) that you can actually say something, because making jokes or talk about what you just said is an essential part of some social games. But the time for discussion is too short in the game.” [p2]

“For this game, people need to talk to each other between their turns, but the light is changing continuously.” [p7]

### 4.4.2 Ambient light vs Spot light

Most participants thought the ambient light creates more immersive experience, aesthetically pleasing and makes players feel more comfortable. It’s easy to follow the light effect changing during the gameplay. While the Hue Go is more noticeable and obvious, and Hue Go creates more tense. But flashing effect on Hue Go kind of distract their attention.

“I prefer the ambient light. It’s more immersive and easier to follow while thinking, because it’s kind of like surrounds you.” [p9]

“I like the ambient light. You don’t need to have a look at the light to see what is happening, you just knew it. But the blinking is still kind of annoying, of course it’s better than blinking on the table lamp. But if you do the ambient light with green to red, it will work out really good.” [p10]

“The light effect on the table light is obvious because it’s put on the table. But it kind of distracted my attention when it started to blink to my eyes, which made me couldn’t think anymore.” [p12]

### 4.4.3 Warning timer

For the warning timer, we use a combination light effect of flashing faster and faster along with the brightness increasing. The majority participants agreed that this light effect gives them the most time-pressure, but kind of annoying at the same time.

“The one that flashes faster and faster made me feel most tense.” [p11]

“The light effect on the table light is obvious because it’s put on the table. But it kind of distracted my attention when it started to blink to my eyes, which made me couldn’t think anymore.” [p12]
4.4 Results

4.4.4 Reminder timer

We intend to use color to represent the different phases of the reminder timer. And it was reported that the color changing from green to red worked well for the participants in reminding the start and the later phase of the timer.

“Yeah, I noticed that. When the light shows green color I know I am safe. And when it’s getting redder and redder, it’s close to the end. Not difficult to tell.” [p5]

4.4.5 Combination timer

The combination timer of reminder and warning uses the combination light effect of highlighting every 5 seconds and brightness increasing. Some players thought the light effect was strong and created much tension. And some players thought the light effect was a little bit complicated, which might mainly result from the short duration of the timer in this game.

“At first, the highlighting effect was annoying to me and it’s too frequent for a 10-second turn. After few rounds, I noticed it was for reminding us five seconds, but the timer is just for 10 seconds. Maybe it would work well if the timer duration is longer.” [p12]

“This light effect is quite complicated for us to perceive. Maybe it’s better to have a simple light effect for such a short duration of timer. But it makes me feel really tense and is quite impressive for me.” [p1]

4.4.6 Questionnaire results

After processing and analyzing the quantitative data acquired from the questionnaire, it was found that the significant difference was shown in dimensions of sensory and imaginative immersion and the time pressure. While the results acquired from the questionnaires are not representative with the low number of samples, they are still in line with what the participants said about the games. Which is, the ambient light creates more immersive experience but less tension; The light effect of flashing faster and faster and the turn-taking timer give the players more time pressure. On the following charts, the results of the two dimensions of game experience under 6 conditions were shown.
4 Evaluation of lighting based timers

Figure 4.6: Sensory immersion of the players when playing social board games with lighting enhanced timers.

Figure 4.7: Time pressure of the players when playing social board games with lighting enhanced timers.
While the previous chapter gave an insight in the test sessions and their results, in this chapter we discuss their implications.
Before we discuss the results, let’s restate our research questions in this project. The topic of this thesis is based on the light enhanced social board games and the research question is: how can different types of lighting based timers enhance the social board gameplay experience? In this chapter, the discussion of the results centers on the research question of this project.

Enhanced immersion and focus

According to the findings, light enhances the social board game gameplay experience by creating an immersive atmosphere, helping players immerse more into the game and forget other distractions.

In this project, light plays a role of timers in social board games, visualizing different phases of the timer. In addition, the timer itself is connected to the game rules. In this case, players have to pay more attention to the light timers, because they need to recognise and interpret the light effect during the gameplay.

Some players reported that they were more focused on the light around the start and end phases of the timer and didn’t fully focus on the light for several seconds when they were thinking hard. However, when it’s other players’ turn, they watch the light changing and have fun bullying the talking person when the light indicates the time is about to up. In general, the finding suggests that the players’ focus is enhanced with the light timer.

Excitement and tension

The light enhanced timers also creates excitement and tension during the game. Time is kind of the thing that we cannot see or touch. Through visualizing the passing of time, players can feel the time passing more obviously from the perspective of visual, which gives players more time pressure and increases player’s feeling of excitement and tension as a result.

According to the results, as for the light effect, brightness increasing has a better effect on making players feel excited while flashing faster and faster create the most tension for players. The turn-taking timer also kind of motivates the players and create some tension, as the players don’t know the order on the first round which creates uncertainty to the game.

More fluent gameplay
According to the qualitative data from the discussions with the participants and the observation during the experiments, the light timers also make the gameplay more fluent, especially the turn-taking timer. With visualizing the time passing, players don’t need to take care anymore about turning on the timers, paying attention to timers and passing on the timer to next one manually, as the start, stop and switch feedback are considered to be obvious. Players just get all the information about timers from the light.

Especially for the turn-taking timer, when there are quite a lot players participating the social game play, it is common that some players who are not focused enough lose the track of the turn taking. With the light timers, players can easily keep track of the turn taking during the game just by remembering their own ID colors, avoiding breaking the game process.

The digital factor of the light timers also contributes to enhance the game flow, as it helps with the automation of the board game mechanics. For example, we implemented a function for turn-taking timer, which is by flipping the phone the timer will automatically switch to next ones turn if the player finishes his or her task ahead of the time.

**Remind time passing**

For reminding time passing, we designed two light effects: color changing from green to red which indicates the time passing roughly; and highlight every fix amount of seconds to indicates the specific time passing. The results of the experiments suggests that the concept of using color to indicate the remaining time works better. As the green color is usually used to stand for safety and okay while the red color usually indicates danger and stop, players recognize the indications of light naturally in this case.

The light effect of highlighting is also quite obvious for players, but they just don’t keep it in mind when they are thinking on their turn. In addition, the duration of the timers for board games are usually less than 30 seconds. Therefore, there is less point reminding them frequently. In stead, reminding players at the middle of the time passing can be considered for the later redesign.

**Ambient light vs Table lamp**

In our research, as different types of lamps can create different light effect, it is also interesting to find how different types of lamps influence people’s experience, which can contribute to the design of the light timers.

The ambient light changes the illumination of the whole room and creates a very immersive atmosphere and experience for players. According to the results, the ambient
light got the highest score in the dimension of sensory immersion of the players, that is the sensation of being surrounded by a completely other reality, that takes over all of our attention \[9\]. Therefore, the light effect of the ambient light is considered to be easier to follow.

Table lamp, in this project we use Philips Hue Go, is put on the table with players surrounded and illuminates the table area. According to the participants’ feedback, the light effect of the Hue Go is more noticeable and obvious. The identical light effect applied on the Hue Go creates more tense compared with the ambient light. But the warning light effect of flashing faster and faster on the Hue Go kind of distracts players’ attention, as the light flashes to the players’ eyes.
In this chapter, we redesign the light effect and give a guideline of designing the light effect for timers in social board games according to the previous evaluation results and discussion. Examples about designing for the light timers based on the guideline are given. After that we give an example of a commercial application of the lighting enhanced timer for board games.
6.1 Redesign

Brightness changing trend

In the previous design of the light effect about brightness, we proposed three changing trends which are illustrated by the lines a, b, and c in Figure 6.1, indicating the brightness increasing, fixed brightness for flashing, brightness decreasing. For the timers with a longer duration, there is an issue that if the brightness increases evenly, the change of the light effect is not that obvious because the brightness range is fixed. As we have discussed in the results, players tend to focus more on the light in the end phase. To make the effect better, we add two lines d and e in Figure 6.1, which indicates that the brightness starts to change when the remaining time is less than half.

![Figure 6.1: Brightness changing trends.](image)

Reminder timer

According to the findings, the light effect of highlighting every fixed amount of time doesn’t work very well and even annoying sometimes, as the board game timers are usually between 10 to 30 seconds. Thus, we still keep the light effect of color changing but add a highlight effect in the middle to indicate players that half of the time has passed.

Warning timer

For the warning timer, the light effect of flashing faster and faster with brightness increasing is kept as it is, as most participants agreed it creates the most tense. In the
6.2 Commercial application

discussion, we mentioned that the light effects with same parameters have different
effect when applied on ambient light and Hue Go. The light effect on ambient
light is less strong compared with Hue Go. Thus, when using the ambient light for
warning timer, the brightness increment ought to be higher to create the tense atmo-
sphere.

Turn-taking timer

To bring the turn-taking timer to next level, we consider to integrate the warning
timer and reminder timer into the turn-taking timer, which adds a new dimen-
sion for the turn-taking timer. For the turn taking, we still use the “ID color” to
identify all the players. As for timing each player’s turn, reminder timer or warn-
ing timer are embedded here, instead of the previous normal breathe cycle (The
light do one smooth transition from the current state to a higher brightness in the
current color to a lower brightness in the current color and back to the original
state.)

For the turn-taking timer with reminder light effect, the light will highlight in the
middle of the time and keeps flashing regularly in the current “ID color” during the
turn. As for the turn-taking timer with warning light effect, the light uses the light
effect of the warning timer we designed in last section (flash faster and faster with
the brightness increasing) but flashes in the “ID color”.

We redesign the light timers based on the results of the experiments in this project.
And all the effect of these redesigned light timers will be tested in the future
work.

6.2 Commercial application

We also consider how to utilize the findings of this project to practical applica-
tion. In this section, a prototype of the light timer application is proposed and
designed for playing social board games. With this application, a customized
set up of social board games with lighting based timer is provided for the play-
ers.

Before playing the game, users input the amount of players, timer duration for each
player and select relax mode or tense mode for the gameplay. The system will assign
each player an “ID color” and generate customized light timers for the gameplay. The
light timer keeps running for a round automatically and continuously. Philips Tap
Switch is used to control the timer during gameplay: switch to next player’s turn when
the previous player finishes his or her turn ahead of time; pause and resume the timer
when they need to have a discussion during the turn taking; start the light timer for
next round; stop the light timer. Figure 6.2 illustrates the interaction process of this application.

<table>
<thead>
<tr>
<th>Input</th>
<th>Process</th>
<th>Output</th>
<th>Timer control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Players amount</td>
<td>Light based timer app</td>
<td>A customised setup for social games with lighting based timer</td>
<td>Switch to next one</td>
</tr>
<tr>
<td>Time duration</td>
<td></td>
<td></td>
<td>Stop the timer</td>
</tr>
<tr>
<td>Tense mode or relax mode</td>
<td></td>
<td></td>
<td>Pause and resume</td>
</tr>
<tr>
<td>Turn-taking mode on/off</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.2: A mobile application of light based timer

6.3 Guideline

In this section, a guideline for designing the light based timers is provided according to the results and discussion in chapter 4 and chapter 5. The characteristics of the lights are listed and explained, which is necessary for designing light effect for timers. The category of the light timers is introduced as well as the suggestions of light effect design for each type of timer. Besides, some other guidance related to the design of light timers is also presented in this guideline.

Characteristics of the lights

- **Hue**
  
  Hues are colors and what hue we see is dependent on the wavelength of light being reflected or produced. Colors with a specific name are easily recognized by people, like red, yellow, green, blue, purple. Colors with shorter wavelengths (which we call “blue”) tend to make us calm, whereas longer wavelengths (yellow, orange and red) make us more alert.

- **Brightness**
  
  We list five options about the brightness change trend as shown in Figure 6.1 in section 6.1. Line a, b and c are proper to be used for short duration timers while d and e are more appropriate to be used for long duration timers. As for the brightness changing ways, there are 3 ways suggested in Figure 6.2.
6.3 Guideline

- **Saturation**
  Saturation is the colorfulness of a color relative to its own brightness. A color’s saturation can be changed by adding white. And changing saturation can create more colors.

- **Flash frequency**
  Flashing is a significant element for creating dynamic light effect and is quite noticeable for people. For the light timers, we list three usages of flashing effect: (1) highlighting at some point to indicate players the time by flashing once; (2) denoting the time passing by flashing regularly; (3) creating tense atmosphere by flashing faster and faster.

- **Types of the lamps**
  The same light effect shows different effect when applied to different types of Hue lamps. For the light timers design, we take ambient light and table light Hue Go into consideration. The ambient light colors the whole room and creates a more immersive atmosphere and experience for people. Furthermore, the same light effect is perceived more gentle on the ambient light when compared with the Hue Go, while the light effect on the Hue Go is more obvious and noticeable.

**Design for different categories of the light timers**

When designing light effect for light timers, it is essential to determine what the timer is used for on the first step. The usages of timers in social board games are categorized into three types: warning timer, reminder timer and turn-taking timer.

**Warning timer**

The warning timer aims at creating tension, panic and excitement for players during the gameplay.

Colors with longer wavelengths like orange and red are suggested to be used as they make us more alert. And the most saturated red creates the most tense in all colors.

Brightness increasing from the middle or later phase of the timer are suggested to used for creating tense, since people tend to focus more In addition, a stronger light effect will be created by increasing the brightness to a certain value in a short duration.

As for the flash frequency, flashing faster and faster works better due to the similar reason that people focus more in the later phase of the time.

The table light Hue Go creates more tense than the ambient light. When designing warning light effect for ambient light, it is suggested to magnify the light effect through
adjusting the parameters like increasing the brightness increment, increasing the flash frequency, using a more saturated red color and so on.

**Reminder timer**

The reminder timer indicates players the passing of time in due time and assists the players to manage their time wisely.

Color changing from green, yellow, orange then to red is suggested to indicating the passing of time, since green usually stands for safety and okay while red is frequently used as a danger or stop signal in people’s daily life. With this light effect, players get to know the remaining time very roughly.

Flashing once for highlighting is suggested to be used for indicating players a specific passage of time. What’s more, highlighting in the middle of the timer is recommended, as people won’t calculate the highlight times during the gameplay.

**Turn-taking timer**

The turn-taking timer works as a part of the social board game mechanics. Each player is assigned an amount of time to make a move. The next player’s timer will start automatically when the current player’s turn is over.

“ID color” is suggested to be used for turn-taking timers, which means using different colors to identify different players. Players just need to remember their own ID color. When the light shows one player’s ID color, it is his or her turn to make a move. Between player’s turns, the light color changes from Player 1’s ID color to white (by decreasing the saturation value) for the last two seconds of the Player 1’s timer, which means the Player 1’s turn is close to the end. After that, the light color changes to the Player 2’s ID color gradually for two seconds, which means the Player 2 need to prepare for his or her turn. When the the light shows the most saturated ID color for Player 2 and starts to flash, it’s Player 2’s turn to make a move.

For the normal turn-taking timer, the light just flashes in some ID color regularly during one player’s turn to denote the passing of time. It is also a good idea to integrate the warning light effect and reminding light effect into the turn-taking timer.

For the turn-taking timer with reminder light effect, the light highlights in the middle of the time and keeps flashing regularly in the current “ID color” during the turn. As for the turn-taking timer with warning light effect, the light flashes faster and faster in the “ID color” with brightness increasing.

When choosing colors to identify the players, it is suggested to use the most saturated colors that can be named accurately by people, such as red, orange, yellow, green, cyan, blue and purple. And the saturation can be changed into half to create more colors if the amount of players are between eight to fourteen. The ID color
idea doesn’t fit for the situation that there are too many players like more than 15.

**Timers with different durations**

For the timer with short duration, the light effect should be clear and simple. Only one type of the lights, either ambient light or the table light, should be considered to display the light effect. Otherwise, the complicated light effect will confuse players and burden them with recognition issues.

If the timer has a long duration, combinations of the ambient light and table light, along with the warning light effect and reminding light effect can be considered to design the light timers.

### 6.4 Examples

In this section, we give an example of designing the light timers for a social board game according to the guideline. The game we choose is the mafia game. Mafia [25], also known as Werewolf, is a social board game modelling a conflict between an informed minority, the mafia, and an uninformed majority, the innocents. At the start of the game, each player is secretly assigned a role affiliated with one of these teams. The game has two alternating phases: night, during which the mafia may covertly “murder” an innocent, and day, in which surviving players debate the identities of the mafia and vote to eliminate a suspect. Play continues until all of the mafia have been eliminated or until the mafia outnumbers the innocents.

In this example, there are 9 players and each player is assigned 15 seconds to explain why they are not mafias and who could be the mafia. A tense and immersive atmosphere is needed for this game.

As players take turns to talk, the turn-taking timer is chosen as the base timer used in this game. Then we assign “ID colors” to each player. The 7 basic colors with the most saturation as well as 2 basic colors with half saturation are going to be used, which are red, orange, yellow, green, cyan, blue and purple, light red and light blue. To make players feel more tense and excited, the warning light effect is going to be integrated in the turn-taking timer. For each player’s turn, the light flashes in the player’s “ID color” and with a higher and higher flash frequency. In addition, the ambiance light is going to be used here to create an immersive atmosphere. In a word, a turn-taking timer with warning ambient light effect is suitable to be used for this game.
In the previous chapter 4 and chapter 5, the evaluation of the different types of light timers were introduced and discussed. This chapter summarizes the key findings of this project and concludes the thesis in listing the possible next steps of the research.
7 Conclusions

7.1 Key findings

The goal of the thesis work was to explore how light can enhance the gameplay of modern social board games as a gameplay element. After exploring the light modalities that could be used in the social board game, we choose timer to be our study object. Therefore, the study focused on investigating how different types of light extended timers affect people and enhance the gameplay experience for social board games. We propose 3 categories of timers after researching the usage of timers in the modern social board games. These are the reminder timer, the warning timer and the turn-taking timer. In this thesis, we also explore the combination timer which is a mix of the reminder timer and warning timer.

After framing the design space of the light extended timers, we designed and implemented several light effects for each type of timer. A pilot test was conducted to collect feedback and choose several light timers for the subsequent redesign and formal experiments. The experiment was carried out within 3 groups of 5 participants, under 6 conditions. The evaluation of the light enhanced timers obviously showed that visualizing the time passing by light create an immersive experience for them, and the varying light effect makes them feel tense, excited and also creates a lot of fun. The results suggest that the players put more focus on the gameplay not only in their own turn but also in others’ turns.

The results were also analyzed for each type of timer. The turn-taking timer got the most positive feedback, as it helps the players to keep track of the turn taking and influence the game flow. The light effect of warning timer and reminder timer works well according to the result of the experiment. Regarding the combination timer, due to the short duration of each player’s turn, the light effect is a little bit complicated for some players to recognize.

The findings about how the light effect affects players and how they perceive the light effect is interesting and worthy to be noticed for further study. Flashing faster and faster creates the most tense in all the light effects. When the light highlights several times to indicate the time passing, players usually don’t calculate the passing of time by the highlight amounts. In addition, players usually notice the start and the end phase most, as they tend to ignore the light effect changing when they are thinking hard. And some light effect with various changing seems to confuse the players. When designing the light effect for timers, the duration of the timer is also a significant factor that need to be taken into consideration. We also find that the ambient light and table light have different effects on people. The same light effect has a stronger visual effects when displayed on the table light Hue Go than the ambient light, but kind of distracts players’ attention while flashing. The ambient light is easy to follow as it surrounds you and create a more immerisive experience compared with Hue Go.
At the end, we summarize the findings of the study and give guidelines (in chapter 6) about how to design light effect for light enhanced timer based on those findings. A commercial application prototype of light timers is proposed for the general social board games with timers. It provides a customized setup for the social board games with light timers as well as an automation system for players to play the game.

7.2 Future work

Throughout the previous chapters a few future directions for exploring light extended board games further have been pointed out. These were mainly about evaluation the redenigns and updating the guidelines.

Further exploration could focus on the combination timers using both of the ambient light and table light. Therefore, for the long duration timer, the combination timer could create better experience by combining the benefits of the two types of light.

In addition, the application we proposed in section 6.2 is also needed to be developed and evaluated to see how the automation system helps to enhance the game flow. And exploring the interaction ways to control the timer is also a potential future direction.

Apart from the further exploration of light enhanced timers, the other light modalities of gameplay element in board game, as we have discussed in section 2.5, are also worthy to be explored more. For example, taking advantage of the light features to create challenge caused by special light condition, reveal the clues, set or remove obstacle on the board, make the fast track visible and so on. What’s more, light itself can act as the gameplay element like integrating color creating or color guessing in the gameplay.

The area of light extended board games offers numerous potentials. There are much directions to explore beyond the ones that were presented in this thesis. Besides using light to enhance the already existing board games, new types of games could be created in the future.
References


References


