Exploring Mind-Wandering Experiences in Gameplay

by

Kateryna Morayko

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Mind-wandering—spontaneous thoughts—is a common process that can interfere with attention and focus, but can also be beneficial for mental health, creativity, learning, and (in some cases) task performance. Digital games may offer a unique medium to leverage the benefits of mind-wandering, yet there has been little to no investigation of mind-wandering on player experience. Therefore, it is unclear whether and how players experience mind-wandering and whether it should be encouraged by game designers. We conducted an observational study of people playing digital games from a list of games available to the researcher in three categories: one they found relaxing, a second in which they lost track of time while playing, and a third that they spent most hours playing. Results of the thematic analysis of eye-tracking data and gameplay, as well as a quasi-random experience sampling probe, revealed that eye-tracking and gameplay data should be viewed together in context for the understanding of mind-wandering experiences during gameplay.

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Dedication

This thesis is dedicated to my family and friends who supported me throughout this journey.

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Chapter 1

Introduction

> Some writers describe the possessor of this power of vivid imagination, whereby things, words and actions are presented in the most realistic manner, by the Greek word εὐφανταστος and it is a power which all may readily acquire if they will. When the mind is unoccupied or is absorbed by fantastic hopes or daydreams, we are haunted by these visions of which I am speaking to such an extent that we imagine that we are travelling abroad, crossing the sea, fighting, addressing the people, or enjoying the use of wealth that we do not actually possess, and seem to ourselves not to be dreaming but acting. Surely, then, it may be possible to turn this form of hallucination to some profit. (Quintilian, 1921)

It is unknown how long the concept of mind-wandering as we understand it today has been around, but fantasizing of future happenings has been recorded in writing as early as ancient Greece. Mind-wandering has historically been eluded to in different mediums, including art, philosophy, and science, dominating the conversation negatively. Colloquially, daydreaming is used in place of mind-wandering and is defined as a series of pleasant thoughts that distract one's attention from the present. Often, it is used with the term "attention" to compare it to other activities. If the task being performed is deemed necessary, such as sitting in a class or at a meeting, then daydreaming is considered a bad thing. The daydreamer is spacing out and not paying attention. Conversely, if the activity is considered leisurely, such as taking a walk, daydreaming is appropriate for the context. However, if the content of the thoughts involves work or study during the walk, then daydreaming is good. This daydreamer is creative; they are perhaps experiencing a "Eureka!" moment.

In my research, I explored mind-wandering behaviour in digital games, with the intent of understanding how designers could use this knowledge to target positive mind-wandering experiences and leverage the potential cognitive benefits that mind-wandering can provide. Playing digital games is an activity that is engaged in by children and adults alike. Learning about how digital games affect players can contribute to better game design practices and thus provide better player experience. In this thesis, mind-wandering is treated as an ordinarily occurring behaviour that can shape people's experience when engaging in various day-to-day activities, as well as being shaped in return by environmental experiences.

In the context of this thesis, mind-wandering is used as an umbrella term for words such as: daydreaming, task-unrelated thoughts, stimulus-independent thoughts, zoning-out, and conscious fantasy, which have been used to refer to the concept of spontaneous thoughts (Christoff et al., 2016). Mind-wandering has been studied in various academic fields such as psychology, neuroscience, mental health, and human-computer interaction (HCI). In recent years, evidence has accumulated that not only is this a common behaviour reported through experience sampling and questionnaires (Stawarczyk et al., 2013; Stawarczyk et al., 2011), but a unique brain network has been directly linked to the function of mind-wandering (Andrews-Hanna, 2012; Fox et al., 2015; Mason et al., 2009; Poerio et al., 2017; Xu et al., 2016).

Despite the evidence of its prevalence in day-to-day life (Killingsworth & Gilbert, 2010; Klinger & Cox, 1987; Singer, 1974), a negative association continues to dominate the discussion, often ascribing mind-wandering not as a regular occurrence but as "cognitive failure" (Unsworth et al., 2012). This association with maladaptive behaviour is prevalent in fields that measure performance on different tasks, where mind-wandering often decreases performance on the task. However, the effect of mind-wandering on task performance is nuanced, and it may be beneficial for some cognitive processes such as creativity (Zedelius et al., 2020) and goal orientated thought processes (Medea et al., 2018). Within psychology, the notion that daydreaming is maladaptive has been challenged as early as 1974 (Singer, 1974).

While attributing mind-wandering as maladaptive may not always be appropriate, there are activities that result in dangerous situations because of a lack of attention, such as driving (Yanko & Spalek, 2014; Young et al., 2018) or operating heavy machinery. Another factor to consider is the content of mind-wandering, which can be positive or negative. While there are known benefits of mind-wandering with positive content (Gable et al., 2019; Westgate et al., 2021), when the content is negative (e.g., remembering past traumatic events or imagining future failure), this is often referred to as "rumination" and can be a sign of negative mental health, and even worsen it directly (Van Vugt et al., 2018; Watkins, 2008). On the other hand, some evidence suggests that mind-wandering may not be a direct

cause of negative mood (Poerio et al., 2013), and other research shows that retrospection on rumination can be used as a tool to induce behavioural change (Oettingen & Schwörer, 2013). A deeper understanding of how mind-wandering manifests in game play can help inform designs that leverage its possible benefits, while keeping these negative possible associations in mind.

Despite the various fields involved in researching daydreaming, the study context tends to be under low-engagement conditions such as reading tasks, vigilance tasks, and rest. Except during driving tasks, little is known about daydreaming under more complex stimuli and context, despite the evidence that daydreaming occurs throughout the day, during different activities (Klinger & Cox, 1987). Thus, my research provides some of the first empirical data of mind-wandering behaviour while people play digital games.

1.1 Motivation

The purpose of the current study is to observe the relationship between mind-wandering and gameplay behaviour within various games to help develop mind-wandering behavioural measures and see if specific contexts within games are related to mind-wandering. I use a thematic analysis approach to provide a qualitative analysis of mind-wandering within digital gameplay in the present study. This approach is meant to be exploratory and hypothesis-generating. More specifically, the study aims to describe behaviour within the context of video-game play and how particular eye patterns and behaviours may be related to mind-wandering. I hope that the findings from this study can be used by game and user experience designers to build positive mind-wandering experiences in their games for players.

1.2 Scope of the research

The creation and study of digital games involve many disciplines, including art, mathematics, psychology, and human-computer interaction (HCI), to name a few. However, in recent years, more focus has been put into understanding players and their experience of games to explore the impact of digital games in an academic setting and within the game industry to help create better game experiences for players (Nacke, 2017). Games user research (GUR) is a newly developing field that aims to study human experience during videogame play within industry (Drachen et al., 2018). Although novel within videogame development and research, the concept of studying experience is already prevalent in user experience

research (UXR). Many UXR methods have been utilized within GUR (Bernhaupt, 2015). Both share the same goal of understanding how people experience and interact with technology and advocating for the needs of people using technology-related products. Both within HCI and GUR, videogames have been studied extensively (Bernhaupt et al., 2015). However, mind-wandering research is less prevalent in either field.

1.3 Methods

The primary method was to use thematic analysis on gameplay footage and eye-tracking data to find patterns between gameplay context, eye-tracking, and player behaviour. Most of the research that has examined mind-wandering involves in-lab studies using quantitative measures such as self-reporting methods; various mind-wandering questionnaires and experience sampling, brain imaging techniques; functional magnetic resonance imaging (fMRI), electroencephalograph (EEG), and other physiological measures. Not much is known about mind-wandering in the digital game context and there is little insight into mind-wandering during commercially available games. Thematic analysis provides the tools to qualitatively describe patterns observed in interviews related to speech and behaviour. By applying this method to gameplay, the data can be analyzed in a descriptive way.

1.4 Contribution

In my thesis, my main contributions are:

- I provide evidence for eye behaviour associated with mind-wandering, such as fixations in the context of various games.
- I identify particular contexts within games that may contribute to mind-wandering.
- I identified four themes in my analysis: *mind-wandering in repetitive gameplay*, *future planning and problem solving*, *wandering eyes*, and *hitting walls & missed opportunities*.

1.5 Thesis Overview

This thesis is organized into the following chapters: In chapter 2, I review the literature related to measures of mind-wandering, the study of mind-wandering within HCI, and

literature more specifically about mind-wandering and games studies. In chapter 3, I describe the methods used in the study as well as the procedure. In chapter 4, I describe the thematic analysis conducted on the data collected and discuss the themes. In chapter 5, I describe the state of my research objectives, limitations of my study, and future work.

Chapter 2

Related Work

In chapter one, I introduced the concept of mind-wandering and gave a brief overview of the topics covered in this thesis. In this chapter, I start by describing a brief history of mind-wandering research, identifying its largely negative undertones, but also more recent suggestions of positive benefits. I then discuss how mind-wandering is measured. At the end of the chapter, I talk about the limited research related to mind-wandering in human-computer interaction and games user research.

2.1 The Study of Mind-Wandering: A Largely Negative Interpretation of Necessary Behaviour

A lot of research on mind-wandering has negative undertones. One of the earliest works in academia that hypothesized about mind-wandering was done in educational research, positing that daydreaming is a significant cause of mind-wandering and results in decreased academic success among children (Brown, 1927). Similar notions regarding mind-wandering as the failure of attention exist today. Previously, Unsworth et al. (2012) categorized mind-wandering as a type of failure within the cognitive system when conducting a diary study to assess whether everyday cognitive failures correlate with SAT scores. These examples suggest that mind-wandering is a negative occurrence in the context of particular settings within society where it has been deemed inappropriate. Killingsworth and Gilbert (2010) also linked mind-wandering to unhappiness in a study using experience sampling via an iPhone app that prompted participants to answer questions throughout their day for several weeks; their results suggest that when people mind-wander, they tended to report feeling unhappy regardless of the content of their thoughts. Although their experiment suggests

mind-wandering causes unhappiness, the reason people felt unhappy was never directly measured. In situations where safety is concerned, mind-wandering can impede people's attention to various tasks, including hazardous workplace situations or daily driving commutes. In particular, when driving on familiar routes, mind-wandering can significantly interfere with driving performance (Yanko & Spalek, 2014; Young et al., 2018). Moreover, when mind-wandering is overdone, also called rumination, it can be a sign of pathology or may perpetuate mental health issues such as depression and anxiety (Van Vugt et al., 2018; Watkins, 2008). However, it is essential to note that rumination has not been identified as the cause of pathology but can instead be considered an indicator.

Most fields studying mind-wandering have been doing so to combat its effects on task performance and loss of attention. However, as suggested by McMillan et al. (2013), a bias against mind-wandering exists, where the majority of research has interpreted mind-wandering as being negative (Mooneyham & Schooler, 2013) while ignoring the positive aspects of mind-wandering that had been investigated. In particular, Jerome L. Singer, was known for investigating daydreaming neutrally, taking into account the problems associated with it but also argued for the beneficial side of daydreaming (Klinger & Cox, 1987; McMillan et al., 2013; Singer, 1974). In more recent years, creativity and problem-solving research have suggested forms of mind-wandering that are beneficial for creative processes (Zedelius et al., 2020). Bogart et al. (2013) go as far as to suggest that the same processes that are involved in mind-wandering and dreaming also affect spontaneous creativity. Williams et al. (2018) provide evidence that both spontaneous thought and attention are part of the same system and are both critical for creative processes. In addition, an investigation following professional writers and physicists used a diary study approach, asking participants a series of questions, including thought sampling questions, found that when participants were at an impasse in their work, ideas that addressed their problems were significantly more likely than unrelated ideas to come during mind-wandering (Gable et al., 2019). It may also be possible to guide individuals to have better mind-wandering experiences through prompts (Westgate et al., 2021), which suggests that external factors can have an impact on mentation content.

Even though the concept of daydreaming has existed long before neuroscience, the recent discovery of the default brain network bridged the experimental observations from psychology and education to its anatomical origins within the brain. The default network (DN) was discovered when neuroscientists set out to establish the baseline activity of the brain during a wakeful state. The crucial finding was the difference between the resting brain when eyes are closed versus when eyes are open. Raichle et al. (2001) observed brain activity in the posterior cingulate and precuneus regions of the brain when participants were resting with eyes open compared to closed eyes. This comparison was essential to show

that studies should use a fixation task as a control instead of asking participants to rest with closed eyes when doing magnetic resonance imaging (MRI) studies. This paper also established that the brain has a baseline activity level capable of processing external and internal stimuli without excessive energy. Although being a basic comparison, this study highlighted a vital function of the brain: during rest, certain brain areas are used that would otherwise be suppressed during goal-directed tasks, suggesting internal behaviours occur during the default state (Fox et al., 2015; Poerio et al., 2017). Other studies looking into the default network have emerged with evidence for specific internal mentation behaviours such as imagining past and future events (Andrews-Hanna, 2012; Mason et al., 2009; Xu et al., 2016), and thoughts about goal setting (Medea et al., 2018).

In this thesis, I build on this research by exploring mind-wandering during videogame play, without implicating positive or negative attributes. For example, it is likely that mind-wandering might hinder performance during some gameplay but may also be beneficial. Alternatively, if external prompts and stimuli can influence mind-wandering, then different types of games may also affect the types of mind-wandering and frequency.

2.2 Measuring Mind-Wandering

The rigorous investigation of mind-wandering through experimental means did not begin until 1956 when Cohen et al. (1956) began to develop ways of measuring attention and mind-wandering through several methods, including having participants self-report when their mind-wandered by ringing a bell, and an indirect observation method where observers watched for behaviour indicators of inattentiveness while participants watched a lecture. Other indirect measures of mind-wandering use self-reporting through diary studies (Gable et al., 2019; Marcusson-Clavertz et al., 2019; Unsworth & McMillan, 2017) and experience sampling (Killingsworth & Gilbert, 2010; Poerio et al., 2017; Zhang et al., 2021). Evidence suggests that some physiological measures such as eye-tracking (Bixler et al., 2015; Brishtel et al., 2020), facial features, and body movements (Stewart, Bosch, Chen, Donnelly, & D'Mello, 2016) can be successfully used to measure mind-wandering indirectly. Direct measures of brain activity include magnetic resonance imaging (MRI), which most neuroscience imaging studies that are investigating mind-wandering use, and Electroencephalography (EEG) (Dhindsa et al., 2019; Dong et al., 2021; Jin et al., 2019).

I investigate mind-wandering during videogame play in this thesis using eye-tracking and the experience sampling procedure used by Poerio et al. (2017). While future work could investigate direct measures, like MRI and EEG (which are expensive and the gathered

data are difficult to analyze), this work is exploratory in nature, so can help build a foundation for what to investigate in such future studies.

2.3 Mind-Wandering in HCI and GUR

Little investigation has been done into mind-wandering while using technology. Within human-computer interaction (HCI) research, the main focus of studies looking at mind-wandering has been to mitigate the adverse effects of mind-wandering during tasks such as reading and driving (Bixler et al., 2015; D'Mello et al., 2016). The narrative that mind-wandering is "bad" has also echoed throughout HCI research, following in the footsteps of psychology and education. Minimizing daydreaming during tasks such as driving and reading can contribute to the safety and efficiency of people engaging in these tasks. However, the positive effects of daydreaming on health and experience with technology are underreported.

Within games user research (GUR), Mekler et al. (2018) investigated reflection and its role in the player experience, where players report "reflecting" on their gameplay during and after play. While it is not clear if reflection is the same as mind-wandering, both have the same characteristic of relating to internal mentation. Other research provides evidence that the tendency to mind-wander is correlated with digital game immersion (Dauphin & Heller, 2010). However, the majority of the field is primarily dominated by an investigation into making games more immersive and engaging without taking mind-wandering into account. In recent work, Olaya-Figueroa et al. (2021) created a game to facilitate mind-wandering by changing different gameplay mechanics such as game speed and challenges within the game. With the research presented in my thesis, I hope to provide more descriptions of mind-wandering behaviour for the use of games user research and design.

Chapter 3

Methods

In Chapter 2, I went over the literature that relates to mind-wandering, emphasizing the lack of neutrality within psychology and HCI in regard to studying internal mentation. I discussed some of the recent work that has been done in psychological game research that relates to mind-wandering.

In this chapter, I go over the design of a study conducted to collect behavioural data of people while they play a variety of digital games with the goal of qualitatively analyzing behavioural patterns that are related to daydreaming.

The purpose of the current study is to observe gameplay though the lense of how it relates to mind-wandering and how different game experiences affect this behaviour. The contribution of this study is to identify patterns in behaviour that may relate to instances of daydreaming during digital gameplay. By being able to identify instances of daydreaming, game designers can further shape their game to allow players to daydream or discourage it.

3.1 Daydreaming Study

The purpose of the current study is to learn:

- How daydreaming occurs during digital gameplay;
- If there are observable behaviours that relate to daydreaming; and
- How people experience daydreaming while playing digital games.

We studied twelve participants to explore behavioural signs of mind-wandering during gameplay in digital games. The contribution of this study is to identify patterns of mind-wandering behaviour during digital gameplay.

3.1.1 Study Design

The study used a mixed-methods approach. Before their play session, participants were asked to pick three games that they had previously played, "Please choose a single-player game that you: 1) find relaxing, 2) lose track of time while playing, and 3) spent most hours playing." We chose to let participants pick their own games to ensure a level of interest and to decrease the likelihood of interruption of play because of having to learn controls and how to play the games. Note that only two of the games that participants played were analyze due to time constrains, these were the games that they found relaxing and lost track of time while playing. Eye-tracking data was collected because previous research found gaze patterns during mind-wandering Bixler et al., 2015.

Before their play session, each participant was informed that the study was looking at how people play the games that they chose and that player behaviour would be studied with the help of an eye tracker, webcam, and gameplay footage. No mention of mind-wandering or daydreaming was given before the play session so participants would not be primed to mind-wander. Each game was played for 30 minutes, during which time the experimenter randomly asked the participant to stop and answer an experience sample questionnaire. At the end of each game, a flow questionnaire was given. A. The maximum expected time for the experiment was two hours. Before each participant session, the experimenter generated a random order that each participant's games were played, as well as between five-to-eight times that a daydreaming questionnaire would be administered, as per Poerio et al. (2017).

3.1.2 Measures of Experience

Methodology for measuring mind-wandering was taken from Poerio et al. (2017) and slightly modified for the current experimental context. Participants' thoughts were sampled using quasi-random thought probes—a method that periodically samples the content of a participants thoughts by asking them to agree or disagree with particular statements—that occurred during each 30-minute play session. Initially, participants received between six-to-fifteen probes, however ten or more probes per session resulted in longer play sessions and to decrease possible participant fatigue, the range was decreased to five-to-eight probes. Each probe initially asked participants to report on the contents of their conscious

experience in the moment immediately preceding the interruption with the prompt "When I was playing just now...". Level of task focus ("My thoughts were focused on the task I was performing") was always rated first, on a scale from zero to one, followed by 12 additional dimensions, as described in Poerio et al. (2017).

Dimensions	Questions	0	1
Focus	My thoughts were focused on the task I was performing.	Not at all	Completely
Future	My thoughts involved future events.	Not at all	Completely
Past	My thoughts involved past events.	Not at all	Completely
Self	My thoughts involved myself.	Not at all	Completely
Other	My thoughts involved other people.	Not at all	Completely
Emotion	The content of my thoughts was:	Negative	Positive
Images	My thoughts were in the form of images.	Not at all	Completely
Words	My thoughts were in the form of words.	Not at all	Completely
Vivid	My thoughts were vivid as if I was there.	Not at all	Completely
Vague	My thoughts were detailed and specific.	Not at all	Completely
Habit	This thought has recurrent themes similar to those I have had before.	Not at all	Completely
Evolving	My thoughts tended to evolve in a series of steps.	Not at all	Completely
Spontaneous	My thoughts were:	Spontaneous	Deliberate

Table 3.1: Table of experience sampling questions taken from (Poerio et al., 2017).

In mind-wandering studies, self-reporting during computer tasks often involves participants having to press a particular key when they catch themselves daydreaming. For vigilance and reading tasks, pressing a key is reasonable. However, during gameplay where participants are engaged and require rapid key presses to succeed at playing, this form of self reporting may get in the way of their playing experience and impede observable behaviours that may be associated with mind-wandering during gameplay. Thus, quasi-random thought probes were used instead of this form of self-reporting. These probes also had the benefit of keeping participants naïve to mind-wandering being the focal measure of the study. A measure of engagement that has been gaining traction within digital game research is the investigation of the state of flow (Klarkowski et al., 2015; Nacke & Lindley, 2008; Sweetser & Wyeth, 2005). Games "are considered most fun if we feel that we are making meaningful decisions and that we are facing increasing challenges that will allow us to learn and train skills" (Nacke, 2012). This relates to the concept of Flow, which describes the "holistic sensation that people feel when they act with total involvement" (Csikszentmihalyi, 1975). Originally identified by studying chess players, artists and musicians as well as sports players (Csikszentmihalyi, 1975; Jackson & Marsh, 1996), Flow was experienced by people rewarded by doing an activity in itself, allowing them to be completely mentally absorbed in the activity. As a related concept, it is interesting to compare Flow to mind-wandering. Thus, at the end of each gameplay session, each participant also answered

a flow questionnaire, taken from (Jackson & Eklund, 2002), to see if flow was related to daydreaming.

Question	Strongly Disagree	Disagree	Neither Agree Or Disagree	Agree	Strongly Agree
I was challenged, but I believed my skills would allow me to meet the challenge	1	2	3	4	5
I made the correct actions without thinking about trying to do so.	1	2	3	4	5
I knew clearly what I wanted to do.	1	2	3	4	5
It was really clear to me how I was doing	1	2	3	4	5
My attention was focused entirely on what I was doing.	1	2	3	4	5
I had a sense of control over what I was doing	1	2	3	4	5
I was not concerned with what others may have been thinking of me	1	2	3	4	5
Time seemed to alter (either slowed down or speeded up).	1	2	3	4	5
I really enjoyed the experience of what I was doing	1	2	3	4	5
My abilities matched the challenge of what I was doing	1	2	3	4	5
Things just seemed to be happening automatically	1	2	3	4	5
I had a strong sense of what I wanted to do.	1	2	3	4	5
I was aware of how well I was doing.	1	2	3	4	5
It was no effort to keep my mind on what was happening	1	2	3	4	5
I felt like I could control what I was doing.	1	2	3	4	5
I was not concerned with how others may have been evaluating me	1	2	3	4	5
The way time passed seemed to be different from normal.	1	2	3	4	5
I loved the feeling of what I was doing, and want to capture this feeling again	1	2	3	4	5
I felt I was competent enough to meet the demands of the situation	1	2	3	4	5
I did things automatically, without thinking too much	1	2	3	4	5
I knew what I wanted to achieve.	1	2	3	4	5
I had a good idea about how well I was doing while I was playing the game	1	2	3	4	5
I had total concentration.	1	2	3	4	5
I had a feeling of total control over what I was doing	1	2	3	4	5
I was not concerned with how I was presenting myself	1	2	3	4	5
It felt like time stopped while I was playing.	1	2	3	4	5
The experience left me feeling great.	1	2	3	4	5
The challenge and my skills were at an equally high level	1	2	3	4	5
I did things spontaneously and automatically without having to think.	1	2	3	4	5
My goals were clearly defined.	1	2	3	4	5
I could tell by the way things were progressing how well I was doing	1	2	3	4	5
I was completely focused on the task at hand.	1	2	3	4	5
I felt in total control of my actions	1	2	3	4	5
I was not worried about what others may have been thinking of me.	1	2	3	4	5
I lost my normal awareness of time	1	2	3	4	5
I found the experience extremely rewarding.	1	2	3	4	5

Table 3.2: A table of questions from the Flow State Scale-2 questionnaire. Each question is rated on a scale of one to five, where one is used to strongly disagree with the question and five when there is strong agreement. The original questions were taken from Flow State Scale (Jackson & Marsh, 1996) and changes to some questions were made as suggested by (Jackson & Eklund, 2002).

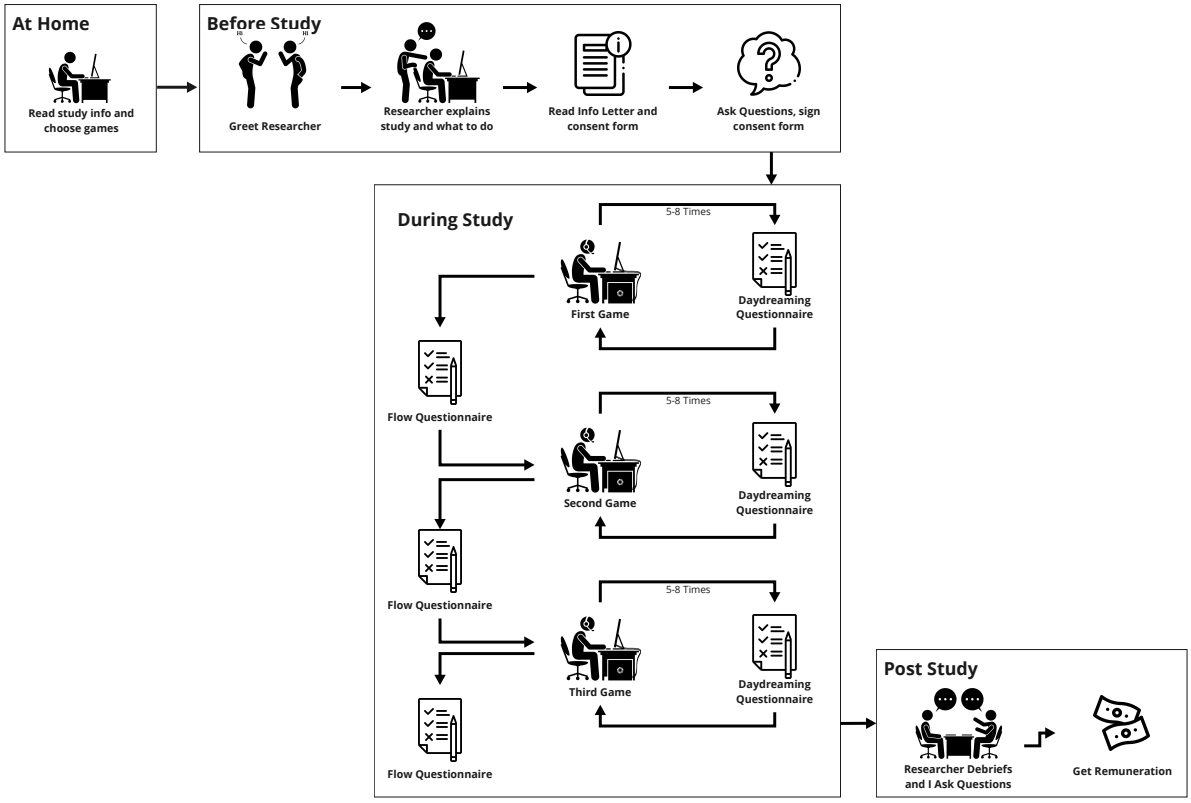

Figure 3.1: A visualization of the procedure that participants went through from their perspective.

3.1.3 Participants

Participants were recruited to the study from our university community. Twelve participants (nine male-identifying, three female-identifying, ages 18–44) were recruited on a volunteer basis through posters put up around the campus, as well as university mailing lists. All participants were motivated to participate in the study and several reported enjoying playing games, but not having enough time for it (weekly time playing per week: eight 0–10 hrs, two 11–20 hrs, two 21+ hrs). After data collection, four of the games that participants played could not be analyzed because of technical difficulties such as gameplay not being recorded properly or the eye tracker failing to pick up gaze information, and P8 was excluded due to the eye tracker not being able to pick up their gaze. Table 3.3 shows a list of all games that were analyzed. In total, 18 games were analyzed.

Participant	Relaxing	Lose Track of Time
P1		The Walking Dead
P2	Worms Reloaded	Warcraft 3
P3		
P4	Worms Reloaded	Resident Evil 5
P5	Her Story	
P6	Candy Crush	The Walking Dead
P7	World of Goo	Worms Reloaded
P8		
P9	Okami	Undertale
P10	Stardew Valley	Skyrim
P11	Candy Crush	Gas Guzzler
P12	Life Is Strange	Grand Theft Auto V

Table 3.3: A table listing what games each participant played. P3 was not analyzed due to a failure to record gameplay, and the eye-tracker failed to detect gaze from P8. P1's relaxing game did not record properly, as well as P5's Lose Track of Time game.

3.1.4 Equipment

To record player behaviour, a setup of two Windows 10 desktop computers, each with a dedicated NVIDIA GeForce GTX 980 graphics card, was used. This setup allowed investigators to run the Tobii Studio software on one device while the second device ran the games that participants played. Each computer was connected to a computer monitor, a keyboard, and mouse. To record the screen of the game-running computer, an external video capture card was connected to the two computers, allowing gameplay footage to be recorded in sync with the Tobii T120 eye-tracker. All equipment was located at a public university.

3.1.5 Procedure

Each participant was sent a brief email with a summary of what the experiment entailed before their play session. Upon arrival, the experiment was described once again (verbally and in writing) along with a consent form. Once they had signed the consent form, the participant was then instructed to sit in front of the computer in a comfortable position looking ahead at the screen. First, the eye tracker was adjusted so the participants gaze

fell to the indicated position in the Tobii software, and then the experimenter executed the Tobii eye tracker calibration routine. After calibration, the participant was asked to play the first game for 30 minutes. When it was time to do the mind-wandering questionnaire, the experimenter would say "Please pause the game and open the questionnaire," and then pause the 30-minute timer until gameplay resumed. At the end of 30 minutes of play, the participant was asked to close the game and answer the flow questionnaire. Participants were asked to complete two more 30-minute play sessions for the remaining two games. Between games, the participants were reminded that they could take a break, and if one was taken, the eye tracker calibration was done again.

3.1.6 Games Played

Participants were allowed to choose from a large list of computer games available to the experimenter. Table 3.3 shows the games that players chose from a larger list and played during their session.

Chapter 4

Thematic Analysis

In chapter 3, I described the experimental methods and procedure as well as the thematic analysis procedure. Qualitative methods were the main focus of this study. They involved collecting qualitative data using eye-tracker behavioural data and gameplay footage that was analyzed using thematic analysis. Quantitative data were also collected about mind-wandering using experience sample questions (Table 3.1).

In this chapter, I discuss my analysis of the data collected in chapter 3. In section 4.1, I describe how I categorized the different types of play into *modes of play*. In section 4.2, I describe the themes most relevant to mind-wandering, the codes used to guide us, and the related literature that informed some of the themes. When discussing examples, participants are labelled as P1–P12, followed by the game label relaxing (RE) or lost track of time (LT). Finally, in section 4.3, I discuss the implications of my analysis.

4.1 Modes of Play

After viewing many of the player session videos and coding them, it became evident that the codes I was using were highly context-dependent on different types of gameplay, so I decided to analyze the games by describing the types of gameplay in the study, here referred to as modes of play. In my analysis, I assumed that different types of gameplay would impact player experience in different ways, for example, playing a fast-paced game may require faster reaction and decision-making in response to game events, compared to a more relaxing game. Ultimately, immersion in the different modes of play could affect mind-wandering behaviour in different ways, such as the rate of mind-wandering as well

at the content of thoughts when experiencing mind-wandering. This assumption informed how I interpreted different modes of play and linked them to the themes found in player behaviour (section 4.2). Modes of play refer to the different ways that players engage and experience events in games.

Although many preexisting categorizations of game mechanics and discussions surrounding their importance exist (Fabricatore, 2007; Sicart, 2008), my focus was on how different game states (that players engage in) impacted player behaviour related to mind-wandering. Thus, the analysis of game modes was done independently from the thematic analysis used to analyze player behaviour, instead the analysis was prompted by using noun-verb diagrams (Ramirez, n.d.) as a guiding tool (Figure 4.1). "Modes of play" is the analysis of a game's built-in systems—the environment that the player interacts with but cannot necessarily change. They are constraints and affordances that exist while playing a given game. Modes of play were established instead of using pre-existing methods of categorizations to create a more tailored description of the specific games that our participants played. Table 3.3 shows how each game played in this study was categorized into different modes of play.

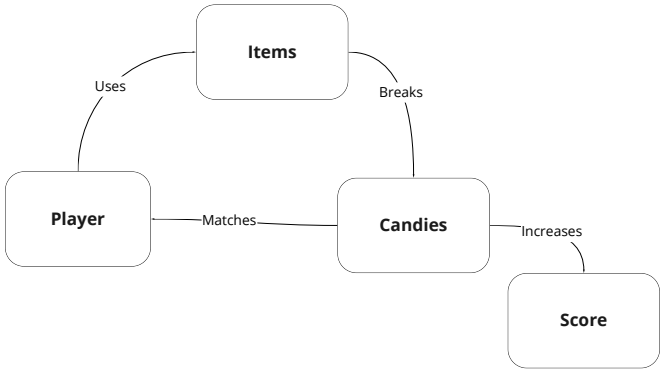

Figure 4.1: An example of the noun-verb diagram for Candy Crush Saga.

4.1.1 Repetition

I described gameplay that consisted of repetitive patterns of actions or sequences as *repetition*. Most games use some form of repetition via locomotion or action, but not all games

Game	Repetition	Playing Through Narrative	Experiencing Narrative	Journeying	Ride the Wave	Waiting for Action
Candy Crush	■		■		■	
Worms Reloaded			■		■	■
World of Goo	■		■		■	
Grand Theft Auto V	■	■		■		■
The Walking Dead		■			■	
Warcraft 3	■		■		■	
Skyrim	■		■	■		
Resident Evil 5			■		■	■
Her Story	■		■	■	■	
Okami			■	■	■	■
Undertale	■	■		■		
Stardew Valley	■	■		■	■	■
Gas Guzzler					■	
Life Is Strange		■	■	■		

Table 4.1: A list of games that were analyzed in the study and what modes of play participants engaged in for each game (highlighted in black): Repetition (subsection 4.1.1), Playing through narrative (subsection 4.1.2), Experiencing narrative (subsection 4.1.3), Journeying (subsection 4.1.4), Ride the wave (subsection 4.1.5), and Waiting for action (subsection 4.1.6).

feel repetitive. For example, in Candy Crush Saga, the gameplay consists of repetitive actions consisting of finding, matching candies, and a matching animation. In The World of Goo, the player picks up and drops goo to create larger structures that manoeuvre through a level, with picking up via clicking and dropping as the primary sequence of gameplay. Both games involve some level of strategy, such as matching some candies over others and building a structure that will work for a given level. However, the majority of gameplay consists of a repetitive loop. Other games contain repetitive or patterned loops, but more gameplay elements prevent them from being purely repetitive. For example, Worms Reloaded consists of the following repetitive loop: player turn, a countdown for next turn, AI turn, a countdown for the next turn; however, each turn may contain different item usage alongside various player locomotion, such as jumping or walking. In contrast, Candy Crush Saga involves matching candies repetitively and may involve using a unique item on occasion. Large or open-world games, such as Skyrim, also contain significant repetitive loops during side activities or mini-games. However, they are not always mandatory and are open to the player to choose to do.

4.1.2 Playing Through Narrative

I described gameplay that involved players impacting the story of the game directly as *playing through narrative*. Games such as Undertale, The Walking Dead, and Life is Strange were highly driven by the story, and the players' actions had an impact on the narrative or outcome of the story. For example, in Life is Strange, most gameplay involves making narrative choices that impact the game's story. Other games such as Okami also involve a storyline. However, the difference is that in Okami, the player does not impact the narrative trajectory of the game. Undertale also involves a main story that is primarily unchanging. Although, through various actions and player choices, the player indirectly changes the story's outcome. Narrative impact refers to situations where players can impact the story of the game that they are playing.

4.1.3 Experiencing Narrative

In contrast, I described story that was imposed or occurred without the need for the player to engage in to play the game as *experiencing narrative*. This mode of play involves the player watching events unfold that build into a larger narrative. Every game has a narrative built in at some level of the game, but in games such as Okami, Warcraft 3, or World of Goo, players do not have any means to influence the story or events of the game. The story is either secondary, such as in World of Goo and Candy Crush Saga, or static, something the player experiences and moves through rather than impacts.

4.1.4 Journeying

I described gameplay that involved moving through the environment for long periods as *journeying*. In games such as Skyrim, Grand Theft Auto, and Okami, players choose to explore the environment and are often encouraged through side quests and other methods to explore. Much of the gameplay occurs outside the main story, with various secret treasures and dungeons scattered around the game world; these games give a feeling of an almost infinite number of things to do or at least a vast number of things. Games that have journeying afford players the opportunity for exploration and discovery.

4.1.5 Ride the Wave

I described gameplay that involved players progressing through the game at a set pace, through either time-based trials or linear story progression as *riding the wave* (a metaphor from surfing that suggests letting the story carry the player through gameplay). Some games, such as Stardew Valley, allow players to choose how to spend their time, but each day has a set time, and some game events are time-limited, so players have to choose wisely about what to do. Other games may impose time constraints through countdowns that players must finish a level or turn by. In contrast, other games do not have a set timeline for players to finish events by, and players are able to freely complete the game in whatever amount of time they want.

4.1.6 Waiting for Action

I described gameplay that involved times when players had to wait before acting or were limited in their actions. For example, in the game Okami in Orochi's Lair, an NPC is stationed at a platform and moves it up and down, allowing the player to travel to different floors. However—while the platform moves—the player can only run around and jump. Likewise, in Worms Reloaded, due to the nature of being a turn-based game, players have to wait for their opponent to take a turn, during which time they cannot do anything in the game.

4.1.7 Summary of Modes of Play

In this section, I described the modes of play that the participants in this study engaged in. I use these modes of play to contextualize the themes identified in my thematic analysis.

4.2 Thematic Analysis

Our thematic analysis was modelled after the reflexive approach as described by Braun and Clarke (2006). The purpose of the current study was to analyze behavioural video data in the context of digital gameplay to find patterns that may indicate players experiencing mind-wandering. Our approach was a mixture of deductive and inductive. The use of the eye tracker was strictly deductive, and was based on previous research that found eye behaviour patterns correlated with mind-wandering during reading (Bixler et al., 2015;

D'Mello et al., 2016). Although we did not suspect that the same patterns would be found in gameplay as during reading, the use of gaze is based on previous ideas and made up part of our coding and theme formation process. Codes related to gameplay events and player behaviour were created inductively by watching gameplay videos, describing observed behaviour through codes, and then interpreting player behaviour and gaze based on the gameplay context.

Familiarization with the data occurred from the start of data collection and continued for several watch-throughs until the data was formatted to its final state. During each player session, I took notes of player behaviour that I noticed as well as any environmental disturbances that occurred. This was the first exposure to the data and the first step to formulating codes. Once all the data had been collected, a first pass through the videos was done using the Tobii eye tracker software to make use of its analysis features. However, because multiple games were used, it was difficult to get any meaning from this discrete analysis. The video files were converted into MP4 format and a first look-through was done with the data primarily to separate the gameplay footage from the answering questionnaire portion of the play session. During this process I took notes and began to establish codes to analyze the data.

After the gameplay videos were viewed over once, I decided to break up the videos into segments that excluded parts of the session where participants were answering the survey, this helped to simplify the coding process and thematic analysis.

4.2.1 Codebook

Initial codes were discrete categories from one another that were made to create a detailed description of the data by observing what the player was doing in the game, what the eyes were doing, and what was happening in the game. I first made a code book by viewing several videos and writing down recurring behaviours or patterns that I observed in the data and the analysis was conducted using the annotation software, Elan. Later the code book was tested and further refined through a two-hour peer brainstorming session using affinity diagramming (Holtzblatt & Beyer, 1997) where eight human-computer interaction researchers, some with no prior thematic analysis training, watched several minutes of different videos and wrote down observations that they noticed on sticky notes. The sticky notes represented broad observations from peers and were pinned on a whiteboard and grouped together to create different codes.

Then the group came up with a codebook that reflected the observations. This codebook was different from the original one in several ways, and the different perspectives of

Codes	Sub-Codes	Description
Event	CUT	a cutscene is playing
	BLANK	Game shows blank/black screen
	ANI	animation during or between gameplay but not cutscene
	DIA	Dialogue, with or without subtitles
	MENU-S	strategic menu: map, inventory.
	SYS	system menu or message
Event Description	open-ended	A brief description of what is happening in the game.
Actions	ACT	Action initiated by player (fully describe in "player behaviour" sub-tier)
	CUR	moving cursor (mouse)
	MOVE	Moving Avatar/ character
	MENU	opening/closing menu
	PASS	Passive behaviour
	SEL	moving cursor to select target
Player Behaviour	open-ended	An interpretative description of what the player is doing based on actions and events.
Gaze Location	PLA	near or on the players avatar/unit
	ENV	on the background/environment
	OTH	other characters or AI units
	INT	an object or AI being interacted with
	AWA	away from screen
	UI	Menu or other interfaces being interacted with
Gaze Type	FIX	fixation on a single location for a long duration of time
	AREA	combination of rapid and fixed gaze on a small area
	RAP	fast eye movement between different targets
	UNK	no visual data, gaze type and location unknown
Gaze Interpretation	open-ended	A description of gaze behaviour based on gaze type, gaze location, and events.
Gaze Coordination	TL	top left of screen
	TM	Top middle of screen
	TR	Top right of the screen
	ML	Middle left on the screen
	MM	In the middle of the screen
	MR	Middle right on the screen
	BL	Bottom Left on the screen
	BM	Bottom middle on the screen
	BR	Bottom Right on the screen

Table 4.2: A list of codes with specific sub-codes associated with them, and a description of each sub-code generated during the process of thematic analysis. Event Description, Player behaviour, and gaze interpretation were used as a way for the researcher to bring the codes together to describe events.

the group produced a more robust codebook. My initial approach was to note every eye movement and player action and although part of this approach remained, more interpretation and holistic analysis was added after the group activity. A second researcher, that also participated in the affinity diagram activity, helped with analyzing part of the data which further helped to create more objective additions to the codebook. This researcher was a research assistant that I helped train to conduct this thematic analysis.

Table 4.2 shows the final state of the codebook. Event description, player behaviour, and eye behaviour are each open-ended, descriptive tiers that are interpretations of the data and are broken down into a more discrete set of sub-tiers. Event descriptions consist of occurrences during gameplay that reflect an interaction between the game system and the player. These interactions can either be triggered by the player, such as starting dialogue with a non-player character (NPC), or can be a feedback mechanism initiated by the game, such as a hint for the player to make a move. This code was used to describe events outside of regular gameplay. Player behaviour included different kinds of actions that the player made, at times player actions were given, an interpretation based on the context of gameplay, and what followed after the action. Eye behaviour was the interpretation of the eye tracker data that occurred during gameplay. The three groups of codes were independent from one another in the sense that they did not always occur in the same time frame, however their occurrence was highly codependent for many described events. The final coding was done on the video from the minute leading up to the participant taking the daydreaming questionnaire (5-8 times per game), with a total of 279 minutes of video coded data.

After the coding was complete, themes were generated by observing patterns within the codes of each particular game. These instances were collected as behavioural descriptions, such as "player running down halfway and watching an avatar," and then grouped into particular themes.

In my data analysis, the code (FIX) described long gaze duration and was treated as fixation instances. However, because (AREA) gaze patterns occurred in a small space, they consisted of (FIX) and (RAP) combinations, and happened around the same subject or object, it may be an indication of fixation. The analysis and themes were created with focus on mind-wandering. Therefore, all discussion surrounding the themes below should be considered in relation to mind-wandering, even if not explicitly stated.

Figure 4.2: P10 using watering can to water crops while playing stardew valley, and fixating on a spot near their character.

4.2.2 Themes

In addition to the modes of play discussed earlier in the chapter, several gameplay and eye behaviour themes were identified and later described in this section;

- Repetition Is Connected To Mind To Wander
- Future Planning/Problem Solving
- Wandering Eyes
- Hitting Walls and Missed Opportunities

Repetition Is Connected To Mind-Wandering

When players engaged with a repetitive element in a game, players often fixated around the area where the repetition was taking place, fixating multiple times if the repetition went on for long enough. There were two different situations where players experienced repetition; 1.) Choosing to do repetitive actions, and 2.) during journeying.

For example, while playing Stardew Valley, one participant (P10RE) often used different tools to interact with the environment, resulting in repetitive actions. In one example, the player used a hoe to till tiles and then plant seeds. The player tilled one tile at a time, and once the tilling was done, they planted a seed in each tile. The act of tilling, planting, and watering were each repetitive actions. During tilling there was fixation that occurred near the avatar. Figure 4.2 shows the screenshot for this example.

Because the act of repetitive tool use is simple and does not require much attention, I suspect that the player could be engaging in intentional mind-wandering. Repetition and familiarity have been previously linked to mind-wandering when driving familiar routes (Burdett et al., 2019; Young et al., 2018), and when readers re-read the same text (Phillips et al., 2016). Although the current study did not measure intentional and unintentional mind-wandering, it may be possible to draw some parallels with findings from Phillips et al. (2016) that, when readers reread a text, they engage in intentional mind-wandering. Likewise, when players choose to engage in a repetitive activity, they are similar to readers that choose to reread a text in that both are putting themselves into a state where it is easy to mind-wander. The observation of Stardew Valley above is an example of repetitive activities that players can choose to do.

Future Planning/Problem Solving

There were times when players would stop what they were doing and fixate on one spot. During these times, players may scan around a small area in the environment but tend to fixate on environmental objects and sometimes relevant locations. This may relate to future planning, as often players would stop between objectives while journeying or in locations where navigation was needed, while other times (e.g., in fast-paced games and situations such as Skyrim, GTA, Resident Evil, Okami, Gas Guzzler, and World of Goo), fixation occurred in times when players were scanning the environment in search of something or simply looking ahead of the avatar while moving.

For example, one participant (P4LT) playing Resident Evil 5 moved slowly and watched a character that seemed to be hacking at something on a table. This player mistook the character for an NPC they were supposed to find. The NPC was a butcher, and because the character was hacking something, the player may have thought the character was the NPC. The player then stopped to figure out what to do next or why the game was not progressing. Figure 4.3 shows the screenshot for this example.

Another participant (P9RE) playing Okami would often stop moving, followed by a series of gazes around the screen, or use the paintbrush menu to stop time and fixate on

Figure 4.3: P4 is watching a character while walking towards them.

objects of importance. This participant was likely thinking about what to do next or was figuring out how to proceed through the game. They were trying to overcome an obstacle or defeat an enemy in front of them. Figure 4.4 shows a screenshot of the example mentioned above.

Other participants (P5RE, P11RE) who played Candy Crush Saga, when the candy matching animation occurred and cascaded, would start looking around the screen for the next candy to match, at times stopping to fixate briefly on some of the falling candies. These players were likely looking ahead to find candies to match next.

In another example, a participant (P10LT) playing Skyrim, after entering a room, defeated an enemy that was just waking up and ran towards the stairs while scanning up around the top entrance to the stairs. This player was anticipating hostile NPCs that would be approaching them soon. Figure 4.5 shows a screenshot of this example.

There is evidence that the state of future planning is a type of mind-wandering behaviour, often called future-orientated mind-wandering, in the literature. For example, self-reporting studies such as (Spronken et al., 2016; Stawarczyk et al., 2013) and imaging studies exploring mind-wandering and the default network (Mason et al., 2009; Stawarczyk et al., 2013; Xu et al., 2016) have both provided evidence that future planning is a type of mind-wandering. In addition, in games such as Stardew Valley and Warcraft, which involve many goals and strategies, players are likely to have future-orientated thoughts

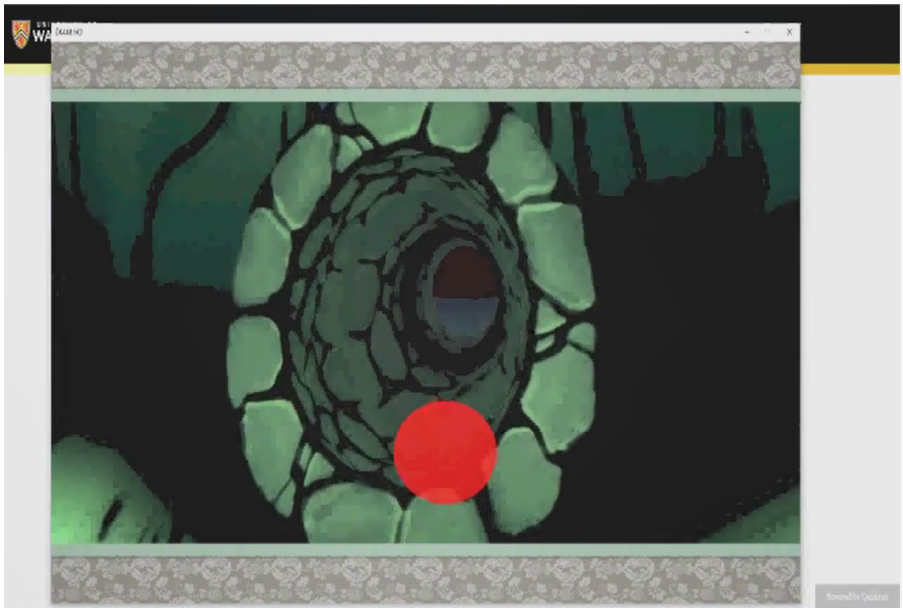

Figure 4.4: P9 is fixating on the entrance to a tunnel at the end of a cut scene.

about what they plan to do in the game.

Wandering Eyes

Participants in this study often directed their gaze away from a focal point of importance at a given time in the game, such as during important story events. It may be that a player was not interested in what was happening or was distracted by other things happening in the game or scene. As a sub-theme, there were a few times where players would look towards the edge of the screen, typically to the bottom edge or to the bottom corners. No discernible patterns were noticed when this occurred; sometimes, players were engaged in gameplay and other times during the Mode of Play "Waiting for Action".

For example, one participant (P12RE), while engaging in a dialogue with a non player character (NPC), kept looking to the bottom corners and edges of the screen in between dialogue choices. This player may have been distracted by something in the room when looking away from the screen. Gaze directed downward, upward, or to the side may be an indicator of mind-wandering, or distraction, but requires future work to confirm. Figure 4.6 shows a screenshot of the above example.

In another example, one participant (P4LT) during the tutorial/opening to the game

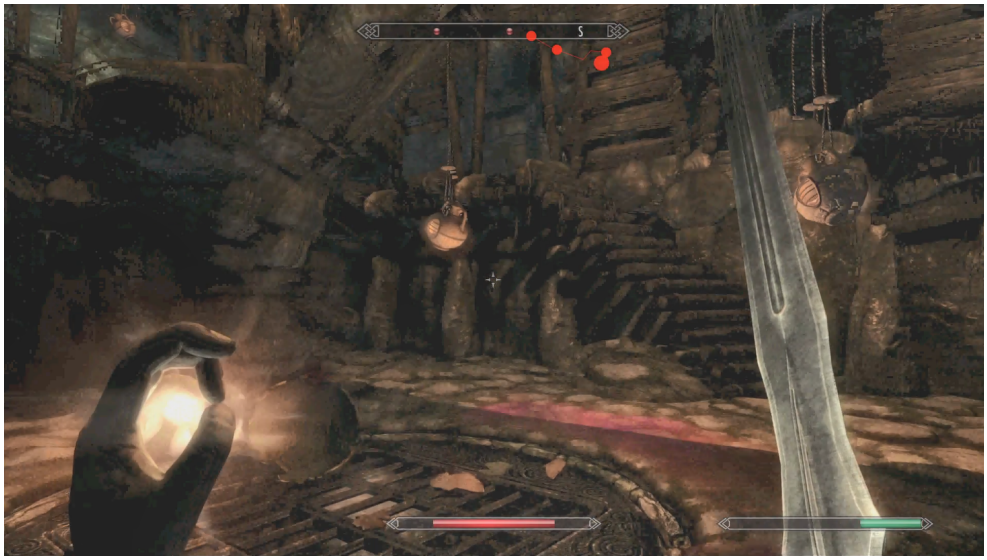

Figure 4.5: P10 is anticipating an enemy to show up from an entrance above the stairs. Their gaze moves rapidly around the area where the entrance is.

Resident Evil 5, walked slowly while dialogue was happening in the background. The participant started to fixate on a location in the environment and then stopped moving. The player gazed at the environment and sometimes missed instructions occurring on screen. They might have been thinking about what to do next or things outside the game.

There were few instances of what appeared to be players looking away from the screen entirely in a distracted manner, however a secondary source of data would need to be used to confirm that this way actually happening instead of a malfunction of the eye tracker.

Hitting Walls and Missed Opportunities

Often players seemed focused on the game but would either make a mistake or were unable to figure out how to overcome a challenge at times due to their focus not being in the right place. The phrase "hitting walls" is being used both literally and metaphorically here. Sometimes, players would run into objects or obstacles unexpectedly or become stuck and not know how to progress through the game. The mistake had to be unexpected and avoidable and not due to game constraints or mechanical mistakes done by the player to have identified it as fitting within this theme.

For example, while playing Gas Guzzlers, one participant (P11LT) seemed to have been

Figure 4.6: P12 is engaging in dialogue with an NPC. The player went from looking at the NPC to the bottom of the screen or away from the screen.

following the road and ignoring signs to turn right, and ended up hitting a dead end. Its important to note that this player would often gaze into the distance at direction signs while driving straight, then turn harshly and lose balance before moving in the direction that the signs pointed towards. The player initially hit the dead end twice before doing one lap and then hit the same dead end three more times. Figure 4.7 shows the screenshots of the first time the player hit the dead end and when they did it again on the second lap. Their gaze was rapid, but focused on a small area on the horizon. Based on the gameplay leading up to this example, it seemed like the player was finding it difficult to see what direction to go in, and this was my initial interpretation of this behaviour. However, this occurred three more times. Due to the player's determination, the player may have thought there was a secret road, but I searched online extensively and determined that there is no secret route in that part of the game. If the player knew that no secret road existed there, they could have been mind-wandering and forgetting to turn at the right place.

Not every instance of players running into things belongs to this theme because some of these instances could be due to mechanical mistakes. Similarly, some players may have forgotten all game mechanics in a given game because of a time gap between their play session and the last time they played the game. Compared to the observations above, P9RE, while playing Okami, spent a significant amount of time figuring out how to complete a simple drawing task. The player did not want to start the game from the beginning be-

Figure 4.7: The screenshot on the left shows P11 rapidly looking at the direction arrows, before they continue driving forward and crashing into a dead end. The screenshot on the right is when P11 encountered the same turn on their second loop of the track. Similar to the first they gaze around where the direction arrows used to be and continue driving straight into the dead end.

cause the tutorial was very long. In Okami, part of the game is spent finding and unlocking powers by locating constellations that the player must complete using the painting menu. Learning how to complete a constellation was done at the start of the game that the player had missed. Since it had been a while since the participant had played Okami, and the player verbally expressed that it had a while since they had done this, I assumed that they had forgotten what to do.

4.3 General Discussion

The current study allowed for participants to choose games they have previously played from a list of available games to secure a level of interest and familiarity for each player. Motivation is a factor to consider when analyzing games for mind-wandering between individuals Carriere et al., 2013; Robison et al., 2020. Another factor that may influence mind-wandering is the game modes that a game provides, for example, the gameplay analyzed in 'Life is Strange' largely consisted of decision making through narrative options and involved a large amount of narrative exploration through cut scenes driven by player decision making. Within literature it has been noted that mind-wandering can frequently occur during cinematic experiences such as watching movies and when experiencing narrative information Mills et al., 2016; Stewart, Bosch, Chen, Donnelly, and D'Mello, 2016 making it highly likely that narrative games such as 'Life is Strange' provide an experience where mind-wandering is likely to occur. Behaviours that indicate mind-wandering such as

fixation Zhang et al., 2021 occurred throughout P12RE gameplay during 'Life is Strange'.

4.3.1 Eye-behaviour as an indication of mind-wandering

A recent study that discusses eye behaviour and mind-wandering found that fixation occurred less frequently during intentional than unintentional mind-wandering episodes (Zhang et al., 2021). However, when it did occur during unintentional mind-wandering the fixation was longer in duration. During our coding and analysis process fixation as an indicator of different types of mind-wandering was not considered, instead fixation was assumed to be a possible indicator of mind-wandering overall.

Fixation may pertain to mind-wandering during particular situations in games. Situations such as where diligence to a specific location was not necessary for engaging in gameplay (Figure 4.8), or during times when the player was highly familiarized with the game.

Fixation often occurred in games that allowed players to pause what they were doing without consequence, or provide a window of time where players cannot/do not need to act. However, some fixation was observed during times of highly active gameplay. In the results, I attributed many instances of fixation occurring during repetitive actions and as being akin to future planning, because of the specific context when observations were made. It is important to note that most research looking into mind-wandering related behaviour uses in-lab tasks that use static images or other simple stimuli designed for simple tasks such as vigilance tasks (Martínez-Pérez et al., 2021; Thomson et al., 2015; Zhang et al., 2021). These types of studies are essential to understand mind-wandering under different conditions fully, but a difference that may be critical between a word task and playing a digital game is the breadth of stimuli between the two tasks. Digital games are more complicated and are often designed for players to immerse themselves in a virtual world that affords its own goals. Although known gaze patterns exist during reading tasks, such as the repetitive scanpaths identified by Zhang et al. (2021) during unintentional mind-wandering, different games might exhibit a similar tendency yet with different types of patterns. For this reason, it may be beneficial to break a particular game up into a set of tasks and compare game tasks between multiple games.

4.3.2 Digital Games as a Set of Tasks

I argue that complex game tasks should be treated as a set of tasks that interact with visual and auditory elements to provide a player with a particular experience. When studying

Figure 4.8: In Warcraft 3 players select individual or grouped units and move them across an area to perform different tasks. In the current figure the participant engaged a selected group of units in battle. The player is waiting for the battle to conclude and fixates on the units.

mind-wandering during digital gameplay, it is important to try and define what tasks players are engaging in when mind-wandering occurs to properly identify whether the thoughts the player is experiencing are task-related or task-unrelated. Breaking down videogames conceptually into more specific and simpler tasks may be beneficial to study behaviours attributed to mind-wandering, such as specific gaze patterns, in a more controlled way. The current study took a broader approach by identifying "Modes of Play", but the addition of analyzing games as specific sets of tasks can help to map specific behaviour more closely to game mechanics, and help to identify task-related and task-unrelated thoughts.

In the case of our study, in the the future planning theme, I assumed players may be planning goals or actions, related to the game, but I argue that not all future planning in games is task-related thinking because the thoughts may be directed at future tasks in the game, some of which may be different to the current game task. There is also the possibility

of thoughts completely unrelated to the game at all. The boundary between task related and task unrelated may be difficult to define in all games. It is unclear how an individual player breaks up a game in terms of tasks, or if they do so. For example we can take the game Skyrim and break it up into different tasks arbitrarily, such as combat, exploration, lock picking. However, when discussing the term "task" in the context of mind-wandering, it often refers to specific activities such as diligence tasks, or reading. Driving is the most complex task that has been studied in terms of mind-wandering that could also be broken up into several sub-tasks, but despite the multiple factors, there is the primary goal of being diligent and watching the road. In contrast, not all digital games involve one set goal that a player must keep track of at any given time.

Mind-wandering is likely to occur differently when cognitive load is low compared to when it is high (Iijima & Tanno, 2012). More specifically Iijima and Tanno (2012) identified that future-related thoughts occur more frequently during states of low cognitive load. A possible example of where low cognitive load took place is P10LT, while playing Skyrim, was playing a dungeon that was familiar to them. Even though they were constantly moving and taking actions, if the player was used to doing this, then the future planning of their next step would not impede their cognitive load. Another example would be games like Candy Crush—a mechanically repetitive game that requires matching candies of the same colour— that also provides some breaks from the matching task by the addition of animations.

4.3.3 Mind-wandering Experience Sampling

No significant result was found for game type and reported mind-wandering. The low sample size could be responsible as well as a low administered questionnaire number. In the original study where this questionnaire was used, the average number of probes per participant used was 14.07 during each session of the task (Poerio et al., 2017). In contrast, our average was 7.8. A brief qualitative analysis of how participants answered the questionnaire was done while the gameplay videos were being edited. It was evident that some participants answered the survey in the same way every time because of the speed of their answers and the tendency to choose the same choice, with a small sample size, these results have a large influence on the rest of the data.

When gameplay segments were separated from the survey part of the video, the survey results immediately following a segment were loosely used to identify any daydreaming that occurred during the segment. These are not conclusive instances. Instead, the results were combined with other behaviours noticed during gameplay as evidence for potential daydreaming.

In the current study, we do not claim definitive instances of mind-wandering. Instead, we analyzed the context and various behaviours for potential patterns that may indicate mind-wandering. These patterns are based on observation and supplemented by other research that reports similar behaviour.

4.4 Summary of Findings

The findings of my study were:

- Participants engaged in various modes of play, and these modes helped determine the behaviour associated with mind-wandering. Six modes of play were identified: Repetition (subsection 4.1.1), Playing through narrative (subsection 4.1.2), Experiencing narrative (subsection 4.1.3), Journeying (subsection 4.1.4), Ride the wave (subsection 4.1.5), and Waiting for action (subsection 4.1.6).
- Participants seemed to be mind-wandering during games with highly repetitive play or when players themselves engaged in highly repetitive gameplay (Theme: Repetition Is Connected To Mind-Wandering)
- Participants also tended to stop what they were doing and stand still as though trying to figure out what to do next, or scan ahead in anticipation of something. (Theme: Future Planning/Problem Solving)
- When engaging in a mode of play that was not demanding or did not require attending to players would at times look away from primary focus points of events, such as during cut scenes or AI turns. Although rarely, players at times gazed away from important game events and fixated on seemingly unrelated locations. (Theme: Wandering Eyes)
- The last theme describes times when players make mistakes in the moment in unexpected ways. This theme did not occur often; however, when it did occur, it was salient to the researcher. (Theme: Hitting Walls and Missed Opportunities)

Chapter 5

Limitations, Future Work, and Conclusion

In chapter 4, I discussed the recurring themes found through gameplay and eye tracker analysis from our exploratory, in-lab study of players and the games they played. In this chapter, I cover the limitations of my study, potential future work, and conclude my thesis.

5.1 Limitations & Future Work

The results of the thematic analysis presented in chapter 4 are not intended to provide evidence for mind-wandering during digital gameplay, but are rather an exploration of possible mind-wandering experiences. These results are meant to be used to posit new hypotheses related to digital gameplay and mind-wandering. Some limitations of the current study are as follows:

- Small sample size, with three participants having corrupted data.
- We did not balance for gender
- The age range of our study was 18–44, and some studies suggest that younger and older populations have different mind-wandering frequency and experience (Diede et al., 2022; Frank et al., 2015; Jackson & Balota, 2012). It is important to note however that, in these studies, young adults were defined at being in their twenties and older adults as being 60 or older, so our participants fall outside the category of older adults.

- The thought sampling questions although used in previous studies, are not a validated questionnaire. For this reason other ways of collecting mind-wandering during digital gameplay may be worth considering, such as the use of a foot pedal for participants to press when they catch themselves mind-wandering.

- The game variety was too large. While I allowed participants to choose their own games to make sure they were playing games they were familiar with and were motivated to play, having participants play the same game or a set of games would provide a better control.

- When gaming, there is a lot going on in terms of stimuli and experience, and it is hard to isolate specific types of mind-wandering (mind-wandering about game vs outside the game) from one another, as well as non-mind-wandering behaviour such as distractions.

The following are some research questions I have identified based on the limitations of this work and my findings:

- Does the default network activate during digital gameplay? Further research requires brain scanning technology to verify default network activity during different digital gameplay. One of our themes noted that players might be engaged in future planning in the game; assuming they were doing this, it is unknown whether planning their game activity is the same as future planning about daily life events.

- Familiarity and repetition: Previous research suggests that mind-wandering increases during familiar events like driving the same route (Young et al., 2018), and the observations in the present study where players fixated during the repetition reinforce these findings. Further research could investigate and test how familiar game events or repetitive elements may contribute to mind-wandering.

- Content of mind-wandering: In future work, it would be beneficial to measure the types of mind-wandering that people experience during different game events. As suggested in recent work by Westgate et al. (2021), it is possible to guide intentional mind-wandering through dialogue prompts, which raises the question: do other elements, such as music or art style, also have an impact? Future research could more carefully isolate this factor and interrogate this question.

In the results, I discussed the analysis of different modes of play experienced while playing games. These modes were meant to provide some insight into game-specific activities that the player is afforded in different games, using noun-verb diagrams (Ramirez,

n.d.). These diagrams are often used by game designers when creating a concept for a new game. The diagrams involve creating bubbles that are labeled with important nouns, such as "player," that are connected by arrows labelled with verbs, such as "explore." These diagrams are meant to establish a general idea of what a player will be doing in the game, and the general structure of the game itself (e.g., Figure 4.1). Unfortunately, although noun-verb diagrams are suitable for laying out the game's core mechanics, they do not thoroughly plan for the player experience. The tendency to mind-wander may be of particular interest to the e-sports community because mind-wandering can impede adaptation to in-game situations and reduce player performance. It is also important to take into account that post-game rumination is likely to occur when players have a bad game, but luckily it may be possible to mitigate this through post-game design by guiding players' thoughts away from the negative. It is also possible to experiment with various repetitions of game elements to induce a state of relaxation. Providing players with the opportunity to relax can be beneficial for their mental health, and the rest for their brain can help them overcome future obstacles they might face in a game.

5.2 Conclusion

In this thesis, I contributed a thematic description of various game elements and player behaviour during digital gameplay, providing supporting evidence for eye behaviour, such as fixation, that is associated with mind-wandering in the context of playing digital games. I identified four themes: *Repetition Is Connected To Mind-Wandering*, *future planning and problem solving*, *wandering eyes*, and *hitting walls & missed opportunities*. These themes provide a basis for future research and design to consider the impacts of mind-wandering in digital gameplay. For example, designers might intentionally incorporate repetitive play to encourage mind-wandering, or might use gameplay data of players hitting walls to predict mind-wandering and intervene when avoiding it is desirable (e.g., an e-sports competition). This thesis provides a foundation to move this research area forward.

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APPENDICES

Appendix A

Questionnaires

A.1 Qualtrics Experience Sampling Questions

This section shows the experience sampling questions as participants would have answered them in Qualtrics.com.

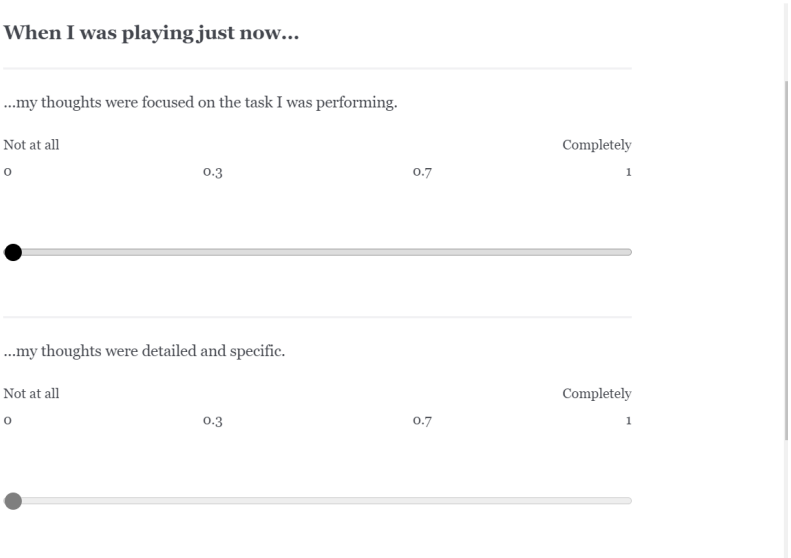

Figure A.1: First page of Experience Sampling Questionnaire

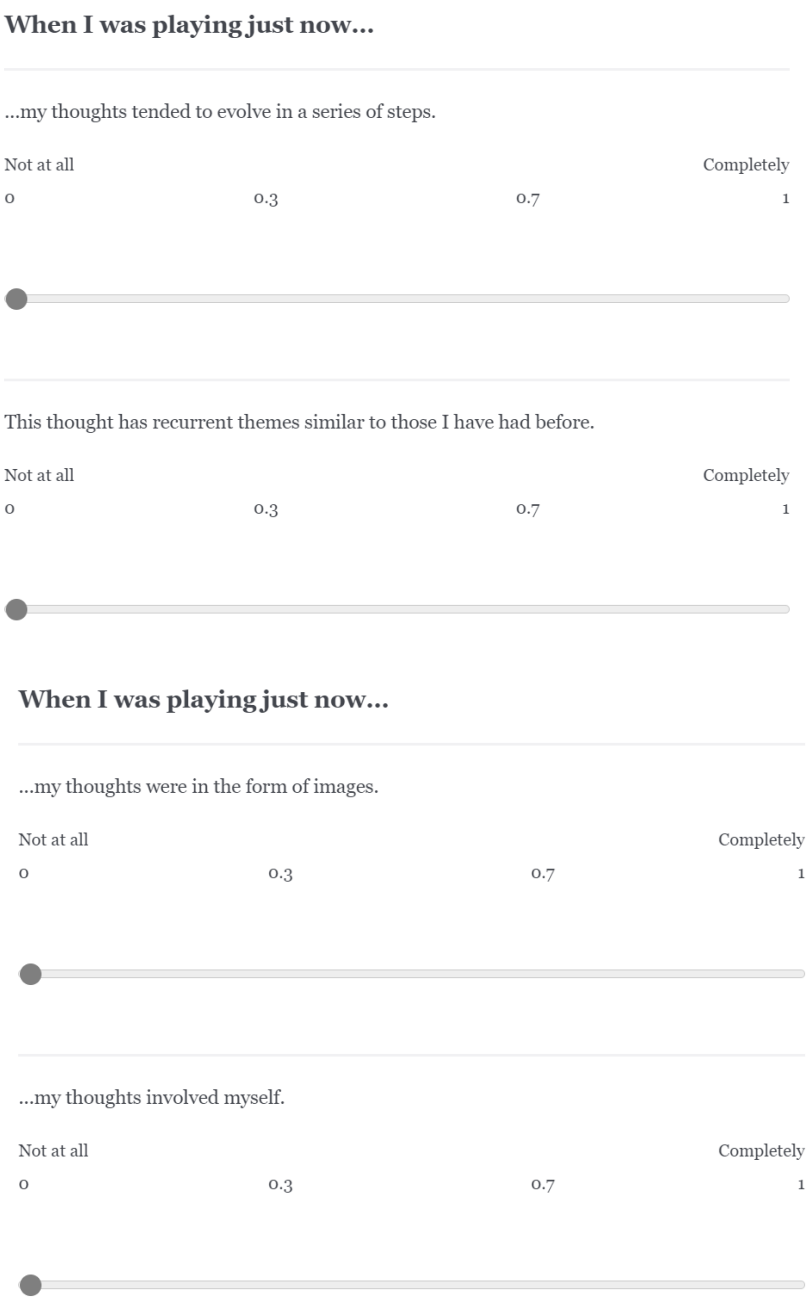

Figure A.2: Pages 2-3 of Experience Sampling Questionnaire

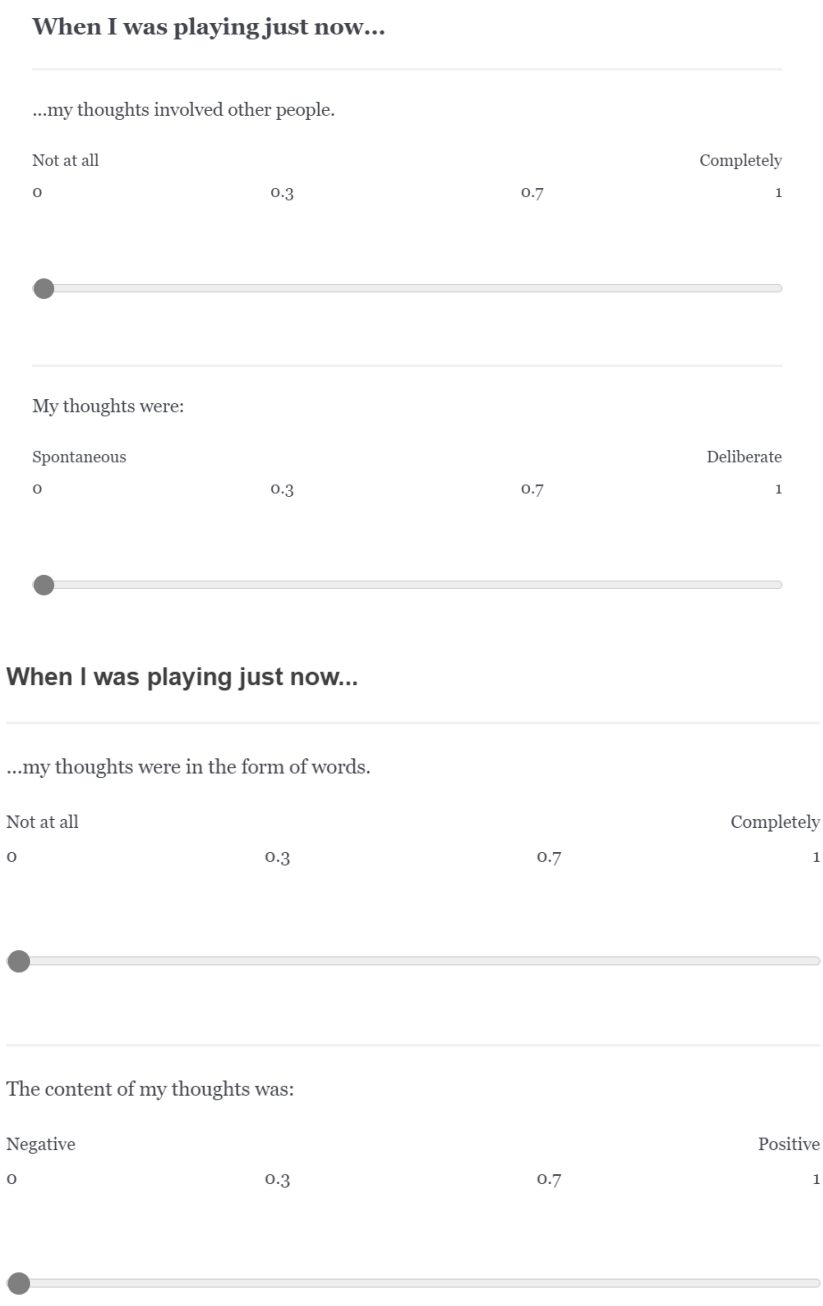

Figure A.3: Pages 4-5 of Experience Sampling Questionnaire

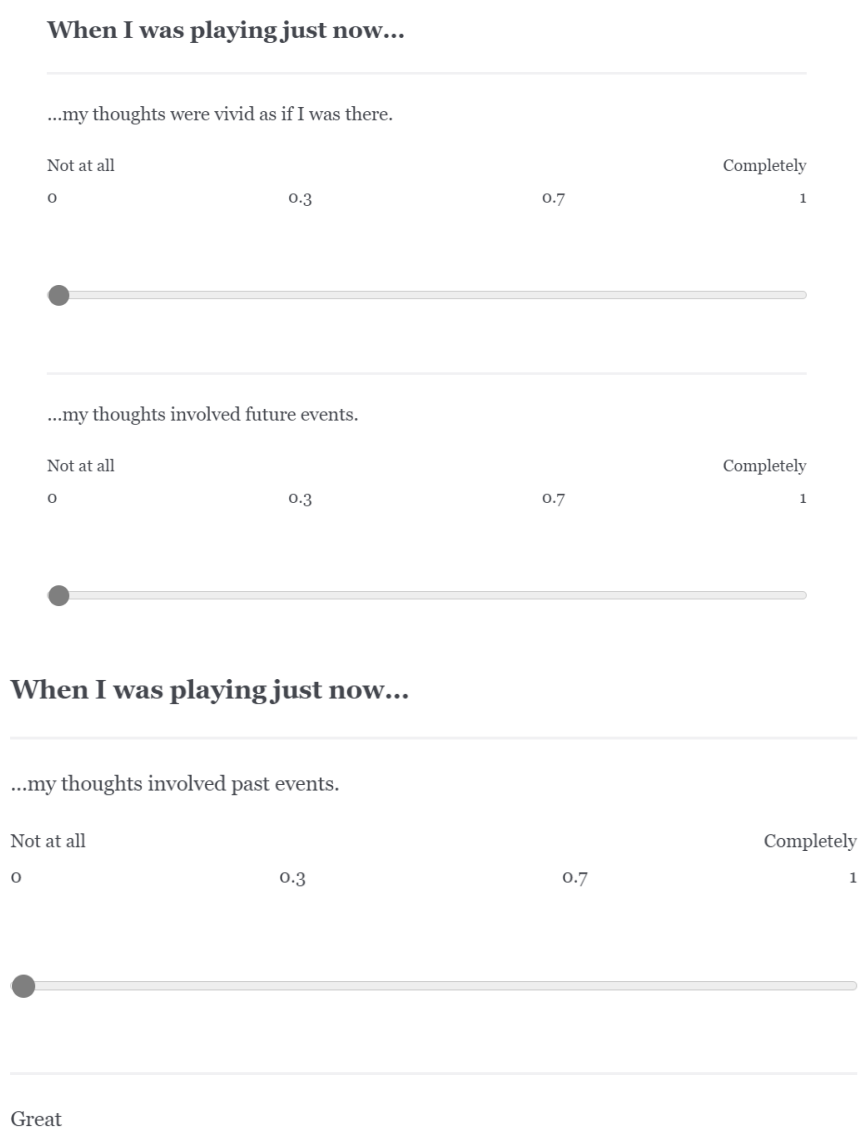

Figure A.4: Pages 6-7 of Experience Sampling Questionnaire

A.2 Flow Questionnaire

This section shows the Flow Questionnaire as participants would have asnwered it in Qualtrics.com.

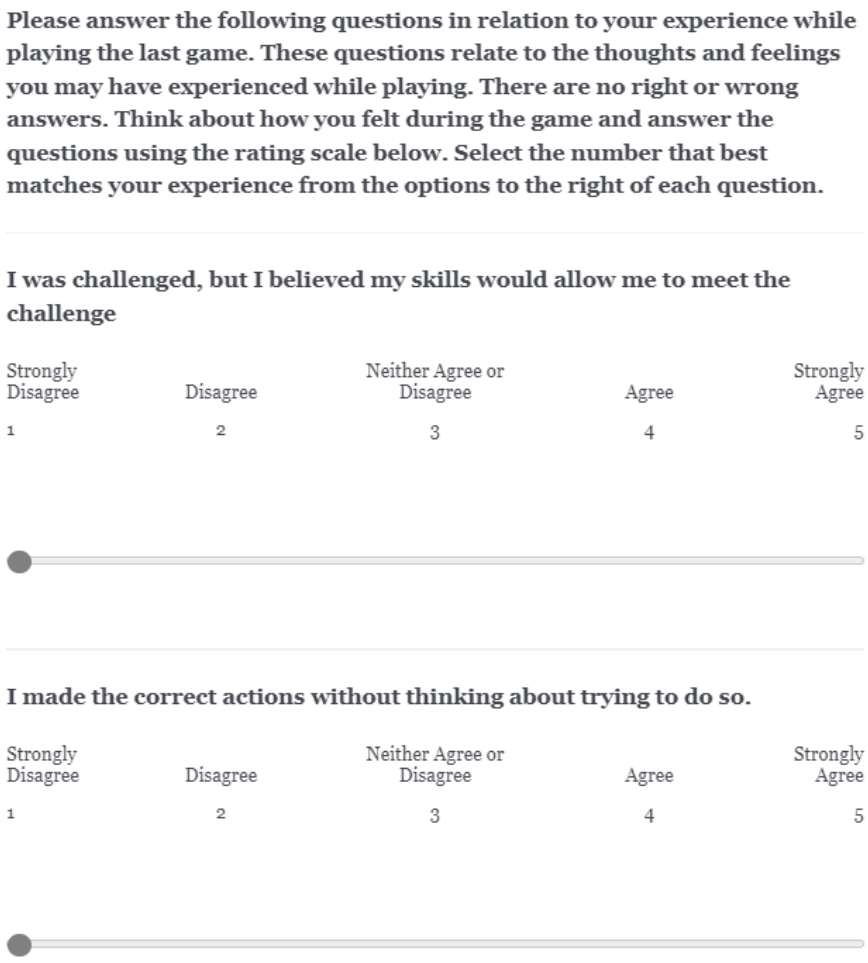

Figure A.5: First page of Flow Questionnaire

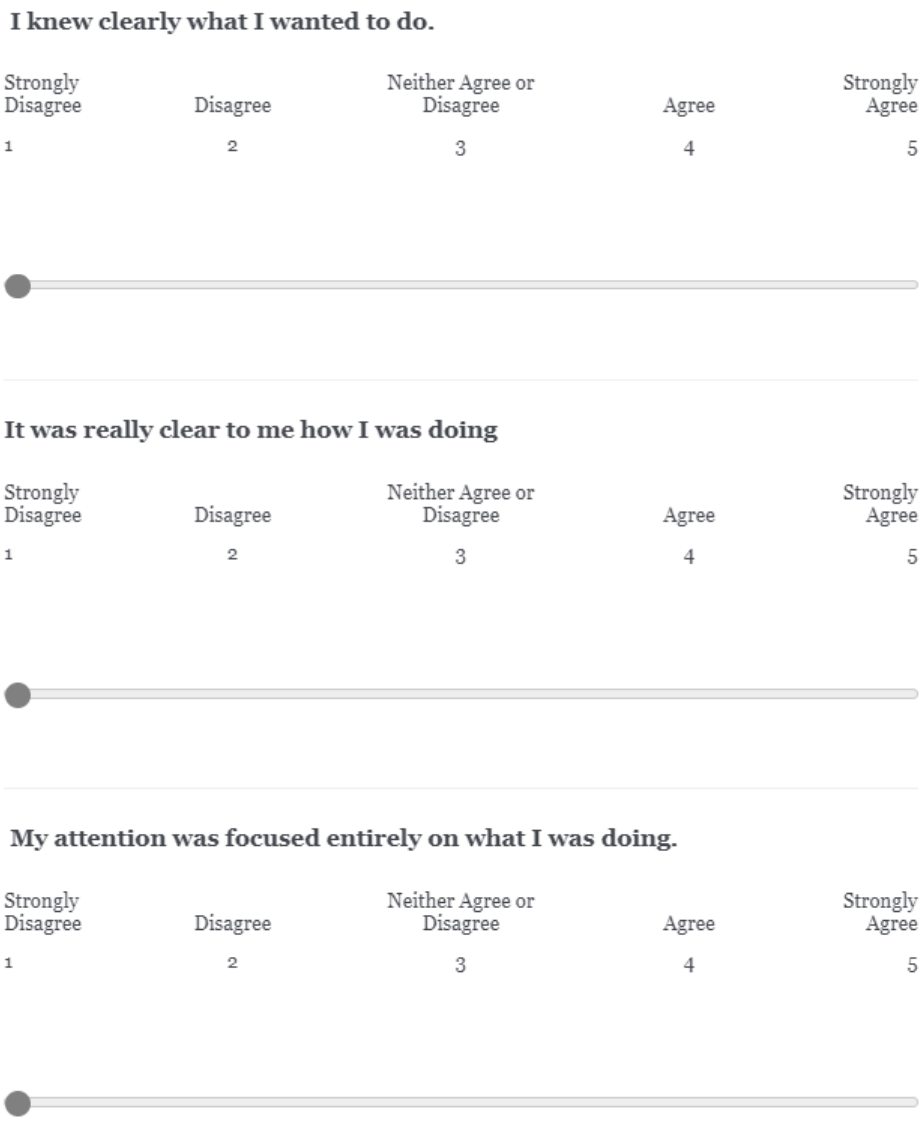

Figure A.6: Second page of Flow Questionnaire

I had a sense of control over what I was doing

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I was not concerned with what others may have been thinking of me

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Time seemed to alter (either slowed down or speeded up).

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.7: Third page of Flow Questionnaire

I really enjoyed the experience of what I was doing

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

My abilities matched the challenge of what I was doing

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Things just seemed to be happening automatically

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.8: Fourth page of Flow Questionnaire

I had a strong sense of what I wanted to do.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I was aware of how well I was doing.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

It was no effort to keep my mind on what was happening

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.9: Fifth page of Flow Questionnaire

I felt like I could control what I was doing.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I was not concerned with how others may have been evaluating me

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

The way time passed seemed to be different from normal.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.10: Sixth page of Flow Questionnaire

I loved the feeling of what I was doing, and want to capture this feeling again

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I felt I was competent enough to meet the demands of the situation

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I did things automatically, without thinking too much

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.11: Seventh page of Flow Questionnaire

I knew what I wanted to achieve.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I had a good idea about how well I was doing while I was playing the game

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I had total concentration.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.12: Eighth page of Flow Questionnaire

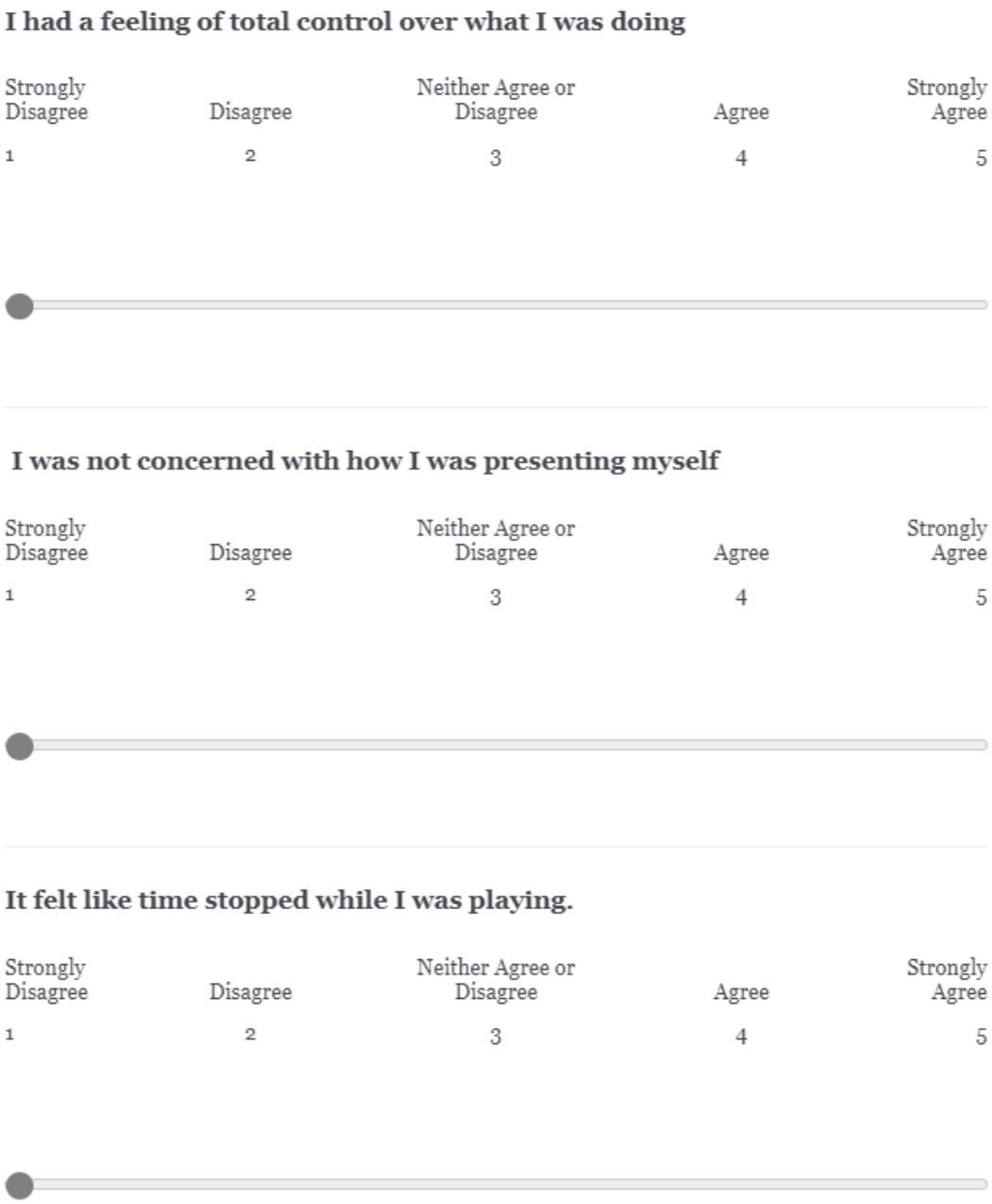

Figure A.13: Ninth page of Flow Questionnaire

The experience left me feeling great.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

The challenge and my skills were at an equally high level

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I did things spontaneously and automatically without having to think.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.14: Tenth page of Flow Questionnaire

My goals were clearly defined.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I could tell by the way things were progressing how well I was doing

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I was completely focused on the task at hand.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.15: Eleventh page of Flow Questionnaire

I felt in total control of my actions

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I was not worried about what others may have been thinking of me.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

I lost my normal awareness of time

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	2	3	4	5

Figure A.16: Twelfth page of Flow Questionnaire

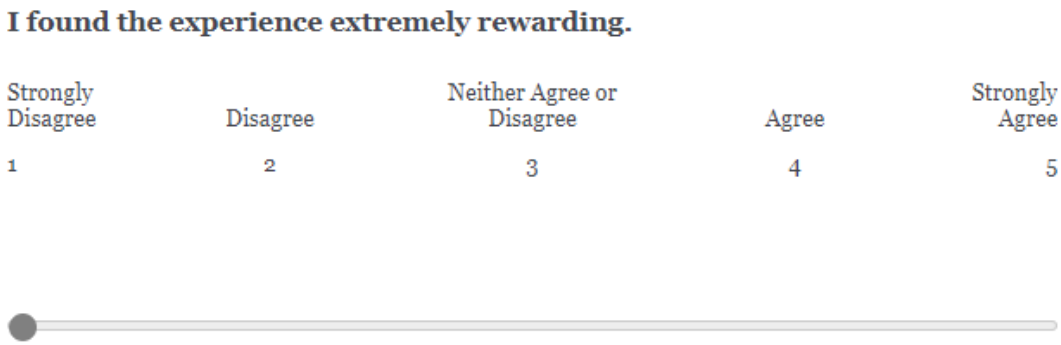

Figure A.17: Thirteenth page of Flow Questionnaire

Appendix B

Ethics Statement

B.1 Ethics Approval

This study has been reviewed and received ethics clearance through a University of Waterloo Ethics Committee. (ORE #40291). If you have questions for the Committee contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca