Not All Those Who (Mind-)Wander Are Lost: Exploring Game-Unrelated Thoughts

Cayley MacArthur
Stratford School of Interaction Design and Business
University of Waterloo
Stratford, Ontario, Canada
cayley.macarthur@uwaterloo.ca

Kateryna Morayko
University of Waterloo
Waterloo, Ontario, Canada
kmorayko@uwaterloo.ca

Alessandra Luz
Cheriton School of Computer Science
University of Waterloo
Waterloo, Ontario, Canada
alessandra.luzlam@uwaterloo.ca

Mark Hancock
Management Science and Engineering
University of Waterloo
Waterloo, Ontario, Canada
mark.hancock@uwaterloo.ca

ABSTRACT

Task-unrelated thoughts (TUTs), colloquially referred to as mind-wandering or daydreaming, are phenomena that can interfere with attention and focus, but are also associated with mental health, creativity, and learning. In digital games, it is unclear how players experience game-unrelated thoughts (GUTs), whether GUTs should be encouraged by game designers, or how it may impact player experience. We ran an initial study to confirm whether GUTs are common (50 of 100 participants reported experiencing them). We then collected 840 minutes of gameplay data from 12 participants playing games they: (1) found relaxing, (2) lost track of time in, and (3) spent most hours playing. Eye-tracking data and experience sampling were used to contextualize a phenomenological analysis of gameplay data. We identified four themes encompassing gameplay, GUTs, and gaze behaviour: these provide a foundation for future research and game design incorporating GUTs.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in HCI*; • **Applied computing** → *Computer games*.

KEYWORDS

mind wandering, daydreaming, games, play experience

ACM Reference Format:
Cayley MacArthur, Kateryna Morayko, Alessandra Luz, and Mark Hancock. 2024. Not All Those Who (Mind-)Wander Are Lost: Exploring Game-Unrelated Thoughts. In *Designing Interactive Systems Conference (DIS '24), July 1–5, 2024, IT University of Copenhagen, Denmark.* ACM, New York, NY, USA, 18 pages. https://doi.org/10.1145/3643834.3661590

DIS '24, July 1–5, 2024, IT University of Copenhagen, Denmark

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 εὐφαντασίωτος 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.
>
> —Quintilian, *Institutio Oratoria* [75]

Daydreaming has been written about as early as 95 AD, often in a negative light, as the above quote from Quintilian highlights using the Ancient Greek word εὐφαντασίωτος (*effantasíotos*, which translates to "gifted with a vivid imagination" [38]). Task-unrelated thoughts (TUTs), colloquially called mind-wandering or daydreaming, have been studied in 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 [87, 88], but a unique brain network, the *default mode network*, has been directly linked to the function of TUTs [2, 30, 54, 71, 104]. In our research, we explored the phenomenon of TUTs in digital games, which we call game-unrelated thoughts (GUTs) when appropriate, to produce knowledge to assist game designers in targeting positive GUT experiences and leveraging the potential cognitive benefits that this phenomenon can provide. It is also important to note that there is some nuance around the concept of "game-unrelated" in GUTs, where thoughts can be unrelated to the current gameplay experience, but still related to the game as a whole (e.g., thinking about the future plans in the game, but forgetting about the current game task). This mirrors the TUT literature, where thoughts can be unrelated to the task in the current moment, but still be relevant to the task as a whole [54, 86, 87, 104].

Like TUT research, digital game design and research is highly interdisciplinary, involving fields including art, mathematics, psychology, and HCI, to name a few. Games user researchers have sought to inform designers as to how they can create more engaging games through the lenses of concepts like self-determination theory

and motivation [73], continuation desire [81], immersion [e.g., 92], or flow [e.g., 14, 18, 60], among others. In general, maintaining a player's engagement promotes the desired behaviour of continued gameplay. As such, designers may be inclined to want to reduce GUTs. However, due to the prevalence of TUTs in day to day life, GUTs are inevitable and should instead be expected to occur. Previous research showed that TUTs themselves might not hinder engagement [64], but can add depth to the existing gameplay experience. Therefore, understanding this natural phenomenon would be beneficial to harness it as another tool in the researcher's and designer's toolbox, aiding with the pursuit of designing more holistic player experiences.

In the context of this paper, "TUTs" and "GUTs" (task- and game-unrelated thoughts) are used as umbrella terms for words such as: daydreaming, mind-wandering, stimulus-independent thoughts, zoning-out, conscious fantasy, or spontaneous thoughts [15]. Games and TUTs alike have received similar social treatment in that they are often spoken of as frivolous or poor for mental health, even though there is growing evidence that the reality for both is much more nuanced and complex. Despite the evidence of its ubiquity [46, 48, 83], a negative association continues to dominate the discussion around TUTs, often ascribing TUTs not as a regular occurrence but as "cognitive failure" [95]. In the bigger picture, TUTs may be beneficial for other cognitive processes such as creativity [107] and goal-oriented thought processes [56]. We believe that this line of research generates value for the HCI and games user research (GUR) communities because this promising information, coupled with evidence for how digital games can be used for promoting positive psychological outcomes [e.g., 1, 36, 41, 100], motivates further investigation into the ways that one might build games that are both engaging *and* beneficial for players through a strengthened understanding of underlying cognitive processes.

To this end, we aim to address the following research objectives (ROs) in this paper:

RO1. Establish the prevalence of experiencing game-unrelated thoughts (GUTs).

RO2. Determine what observable behavioural patterns (i.e., eye movements, gameplay actions) may relate to instances of GUTs.

RO3. Determine what game contexts are related to GUTs. For example, we aimed to identify game mechanics, modes of play, types of activity, and so on that may be connected to this phenomenon.

In addition to addressing these research objectives, we also determine additional areas for research questions and future work in GUTs. We conducted two studies:

- An online study of 100 participants to see if people have GUTs while playing games;
- Live gameplay with 12 other participants, where each participant played three different games and answered experience sampling questions.

Through our research, we hope to provide game designers and researchers with tools to understand the phenomenon of GUTs, and incorporate them into their game mechanics.

2 RELATED WORK

To situate our research, we describe the trends and perspectives pertaining to the study of task-unrelated thought (TUT) in past research, followed by an overview of approaches to measure mind-wandering, and then discuss instances of mind-wandering research in the fields of human-computer interaction (HCI) and games user research (GUR).

2.1 A Brief History of Mind-Wandering

It is unknown how long the concept of mind-wandering as we understand it today has been around. However, fantasizing of future happenings has been recorded in writing as early as ancient Greece [75]. Mind-wandering has historically been alluded to in different mediums including art, philosophy, and science, dominating the conversation negatively. Colloquially, "daydreaming" is used instead of "mind-wandering" and is spoken of as a series of usually 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 class or at a meeting, then daydreaming is considered a bad thing: the daydreamer is spacing out and not paying attention. Conversely, daydreaming is appropriate for that context if the activity is considered leisurely, such as strolling. If the content of the thoughts involves work or study during the walk, then daydreaming is deemed good. This daydreamer is creative; they are perhaps experiencing a "Eureka!" moment.

A lot of research on mind-wandering carries negative undertones. One of the earliest studies hypothesizing about mind-wandering was published in educational research in 1927, positing that daydreaming about love affairs, athletic activities, and professional accomplishments decreased academic success among children [10]. Similar notions regarding mind-wandering as the failure of attention exist today. Previously, Unsworth et al. [95] 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 certain societal settings where it has been deemed inappropriate. Killingsworth and Gilbert [46] 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 interfere with driving performance [105, 106]. Moreover, when mind-wandering is overdone, also called rumination, it can perpetuate mental health issues such as depression and anxiety [97, 99]. However, it is essential to note that rumination has not been identified as the cause of mental health issues [63]. What we take from this is that, in general, mind-wandering has existed in our social consciousness for centuries. At the same time, social expectations have shaped

perceptions of how and whether this occurrence is or is not desirable. It is, therefore, necessary to take a closer look at the literature pertaining to this phenomenon to parse what we can learn about the process independently from the influence of social norms.

2.2 The Study of Mind-Wandering: Negative Interpretations of a Necessary Behaviour

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. [55], a bias against mind-wandering exists whereby the majority of research has interpreted mind-wandering as being negative [59] while ignoring the positive aspects of mind-wandering that have been investigated. In particular, Jerome L. Singer was known for adopting a more neutral stance when investigating daydreaming, taking into account the problems associated with it but also arguing for the beneficial side of daydreaming [48, 55, 83]. In recent years, creativity and problem-solving research have explored forms of mind-wandering beneficial for creative processes [107]. Bogart et al. [7] go as far as to hypothesize that the same processes involved in mind-wandering and daydreaming also affect spontaneous creativity. Williams et al. [103] provide evidence that spontaneous thought and attention are part of the same system and are critical for creative processes. In addition, an investigation following professional writers and physicists used a diary study approach in which participants were asked a series of queries, including thought sampling questions, finding 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 [33]. It may also be possible to guide individuals to have positive mind-wandering experiences through prompts [102], which suggests that external factors can impact mind-wandering content. We consider this one of the exciting avenues for future work in mind-wandering research, where technology could be used to promote beneficial types of mind-wandering behaviour.

2.2.1 Parallels Between Mind-Wandering and Video Games. Parallel to mind-wandering, various gameplay has also been regarded with a negative bias among scholars despite inconsistent availability of evidence, even associating digital gameplay with adolescent delinquency [28]. This literature expresses concerns about the number of hours spent gaming or daydreaming and a possible reflection on an individual's mental health [72, 74, 85]. However, there are benefits to both digital gameplay and mind-wandering on mental health [32, 68, 78, 101], as well as a link between creativity [37, 66] and an ability to take our brain on a journey through time and space. As game designers and researchers, acknowledging that there are positive, negative, and as-yet-unknown effects stemming from complex topics such as digital games and mind-wandering is important to move forward with nuanced and responsible game design and gameplay. Although indirectly related, Dias da Silva et al. [21] provide evidence that TUTs relate to various behavioral factors such as the variability of behaviour increasing before TUT episodes, higher variability in reaction times, eye movements, and fidgeting. Although behaviour in the context of games is not discussed, player behaviours provide another context for the potential external expression of factors relating to TUTs.

2.2.2 The Default Network. The concepts of daydreaming and mind-wandering have been connected more recently to neuroscience by the recent discovery of the default brain network. This discovery 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 [76], suggesting that functional magnetic resonance imaging (fMRI) studies should establish a control by having participants rest and passively look at a fixation cross hair instead of asking participants to rest with closed eyes. This study highlighted a vital brain function. During wakeful rest, certain brain areas that would otherwise be suppressed during goal-directed tasks are used, suggesting internal behaviours occur during the default state [30, 71]. Other studies looking into the default network have emerged with evidence for specific internal mentation behaviours such as imagining past and future events [2, 54, 104], and thoughts about goal setting [56]. In other words, there is significant evidence that this restful, active brain behaviour serves an important cognitive function, and participants in these studies report experiencing mind-wandering and daydreaming-like behaviour while engaging the default network. These findings further show how prevalent mind-wandering is in everyday brain function. While our work does not involve measurement of brain activity (e.g., with an fMRI), observing patterns of play that may connect to mind-wandering can provide insights about future work that might explore brain activity and how it relates to gameplay.

In this paper, we build on this research by exploring game-unrelated thoughts (GUTs) during video game play, without implicating positive or negative attributes. For example, GUTs may hinder performance, but may also benefit experience during gameplay. Alternatively, if external prompts and stimuli can influence TUTs, then different types of games or game events may also affect the content of GUTs and their frequency. In the latter case, digital games could potentially be used to increase positive GUTs.

2.3 Measuring Mind-Wandering

The rigorous investigation of mind-wandering through experimental means did not begin until 1956 when Cohen et al. [16] 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 viewed a lecture. Other indirect measures of mind-wandering use self-reporting through diary studies [33, 52, 96] and experience sampling [46, 71, 108]. Out of the two self-reporting methods mentioned, experience sampling is most widely used across the study of various thought processes, and recent work has investigated the validity and best practices to implement experience sampling in research [45]. Evidence suggests that some physiological measures such as eye-tracking [6, 9, 31, 35, 108], facial features, and body movements [90] can be successfully used to measure mind-wandering indirectly. Direct measures of brain activity include fMRI, which is seen in most neuroscience imaging

studies investigating mind-wandering, and electroencephalography (EEG) [20, 22, 44].

In this paper, we conduct an exploratory evaluation of mind-wandering in the context of gameplay. As a result, our primary methods of data collection were qualitative. Nonetheless, we triangulate this data with eye-tracking and experience sampling (drawing from a procedure used by Poerio et al. [71]). While future work could investigate direct measures, like fMRI and EEG (which are expensive, require specialized training, and the gathered data are difficult to analyze), this work is exploratory in nature. It can help to build a foundation for what to investigate in future studies using increasingly sophisticated techniques.

2.4 Mind-Wandering in HCI and GUR

Games user research (GUR) is a relatively young and rapidly developing field that aims to study human experiences during video game play [23, 62]. Many user experience research (UXR) methods have been used within GUR [4], and both share similar goals of understanding how people experience and interact with technology. In both HCI and GUR, video games have been studied extensively [5]. To date, mind-wandering research is less prevalent in either field. Instead, we see co-occurrences of mind-wandering and video games in contexts like psychology, where it is often painted with broad, negative strokes.

Little investigation has been done into mind-wandering while using technology. Within HCI research, the main focus of studies on mind-wandering has been to mitigate the adverse effects of mind-wandering during tasks such as reading and driving [6, 24]. The narrative that mind-wandering is "bad" has also echoed throughout HCI research, following in the footsteps of psychology and education. Minimizing mind-wandering 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 mind-wandering on health and experience with technology are under-reported. In the spirit of positive mind-wandering experinces, Eichenlaub et al. [25] recently investigated the relationship between fidgeting and mind wandering by designing and testing an interactive haptic fidget object.

Within GUR, Mekler et al. [57] 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 [19]. In recent work, Olaya-Figueroa et al. [64] created a game to facilitate mind-wandering while keeping immersion high by changing gameplay mechanics such as game speed and challenges. Although the field is primarily dominated by an investigation into making games more immersive and engaging without considering mind-wandering, recent findings such as these highlight an intriguing connection between mind-wandering and gameplay.

3 PRE-STUDY: ESTABLISHING PREVALENCE OF GAME-UNRELATED THOUGHTS

As most of the literature on task-unrelated thoughts (TUTs) has thus far focused on tasks outside of gameplay with few exceptions [6, 19, 24, 57, 64], we conducted an initial online study to confirm the prevalence of game-unrelated thoughts (GUTs) during play. In particular, games are known to be engaging, and we wanted to confirm that there were still opportunities for players to experience thoughts unrelated to what they were doing. We therefore asked participants to respond to a 5-minute questionnaire that asked about GUTs, in addition to demographics and a mind-wandering scale, to measure predisposition to mind-wandering. Our data and study materials are available in an OSF repository[1].

3.1 Participants

We recruited 100 participants (self-identified gender: 60 men, 39 women, 1 non-binary; age: $Mdn = 23$, range: 18–53) using the Prolific[2] platform who were each paid £0.75 for their time. Participants were only eligible to participate if they had already been playing a game for 30 minutes. Note that no data were collected from this gameplay, as it was completed prior to the participant taking the survey, so this remuneration was only for the 5 minutes to complete the survey (completion time: Mdn = 3min 28sec).

3.2 Measures

The questionnaire comprised a single thought probe with a binary yes/no response: "While playing, I was thinking about things unrelated to the game/my mind was wandering." This probe was followed by two questions: first, verifying what game was played and that it was played alone (i.e., as a single-player game); second, the 12-item daydreaming frequency scale of the Imaginal Processes Inventory (IPI) [84] as seen in Table 1 (each item on a 5-point scale, 6 reverse scored, score range: 12–60), which provides a measure of mind-wandering tendencies; finally, we concluded with demographic questions about gender and age.

3.3 Results

Exactly half (50 of 100) of the participants reported "yes" to our GUTs probe, which gives an Adjusted Wald 95% confidence interval of 40.4% to 59.6%, suggesting that a significant number of players experience game-unrelated thoughts (GUTs) while playing for 30 minutes.

We also conducted a Welch two-sample t-test to compare means of participants who reported experiencing GUTs (M = 37.8, 95% CI [36.2, 39.4]) to those who did not (M = 36.5, 95% CI [34.6, 38.3]) using the mind-wandering IPI subscale as a dependent measure, which was not significant ($t_{93.5} = 1.1, p = .27, n.s.$). Thus, there is no evidence to suggest that the game-unrelated thoughts were related to a predisposition to mind-wander. While this may seem to be a surprising result, we think this lack of evidence is likely because we did not control for the nature of play in any way (e.g., which game played, whether it was played in a controlled environment)

[1] https://osf.io/ctpn4/?view_only=4d5d60b23f374ca685c225e194d508ad
[2] https://prolific.co/

Table 1: The 12 questions that make up the daydreaming frequency scale (DDFS), one of 28 sub-scales found in the Imaginal Processing Inventory (IPI) [84] (Note: these questions are copied for your convenience, as digital copies of this source are not easily available). Each question was answered on a five-point scale where: 1 is "Definitely not true for me", 2 is "Usually not true for me", 3 is "Usually true for me", 4 is "True for me", and 5 is "Very true for me".

1	My mind seldom wanders while I am working.
2	At times it is hard for me to keep my mind from wandering.
3	My mind seldom wanders from my work.
4	During a lecture or speech, my mind often wanders.
5	I have seldom found my mind wandering during a speech, concert, show, radio, or TV program.
6	My thoughts seldom drift from the subject before me.
7	I am the kind of person whose thoughts often wander.
8	I have little difficulty in keeping my mind focused on a long, tedious task.
9	I can work at one thing for a long time with relatively little effort.
10	No matter how hard I try to concentrate, thoughts unrelated to my work always creep in.
11	I have difficulty in maintaining concentration for long periods of time.
12	During a speech, meeting, or lecture, I often "come to," realizing that I have not heard a word the speaker was saying.

and that a more controlled lab study, a longer play time, or a large sample might yield different results (see section 7).

There also appears to be no effect of gender, with 30 of 60 male-identifying participants reporting GUTs, 19 of 39 female-identifying participants reporting GUTs, and the 1 non-binary participant reporting not experiencing GUTs. Twenty-seven participants also reported playing a multiplayer game with others present, despite the instructions to restrict the experience to a single-player game or mode. We therefore also conducted the same analysis on the remaining 73 participants, but the findings were similar (39 of 73 reported GUTs, 95% CI [42.1%, 64.4%]; mind-wandering IPI: $t_{61.4} = 1.2$, $p = .22$, *n.s.*).

4 STUDY: EXPLORING: GAME-UNRELATED THOUGHTS

Following our Prolific study, we wanted to understand how to utilize GUTs in game mechanics and/or to enhance the player experience. To do this, we conducted a phenomenological inquiry.

Thus far, most research that has examined TUTs has involved lab studies that use a combination of self-reports, such as mind-wandering questionnaires, diary studies, or experience sampling [46, 96, 108]; observational studies [16]; brain imaging techniques, such as functional magnetic resonance imaging (fMRI) or electroencephalography (EEG) [20, 22, 44]; and other physiological measures [6, 9, 90]. However, little is known about GUTs while individuals play commercially available computer-based games. To build on prior work, we incorporated eye-tracking and experience sampling into our study as secondary measures to implement data triangulation. Still, we focused primarily on a phenomenological analysis, as it provides the tools to understand better and contextualize the essential structure of GUTs, eye-tracking, and player behaviour.

Table 2: The games played by each participant and analyzed in our phenomenological analysis. Cells that appear grey are games that we did not analyze, and include sessions with recording/eye-tracking failures or games labelled as MP (see subsection 4.1). When referring to our study participants, we may use "P6" to refer to Participant 6 generally, "P6RE" to refer to their comments in context of their Relaxing game, or "P6LT" in reference to their Lose Track of Time game.

	Relaxing (RE)	Lose Track of Time (LT)	Most Hours Played (MP)
P1	Recording failure	The Walking Dead	Grant Theft Auto V
P2	Worms Reloaded	Warcraft 3	Torchlight II
P3	Recording failure	Recording failure	Recording failure
P4	Worms Reloaded	Resident Evil 5	Grand Theft Auto V
P5	Her Story	Eyetracker failure	Death Road To Canada
P6	Candy Crush	The Walking Dead	Grand Theft Auto San Andres
P7	World of Goo	Worms Reloaded	Grand Theft Auto V
P8	Eyetracker failure	Eyetracker failure	Eyetracker failure
P9	Okami	Undertale	Recording failure
P10	Stardew Valley	Skyrim	Binding of Isaac, Rebirth
P11	Candy Crush	Gas Guzzler	Stick Sports Tennis
P12	Life Is Strange	Grand Theft Auto V	Skyrim

The current study aimed to analyze the phenomenon of GUTs during gameplay through video data collected in the context of digital games. Thus, our goal was to capture the essence of GUTs in a manner that game designers could use across all types of modes of play. The use of the eye tracker was strictly deductive, based on previous research that found eye behaviour patterns correlated with TUTs during reading [6, 24]. Although we did not assume 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 processes. We grouped data related to gameplay events and player behaviour by watching gameplay videos, demarcating observed behaviours, and interpreting said behaviour and gaze based on the gameplay context. This grouped data reflected an understanding of the lived experiences of players through their GUTs within games and formed our themes.

4.1 Recruitment and Participants

Participants were recruited to the study from our university community. Twelve participants (nine self-identified as men and three as women, ages 18–44) were recruited on a volunteer basis through posters around the campus and university mailing lists. Several participants reported enjoying playing games but not having enough time for it (weekly time playing per week: eight participants reported 0–10 hrs, two 11–20 hrs, two 21+ hrs). Given that the participants played three games, categorized as Relaxing (RE), Lose Track of Time (LT), or Most Hours Played (MP), we occasionally include this information for added context. It should be noted that in the analysis, games labelled as "most hours played" (MP) are not included due to time constraints for completing the analysis. When referring to our study participants, we may use "P6" to refer to Participant 6, "P6RE" to refer to their comments in the context of their Relaxing game, or "P6LT" in reference to their Lose Track of Time game. Table 2 shows a list of all the games that participants

played, where the games that were not analyzed are in grey and the 18 analyzed games in black.

Participants were sent a brief email summarizing the experiment before their play session. Upon arrival, the experiment was described again (verbally and in writing) along with a consent form. Once they had signed the consent form, the participant was instructed to sit comfortably in front of the computer, looking ahead at the screen. First, the eye tracker was adjusted, so the participant's gaze fell to the indicated position in the Tobii software, and then the experimenter ran the eye tracker calibration routine. After calibration, the participant was asked to play the first game for 30 minutes. When it was time to probe the participant, 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. Immediately after, participants were asked to complete two more 30-minute play sessions for the remaining two games, following the same procedure as the first. Between games, the participants were reminded that they could take a break, and the eye tracker was re-calibrated if one was taken.

Sample Determination. A phenomenological approach was used to analyze our data, and the values and assumptions underlying our research are inconsistent with the use of saturation to determine sample size [8]. Instead, we focused on a small purposive sample where we chose participants that played games frequently, and we therefore thought would be more likely to experience mind-wandering behaviour than novice players. Our study aims to explore the understudied phenomenon of GUTs, therefore it is difficult to determine the number of participants needed to establish a full theoretical framework of this phenomenon and future research is required to reproduce our findings.

4.2 Gameplay Capture Equipment

To record player behaviour, two Windows 10 desktop computers, each with a dedicated NVIDIA GeForce GTX 980 graphics card, were used. This setup allowed investigators to run Tobii Studio software on one device while the second ran the games participants played. Each computer was connected to a computer monitor, a keyboard, and a 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.

4.3 Measures of Experience

Our methodology was informed by Poerio et al. [71] 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 participant's thoughts by asking them to agree or disagree with particular statements—that occurred throughout the 30-min play period of each game. In pilot testing, participants received between 6–15 probes; however, to decrease possible participant fatigue, the range was decreased to 5–8 probes. Each probe initially asked participants to report on the contents of their conscious experience immediately preceding the interruption with the prompt "When I was playing just now...". Participants always rated their level of task focus first ("My thoughts were focused on the task I was performing"), followed by 12 additional dimensions presented in random order, as described in Table 3 and Poerio et al. [71]. All ratings were on a 4-point scale using a slider from 0 (completely off-task) to 1 (completely on-task).

Table 3: Table of experience sampling questions [71].

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

At the end of playing each game, each participant also completed the Flow State Scale-2 questionnaire [42] (i.e., we applied the changes to the original Flow State Scale [43] that Jackson and Eklund suggested), to allow the analysis of relationships between flow and GUTs, even if opposing. We measured flow as it has been noted to be a good proxy for engagement in games in previous studies [47, 61, 91].

4.4 Description of the Analysis Approach

We followed a phenomenological approach, where a phenomenon is studied to understand its essence. The phenomenological approach includes numerous strategies for data analysis: analyzing data for recurring patterns, units of meaning, textual and structural descriptions, and descriptions of the nature of said phenomena [17]. We followed the interpretative phenomenological video analysis (IPVA) approach, as outlined in Lee and McFerran [50]. While Lee and McFerran's videos were of music therapy sessions, we focused on gameplay footage to investigate GUTs. We do not have an easy way to identify the specific moment at which GUTs occur, and so relied on previous research to provide us with a starting point for behavioural observation. The following are the stages of our analysis:

Stage 1. *Understanding the moment.* The first stage involved familiarizing with the player's gameplay. During each player session, the second author took notes of player behaviour that they noticed and any environmental disturbances that occurred. This was the first exposure to the data and the first step to formulating a description of the phenomena. Previous research on TUTs coupled with the observations during player sessions were used to establish an initial set of factors used in the video analysis.

Stage 2. *Understanding the Whole.* Towards our goal of developing a detailed description of GUTs in games, from the start of data collection, the second author reviewed the videos and continued reviewing them for several watch-throughs until a composite description of mind wandering was achieved. During a first pass of the gameplay video data , gameplay footage was separated from footage of participants answering the experience sampling questions and flow questionnaire, to bracket any biases or a proiri assumptions. A first pass through the videos was also done using the Tobii eye tracker software to use its analysis features. However, because multiple games were used, it was difficult to derive meaning from this discrete analysis, hence our election to triangulate data, supported by Pelagatti et al. [69]. The second author watched gameplay footage several times to become familiar with the data. Further descriptions of the eyes and player behaviour were made. Building on the initial set of factors created during the first stage, we added observations of gameplay context. At the end of this stage, the second author created a codebook that compiled the observations that had been made to this point.

Stage 3. *Deciding a scope of analysis.* After compiling the initial codebook, we refined what observations to focus on. The code book was tested and further refined through a two-hour peer brainstorming session using affinity diagramming [39] where eight HCI researchers, with a range of zero to four years of experience, 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. The group then developed a codebook that reflected the observations. Our initial approach was to note every eye movement and player action. Although part of this approach remained, more interpretation and holistic analyses were added after the group activity.

Stage 4. *Describing what and interpreting how.* Videos were coded using ELAN by first describing the close-ended behaviours, then writing out a description for each code section and the interpretation of the behaviour as an open-ended code. A detailed description of the final codebook can be found in Table 5. *Event Description*, *Player Behaviour*, and *Gaze Interpretation* 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 a 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* consisted of a player's actions based on the context of gameplay and what followed after the action. *Gaze interpretation* was the interpretation of the eye tracker data that occurred during gameplay. The three groups of codes are independent of one another in that they do not always occur in the same time frame, however, their occurrence is highly codependent for many described events.

Stage 5. *Looking at other parts.* The final coding was done on participant recordings starting from the minute-long period leading up to the participant answering experience sampling questions (5-8 times per game), with a total of 279 video segments (each one minute long) of coded data. Codes are shown in Table 5, and the coding process was broken up into the following steps: *Step 1.* Videos were coded for close-ended codes (Event, Actions, Gaze Location, Gaze Type, Gaze Coordination) (based on Stage 2); *Step 2.* Open-ended fields (Event Description, Player Behaviour, Gaze Interpretation) were informed by step 1 codes and were each unique written descriptions (based on Stage 4); *Step 3.* Initial themes were generated based on the three open-ended descriptions of events (based on Stage 6).

However, after viewing many of the player session videos and during the process of developing clusters of meaning, it became evident that the different meanings we were eliciting were highly dependent on the different types of gameplay that players were experiencing (i.e., game genres, game mechanics, specific actions taken, etc.). We, therefore, decided to support our analysis of the games by describing what we call "modes of play"—the different ways that players engage and experience events in games (described further in subsection 4.5).

Stage 6. *Integrating parts and whole.* The previous five stages generated rich interpretations that we composed into several themes (section 5). Each theme was developed from the cyclical approach to analysis of watching and rewatching gameplay videos and the growing interpretation of the data through each stage. It is important to note that at this point in the process, the focus is on our own interpretation of the data. As Giorgi [34] describes, "one analyzes the raw data to come up with the essential structure of the experience, which is then carefully described at a level other than that of the original description." The analysis and themes were grounded on the concept of GUTs. Therefore, all discussion surrounding the themes in section 5 should be considered in relation to GUTs, even if not explicitly stated.

4.5 Supporting the Analysis: Developing Modes of Play (Stage 5)

Although many pre-existing categorizations of game mechanics and discussions surrounding their importance exist [27, 82], our focus was on how different game states (that players engage in) impacted player behaviour related to game-unrelated thoughts (GUTs). Thus, the analysis of game modes was done independently from the analysis used on player behaviour. Instead, the analysis was prompted by using noun-verb diagrams [77] as a guiding tool (Figure 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 categorization to create a more tailored description of the specific games that our participants played, and helped develop our themes (Stage 5, subsection 4.4). Specifically, we avoided categorizing games into genres due to the

Table 4: 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, Playing Through Narrative, Experiencing Narrative, Journeying, Riding the Wave, and Waiting for Action.

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		■	■	■		

ever-changing definition of what constitutes a particular genre [3]. Table 4 shows how each game played in this study was categorized into different modes of play.

4.5.1 Repetition. We 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 feel repetitive. For example, in Candy Crush Saga, the gameplay consists of repetitive actions 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, picking up via clicking and dropping as the primary gameplay sequence. Both games involve strategic thinking, 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 may involve using a unique item on only occasion. Large or open-world games like Skyrim also contain significant optional repetitive loops during side activities or mini-games.

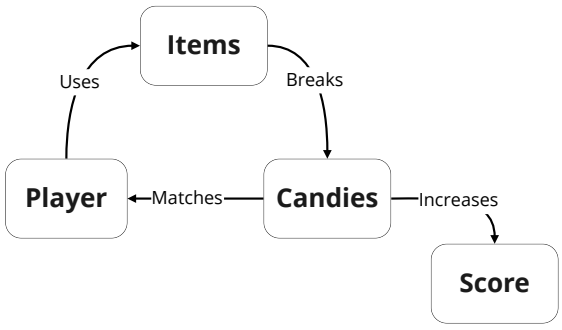


Figure 1: An example of the noun-verb diagram for Candy Crush Saga.

4.5.2 Playing Through Narrative. We described gameplay that involved players impacting the game's story 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 impacted 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.

4.5.3 Experiencing Narrative. In contrast, we described story that was imposed or occurred without the need for the player to engage in it 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.

4.5.4 Journeying. Gameplay that involved moving through the environment for long periods was described 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.

4.5.5 Riding the Wave. We 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 can freely complete the game in any time.

4.5.6 Waiting for Action. We described gameplay that involved times when players had to wait before acting or were limited in their actions. For example, in Orochi's Lair of the game Okami, 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

Table 5: A list of descriptions with specific codes associated with them and an explanation of each code. Event Description, Player Behaviour, and Gaze Interpretation are added to contextualize the descriptor and the code.

Descriptor	Codes	Occurrences	Explanation
Event	CUT	7	A cutscene is playing
	BLANK	21	Game shows blank/black screen
	ANI	280	Animation during or between gameplay but not cutscene
	DIA	61	Dialogue, with or without subtitles
	MENU-S	84	Strategic menu: map, inventory.
	SYS	87	System menu or message
Event Description	open-ended		A brief description of what is happening in the game.
Actions	ACT	433	Action initiated by player (fully describe in "player behaviour" sub-tier)
	CUR	299	Moving cursor (mouse)
	MOVE	172	Moving Avatar/ character
	MENU	28	Opening/closing menu
	PASS	47	Passive behaviour
	SEL	330	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	584	Near or on the players avatar/unit
	ENV	1116	On the background/environment
	OTH	552	Other characters or AI units
	INT	259	An object or AI being interacted with
	AWA	149	Away from screen
	UI	746	Menu or other interfaces being interacted with
Gaze Type	FIX	1370	Fixation on a single location for a long duration of time
	AREA	1243	Combination of rapid and fixed gaze on a small area
	RAP	1559	Fast eye movement between different targets
	UNK	329	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	103	Top left of screen
	TM	460	Top middle of screen
	TR	145	Top right of the screen
	ML	376	Middle left on the screen
	MM	1765	In the middle of the screen
	MR	380	Middle right on the screen
	BL	231	Bottom Left on the screen
	BM	856	Bottom middle on the screen
	BR	254	Bottom Right on the screen

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.

5 RESULTS

In this section, we present our results from our three analyses. We begin by presenting the themes developed through interpretative phenomenological video analysis, followed by preliminary results of our analysis of eye tracking data (subsection 5.2), and finally, experience sampling (subsection 5.3).

5.1 Themes: A Composite Description of Game-Unrelated Thoughts

Several gameplay and eye behaviour themes were identified in our analysis. These four themes, described in the following subsections, comprise our analysis's final stage (per Stage 6, subsection 4.4).

Figure 2: P10 using watering can to water crops while playing Stardew Valley and fixating on a spot near their character.

5.1.1 Repetition is Connected to Game-Unrelated Thoughts. When players engaged with a repetitive element in a game, their gaze often fixated around the area where the repetition occurred, fixating multiple times if it went on long enough. There were two different situations where players experienced repetition: (1) choosing to do repetitive actions, and (2) repetition during journeying.

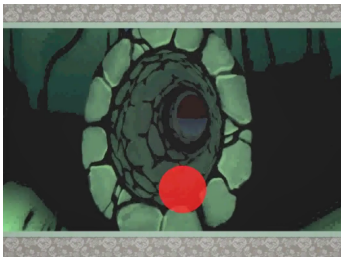
For example, while playing Stardew Valley, P10RE often used different tools to interact with the environment, resulting in repetitive actions (Figure 2). In one example, the player used a hoe to till tiles and then plant seeds. The player tilled one tile at a time, and once the tilling was done, they planted a seed in each tile. The act of tilling, planting, and watering were each repetitive actions. During tilling, there was a fixation that occurred near the avatar.

Because repetitive tool use is simple and does not require much attention, we suspect the player could be engaging in intentional GUTs. Repetition and familiarity have been previously linked to occurrences of task-unrelated thoughts when driving familiar routes [11, 106], and when readers re-read the same text [70]. Although the current study did not measure intentional and unintentional mind-wandering, there may be a parallel with findings from Phillips et al. [70] that, when readers re-read a text, they engage in intentional mind-wandering, which is similar to players who engage in a repetitive activity in that both are putting themselves into a state where it is easy to mind-wander.

5.1.2 Future-Oriented Game-Unrelated Thoughts. 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 [86, 87] and imaging studies exploring mind-wandering and the default network [54, 87, 104] have both provided evidence that future planning is a type of mind-wandering.

Sometimes, 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. At the same time, in other games (e.g., in fast-paced games and situations such as Skyrim, GTA, Resident Evil, Okami, Gas Guzzler, and World

(a) P4 is watching a character while walking towards them.



(b) P9 fixates on the entrance to a tunnel at the end of a cut scene.

(c) P10 may anticipate an enemy coming up from an entrance above the stairs. Their gaze moves rapidly around the area where the entrance is.

Figure 3: Examples of future planning and problem-solving.

of Goo), fixation occurred at times when players were scanning the environment as though 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 (Figure 3a). Based on the gameplay context and player behaviour, this player may have mistaken 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 determine what to do next or why the game was not progressing.

Another participant (P9RE) playing Okami would often stop moving in places with several pathways, followed by a series of gazes around the screen or use the paintbrush menu to stop time and fixate on objects of importance (Figure 3b). This participant may have been 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.

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

In another example, a participant (P10LT) playing Skyrim, after entering a room, defeated an enemy that was waking up and ran towards the stairs while scanning up around the top entrance to the stairs (Figure 3c). Since P10 was highly knowledgable of the game they were likely anticipating hostile NPCs that would be approaching soon.

In addition, in games such as Stardew Valley and Warcraft, which involve many goals and strategies, it makes sense to expect that players will likely have future-oriented thoughts about what they plan to do in the game.

5.1.3 Wandering Eyes May Be Connected to Game-Unrelated Thoughts. 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 (Figure 4). 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 indicate mind-wandering or distraction but requires future work to confirm.

In another example, one participant (P4LT), during the tutorial/opening to the game 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 a few instances of what appeared to be players looking away from the screen entirely in a distracted manner. However, a secondary data source would need to be used to confirm that this was happening instead of a malfunction of the eye tracker.

Figure 4: 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.

Figure 5: 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.

5.1.4 Hitting Walls and Missed Opportunities Could Precede Game-Unrelated Thoughts. Often, players seemed focused on the game but would either make a mistake or could not figure out how to overcome a challenge due to their focus being elsewhere. We use "hitting walls" both literally and metaphorically. Sometimes, players would unexpectedly run into objects or obstacles or become stuck and unable to progress through the game. The mistake had to be unexpected and avoidable, not due to game constraints or mechanical mistakes committed by the player, to have been identified as fitting within this theme.

For example, while playing Gas Guzzlers, one participant (P11LT) seemed to have been following the road, ignoring signs to turn right and ended up hitting a dead end (Figure 5). It is 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 the signs pointed towards. The player hit the dead end twice on their first lap, and then hit the same dead end three more times. Their gaze was rapid, but focused on a small area on the horizon. Based on the gameplay leading up to this example, we initially interpreted the player as finding it difficult to see what direction to go in. However, due to the player's determination, we searched online extensively to determine whether there was a secret route in that part of the game, but found none. Moreover, it is important to note that this is a game the participant chose themselves because they "lose track of time" while playing, thus they were familiar with the game and track. Thus, we suspect they were mind-wandering and forgetting to turn, which is supported by the literature discussed earlier in this paper on occurrences of task-unrelated thoughts when driving familiar routes [11, 106], caused by repetition and familiarity.

5.2 Eye Tracking

As mentioned in section 4, our eye tracking data were collected as a secondary measure primarily intended to inform our phenomenological analysis. We conducted a preliminary, exploratory analysis of the oculomotor specific eye tracking data to investigate whether any interesting patterns were apparent in our data. Here we share the psychophysiological eye-tracking data that may suggest mind-wandering episodes. We caution the reader to not generalize these findings beyond our specific study, as this was not the intent of this analysis.

Procedure and Analysis – We performed brief analysis of pupil eye measures using the right-eye dimensions of our participants. It is known that approximately 70% of people are right-eye dominant [65], in addition, our dataset validity measurements provided by TobiiAB [94] favours the right eye dimensions collected .

First, we calculated an overall average Pupil Size baseline using the entire dataset per participant, next we computed row-wise measurements for each participant. Next, we created artificial trials by slicing the data based on each passed minute. Therefore, our measures are reported per minute, per game, and per participant. Due to eye tracking data collection issues, we removed the data from participants DMNP5, DMNP6 and DMNP8 .

Next we calculated pupil variation sizes (in %), standard deviation (SD), mean, and confidence intervals CI High (CIHi) and CI Low (CILo) grouped per participant, per game. Finally, we computed the overall means per game. It is known that smaller pupil sizes and larger pupil size variations are reliable psychophysiological measures to identify low states of attention and introspective moments, such as feeling exhausted or mind wandering [51].

Game and Pupil Measures – In Figure 6 we can see pupil size changes per game. Candy Crush is one of the games mentioned for their repetitive gameplay in subsubsection 4.5.1 and Stardew Valley in subsubsection 5.1.1. Thus the pupil data analyzed here suggests alignment with our qualitative findings regarding repetition being a game design factor relating to GUTs. Both games with the smallest pupil size changes are the ones that were reported being more inducing to GUTs.

5.3 Experience Sampling

We analyzed the data from the experience samples collected for task-unrelated thoughts by taking the average of all questions as the dependent variable and using a Friedman's test to compare the three gameplay conditions: relaxing (RE), lose track of time (LT), most hours played (MP). The result was not significant ($\chi^2(2) = 0.04$, $p = .978$; $M_{RE} = 0.81$, 95% CI $[0.74, 0.89]$; $M_{LT} = 0.81$, 95% CI $[0.74, 0.88]$; $M_{MP} = 0.81$, 95% CI $[0.75, 0.88]$). Figure 7 also shows Pearson correlations between the average task-unrelated thought

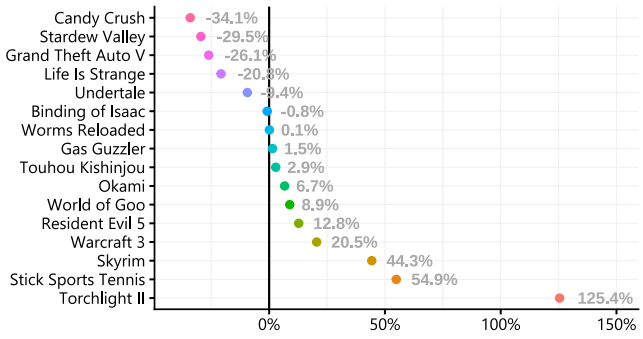


Figure 6: Pupil Size Variation (% changes from Baseline, which corresponds to 0%) are shown and ordered by size, with the smallest, Candy Crush, at the top and the largest, Torchlight, at the bottom. The smallest pupils are found during play of games reported in subsubsection 4.5.1 and subsubsection 5.1.1 for their repetitive gameplay conducive with GUTs..

scores and the dimensions of the flow short scale across all three conditions (top row). These findings indicate that there may have been some relationship between GUTs and some dimensions of the flow experience. However, it is important to note that this paper focused on our qualitative findings, and our sample size was small, so caution should be exercised when interpreting these results.

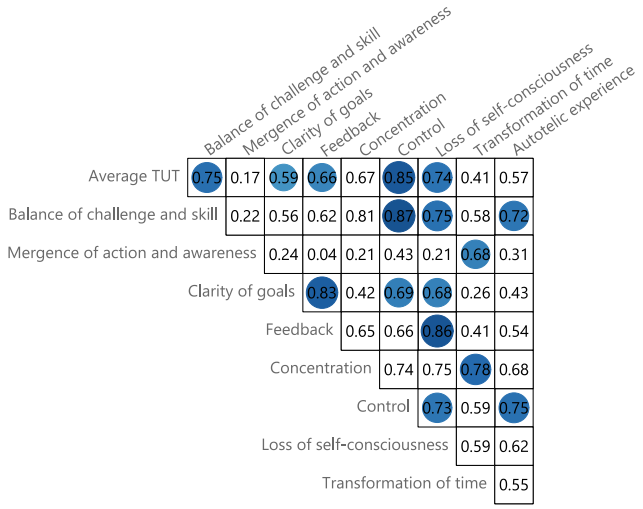


Figure 7: Correlation matrix for the experience sampling questionnaires comparing the average of the task-unrelated thoughts questions to the flow scale. The numbers represent r values ($df = 10$) from Pearson correlations, and shaded circles indicate significant correlations ($p < .05$).

6 DISCUSSION

We begin our discussion by presenting a summary of our main findings. Then, we discuss how our findings could potentially be applied to game design. Finally, we reflect on our experiences studying mind-wandering and how future research can utilize similar methods.

6.1 Summary of Findings

The main findings presented from this study are:

- Participants engaged in various modes of play (see subsection 4.5), and these modes helped determine the behaviour associated with GUTs. Six modes of play were identified: Repetition, Playing Through Narrative, Experiencing Narrative, Journeying, Riding the Wave, and Waiting for Action.
- Participants seemed to experience GUTs during games with highly repetitive play or when players themselves engaged in highly repetitive gameplay (Theme: Repetition is Connected to Game-Unrelated Thoughts)
- 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 as though in anticipation of something. (Theme: Future-Oriented Game-Unrelated Thoughts)
- When engaging in a mode of play that was not demanding or did not require attending to, players would sometimes look away from primary focus points of events, such as during cut scenes or AI turns. Although rarely, players sometimes gazed away from important game events and fixated on seemingly unrelated locations. (Theme: Wandering Eyes May Be Connected to Game-Unrelated Thoughts)
- The last theme describes times when players make mistakes at the moment in unexpected ways. This theme did not occur often due to the small number of visible mistakes that players made; however, it was salient to the researchers when it did occur. (Theme: Hitting Walls and Missed Opportunities Could Precede Game-Unrelated Thoughts)

The findings in our exploratory study pointed strongly to a body of future work being needed to study game-unrelated thoughts (GUTs) better. To assist designers and researchers with this, we discuss some of our major findings and distill them into questions for future research.

6.2 Potential Design Applications

One of the reasons for undertaking this work is the potential to explore game-unrelated thoughts as an exciting new consideration for game design contexts. Whether or not game-unrelated thoughts (GUTs) are something that designers wish game players to experience, we imagine a number of contexts in which GUT experiences could be encouraged or reduced for different purposes. We offer narrative snapshots of speculative design scenarios wherein GUTs are emphasized, separated into three categories that represent hypothetical "buckets" that we imagine could describe different flavours of design and research involving GUTs.

6.2.1 *Category 1: GUTs in the designer's toolbox.*

Maria is a game designer interested in modulating players' levels of engagement. She is curious as to whether creating conditions unfavourable for GUTs to occur might lead to players spending more time actively playing, pushing through the game, and unlocking new

content. She designs levels that require players to constantly keep moving and avoids repetitive elements. She considers what might happen when players make mistakes, and keeps things going so that they do not have an opportunity to pause to reflect. The result is a level design that is very demanding and requires continued focus from its players. Utilizing similarly templated cut scenes between levels, Maria thinks that players will be more likely to experience GUTs during these breaks and could enter the next level feeling recharged.

Engagement is one factor that game designers strive for when designing games, and task-unrelated thoughts (TUTs) have been associated with distraction in studies that focus on performance and focus [105]. However, TUTs can be purposely used as a building block for player experience instead of a negative consequence. By understanding GUTs and what factors affect different kinds of GUTs, game designers can cater holistic player experiences filled with engagement and relaxation by not only planning for action and excitement but also mapping for GUTs in a game's progression.

6.2.2 Category 2: Gameplay for measuring GUTs.

Paolo recently attended an interesting guest lecture and learned that certain player behaviours could indicate task-unrelated thoughts, or game-unrelated thoughts during gameplay. In his next game project, he is experimenting with eye tracking, and decides to include a short survey that is delivered on-screen when players either exhibit a behaviour or engage in gameplay thought to be associated with mind-wandering, with a plan to use machine learning to eventually connect the eye tracking data with mind-wandering behaviour. He is excited for this data to be used both for understanding game-unrelated thoughts and for dynamically adjusting gameplay to allow players to experience game-unrelated thoughts at appropriate times in the game.

It is outside of the scope and expertise offered in this submission to determine whether GUTs are "good" or "bad." However, if we start to collect data around these behaviours then we can use it in the future to develop our understanding. For players interested in understanding their own mind-wandering behaviour, game designers could implement features that track these instances and provide some kind of metric to players.

6.2.3 Category 3: Shower thoughts without the shower.

Rohit has been experiencing some creative blocks while working on his PhD. Sometimes he'll take a break to browse `r/ShowerThoughts` *on Reddit, but usually he likes to play games to try to get his mind off of things. He decides to try out a new game called ShowerGUTs which was designed to induce game-unrelated thoughts by incorporating specific game mechanics across a variety of modes of play. The designers of the game actually had decided to make it for themselves when they got frustrated with having great ideas in the shower or just as they were falling asleep and unable to write things down; it turns out they were really on to something! The intentional integration of conditions conducive to mind-wandering supports just the kind of background stewing Rohit needs to help him get to his next "aha!" moment.*

In section 2 we describe existing research into creativity, problem solving, and the default network. For example, using prompts may guide individuals to have positive mind-wandering experiences [102], which suggests that external factors can impact mind-wandering content. As such, we believe that knowing how to recognize mind-wandering behaviour and understanding how it relates to gameplay activities can help to design games that nurture GUTs deliberately.

6.3 Methodological Reflection

The experience we gained while completing this work provided many insights to future researchers aiming to study mind-wandering and game-unrelated thoughts. We discuss some interesting nuances of how eye behaviour is related to game-unrelated thoughts (GUTs), some key insights into how gameplay can be thought of as both task-related and task-unrelated, and why our experience sampling did not reveal as much insight into our data as anticipated. We also discuss the difficulties with self-reporting of game-unrelated thoughts.

6.3.1 Eye Behaviour as an Indication of Game-Unrelated Thoughts. A recent study that discusses eye behaviour and mind-wandering found that fixation occurred less frequently during intentional compared to unintentional mind-wandering episodes [108]. However, when it did occur during unintentional mind-wandering, people fixated for longer. Given that it occurs during both intentional and unintentional contexts, during our coding and analysis process we did not consider fixation as an indicator of different *types* of GUTs. Instead, fixation was assumed to be a possible indicator of GUTs overall, consistent with the prior literature [26, 29, 49, 109].

Fixation may pertain to GUTs during particular situations in games. Examples of such situations include those where diligence to a specific location was not necessary for engaging in gameplay (Figure 8), or when the player was highly familiarized with the game.

Fixation often occurred in games that provide a window of time where players cannot/do not need to act (e.g., P12RE, P2LT, P9RE, P5RE). However, some fixation was observed during times of highly active gameplay. During analysis, we 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 (in other words, due to the particular mode of play in which the player was engaged at that time). It is important to note that most research looking into mind-wandering related behaviour uses in-lab tasks featuring static images or other simple stimuli designed for simple tasks such as vigilance tasks, where participants are required to pay close attention and react quickly [53, 93, 108]. These types of studies are essential to understand aspects of task-unrelated thoughts (TUTs) under different conditions. Still, a difference that may be critical between a word task and playing a digital game is the contrast of stimuli between the two tasks. Digital games are more complex than static stimuli 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

Figure 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 waits for the battle to conclude and fixates on the units.

tasks, such as the repetitive scanpaths identified by Zhang et al. [108] 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.

The data also shows an example of eye behaviour intersecting with theories about TUTs and narrative immersion. In literature, it has been noted that TUTs frequently occur during cinematic experiences such as watching movies and when experiencing narrative information [58, 89], making it highly likely that narrative games such as Life is Strange, provide an experience where GUTs are likely to occur. However, motivation is a factor to consider when analyzing games for GUTs between individuals [12, 79]. Another factor that may influence GUTs 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. Behaviours that indicate GUTs such as fixation [108] occurred throughout P12RE's gameplay during Life is Strange. This may provide further evidence for the ways in which elements of game design coincide with the activity of GUTs.

6.3.2 Digital Games as a Set of Tasks. When looking to study GUTs, complex game tasks could be treated as a set of smaller discrete tasks that interact with visual and auditory elements to provide a player with a particular experience. During digital gameplay, it can be beneficial to try and define what tasks players engage in when GUTs occur to properly identify whether the thoughts the player is experiencing are task-related or task-unrelated. Breaking down video games conceptually into more specific and simpler tasks may be beneficial to study behaviours attributed to GUTs, 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 behaviours more closely to game mechanics. In the cases pertaining to the "Future-Oriented Game-Unrelated Thoughts" theme, we assumed players may be planning goals or actions related to the game. However, not all future planning in games is task-related thinking because the thoughts may be directed at anticipated tasks in the game, some of which may be different from the current immediate game activity. There is also the possibility of thoughts completely unrelated to the game at all. The boundary between game-related and game-unrelated thoughts 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, or lock picking. In the TUT literature, when studying more complex tasks, such as piloting a plane, researchers have argued that even though there is a difference between immediate task thoughts and future task thoughts, they are different from thoughts completely unrelated to piloting, making the definition of TUTs nuanced [13]. The same can be argued for video games. Although piloting a plane or playing a game can be broken up into sub-tasks, there is a non-obvious relationship between the sub-tasks that may be difficult to account for if studied independently from one another due to the continuity that exists between them.

Mind-wandering is likely to occur differently when cognitive load is low compared to when it is high [40]. More specifically, Iijima and Tanno [40] identified that future-related thoughts occur more frequently during states of low cognitive load. We hypothesize that an example of where low cognitive load took place is P10LT. This participant selected Skyrim as their Losing Track of Time game. In the game, the participant was playing in a dungeon that was familiar to them. Even though they were actively moving about, if the player was used to doing this to the point that they fell into a rhythm (implied by the participant choosing this game in the first place), then we would expect that 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 with the addition of animations. These samples from our data show how GUTs behaviour intersects with the themes developed from our gameplay data.

6.3.3 Experience Sampling of GUTs. No significant result was found for game type and reported GUTs (subsection 5.3); a low sample size causes the threshold for detectability to be high due to low power. In the original study where the experience sampling questionnaire was used, the average number of probes per participant used was 14.07 during each session of the experiment [71]. In contrast, our average was 7.8. A brief qualitative analysis of how participants answered the questionnaire was done while the gameplay videos were edited. At times, some participants chose speed over accuracy when answering the questionnaire prompts, selecting the same responses without much thought. With a small sample size, these results could generate noise among 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 GUTs that occurred during the segment. These are not conclusive instances. Instead, the results were combined with other behaviours noted during gameplay as

evidence for potential GUTs. As such, in the current study, we do not claim definitive instances of GUTs. Instead, we analyzed the context and various behaviours for potential patterns that may indicate GUTs: these patterns are based on observation and supplemented by other research that reports similar behaviour.

6.3.4 Self-Reporting of GUTs. While our choice to use a qualitative phenomenological approach to explore mind-wandering in the context of gameplay was intentional, with the use of eye tracking and experience sampling as methods to help triangulate our data, as suggested by Pelagatti et al. [69], it can be challenging to rely on self-reporting of game-unrelated thoughts and self-reflection in follow-up interviews. Specifically, while our approach followed Lee and McFerran [50] and we did conduct debriefing interviews following gameplay where we asked participants to reflect on their mind-wandering experiences, more in-depth interviews, perhaps with some coaching on how to identify and reflect on mind-wandering experiences, could be integrated into a methodology. However, we would caution future researchers that mind-wandering is notoriously difficult for participants to be aware of in themselves, and so it would be vital to use this as only one element among many triangulated data points [98].

7 LIMITATIONS & FUTURE WORK

We intend the results of the phenomenological analysis presented in section 5 to be used to posit new hypotheses related to digital gameplay and GUTs. As such, some limitations of the current study are as follows:

- In our pre-study, establishing the prevalence of game-unrelated thoughts, we used the crowdsourcing platform Prolific to recruit participants, and as with any crowdsourcing platform, this comes with some limitations. Namely, the sample is likely biased, there is the possibility of participants not paying close attention to the questions, and we had no contact with participants, so cannot easily verify the credibility of their data [67]. Nonetheless, crowdsourced studies have been shown to provide reliable data [80], and in our case, we were only looking to confirm the existence of mindwandering in gameplay, and think this study provides some evidence in that direction.
- In our main phenomenological inquiry, we had a small sample size that does not fully portray the gaming demographic, and of the data collected, three participants' data was corrupted. Because of this, we could not gender balance our participants either.
- The thought sampling questions, although used in previous studies, are not a validated questionnaire. For this reason other ways of collecting GUTs may be worth considering, such as the use of a foot pedal for participants to press when they catch themselves experiencing thoughts unrelated to the game.
- The sample of games that was used in our study is relatively small in comparison to the number of games that exist and it is possible that other themes exist, that we did not identify within the analyzed games.
- While we have attempted to control non-game variables in a lab setting, there is a lot going on in terms of stimuli and experience during gaming. It is hard to isolate specific types of GUTs (thoughts about the current game task vs. thoughts unrelated to the game task) from one another, as well as non-GUTs behaviour such as distractions.

While our work focuses on the empirical findings of our two studies, there are many avenues of future work that can build upon this paper. For example, games (e.g., serious games) could be designed to specifically target or avoid GUTs. In order to achieve this goal, more empirical work is needed to explore GUTs in a wider variety of contexts and other research is necessary to determine appropriate measurement tools. This paper presents the first steps toward this much longer-term goal. Based on our findings, we suggest the following questions as a basis for future work:

- *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.
- *Do familiarity and repetition impact GUTs?* Previous research suggests that mind-wandering increases during familiar events like driving the same route [106], 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 GUTs.
- *What is the content of GUTs?* In future work, it would be beneficial to measure the types of GUTs that people experience during different game events. As suggested in recent work by Westgate et al. [102], 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.
- *Further investigation of eye behaviour.* Our research aimed to explore a variety of games, however this limits how efficiently eye tracking equipment can be used. For this reason, a study that is limited to a set number of games would further test and determine if specific patterns of eye behaviour exist when players experience GUTs and are better at utilizing the analytic capability of eye-tracking software.

8 CONCLUSION

In this paper, we have provided a composite understanding of how eye behaviour is associated with game-unrelated thoughts (GUTs). We identified four themes of interest: Repetition is Connected to Game-Unrelated Thoughts, Future-Oriented Game-Unrelated Thoughts, Wandering Eyes May Be Connected to Game-Unrelated Thoughts, and Hitting Walls and Missed Opportunities Could Precede Game-Unrelated Thoughts. These themes provide a basis to be validated in future research and, used for game design. For example, designers could intentionally incorporate repetitive play to encourage GUTs, or use gameplay data of players hitting walls to predict GUTs and intervene when avoiding it is desirable (e.g., an

e-sports competition). We hope to inspire and educate researchers and designers to consider the impacts of GUTs.

ACKNOWLEDGMENTS

We thank all study participants and the University of Waterloo's Touchlab and Games Institute. This work was made possible by NSERC Discovery Grants 2016-04422 and 2024-05124, Ontario Early Researcher Award ER15-11-184, and NSERC CREATE Saskatchewan-Waterloo Games User Research (SWaGUR) 479724-2016.

REFERENCES

[1] Hamid Allahverdipour, Mohsen Bazargan, Abdollah Farhadinasab, and Babak Moeini. 2010. Correlates of video games playing among adolescents in an Islamic country. *BMC public health* 10, 1 (2010), 1–7.

[2] J. R. Andrews-Hanna. 2012. The Brain's Default Network and Its Adaptive Role in Internal Mentation. . *The Neuroscientist* 18, 3 (2012), 251–270. https://doi.org/10.1177/1073858411403316

[3] Dominic Arsenault. 2009. Video game genre, evolution and innovation. *Eludamos: Journal for computer game culture* 3, 2 (2009), 149–176.

[4] Regina Bernhaupt. 2015. *Game User Experience Evaluation.* Springer Publishing Company, Incorporated.

[5] Regina Bernhaupt, Katherine Isbister, and Sara de Freitas. 2015. Introduction to this Special Issue on HCI and Games. *Human–Computer Interaction* 30, 3-4 (2015), 195–201. https://doi.org/10.1080/07370024.2015.1016573

[6] Robert Bixler, Nathaniel Blanchard, Luke Garrison, and Sidney D'Mello. 2015. Automatic Detection of Mind Wandering During Reading Using Gaze and Physiology. In *Proceedings of the 2015 ACM on International Conference on Multimodal Interaction* (Seattle, Washington, USA) *(ICMI '15)*. Association for Computing Machinery, New York, NY, USA, 299–306. https://doi.org/10.1145/2818346.2820742

[7] Benjamin D. R. Bogart, Philippe Pasquier, and Steven J. Barnes. 2013. An Integrative Theory of Visual Mentation and Spontaneous Creativity. In *Proceedings of the 9th ACM Conference on Creativity & Cognition* (Sydney, Australia) *(C&C '13)*. Association for Computing Machinery, New York, NY, USA, 264–273. https://doi.org/10.1145/2466627.2466639

[8] Virginia Braun and Victoria Clarke. 2021. To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. *Qualitative Research in Sport, Exercise and Health* 13, 2 (2021), 201–216. https://doi.org/10.1080/2159676X.2019.1704846 arXiv:https://doi.org/10.1080/2159676X.2019.1704846

[9] Iuliia Brishtel, Anam Ahmad Khan, Thomas Schmidt, Tilman Dingler, Shoya Ishimaru, and Andreas Dengel. 2020. Mind Wandering in a Multimodal Reading Setting: Behavior Analysis & Automatic Detection Using Eye-Tracking and an EDA Sensor. *Sensors* 20, 9 (2020), 2546.

[10] Gilbert L Brown. 1927. Daydreams: A cause of mind wandering and inferior scholarship. *The Journal of Educational Research* 15, 4 (1927), 276–279.

[11] Bridget RD Burdett, Samuel G Charlton, and Nicola J Starkey. 2019. Mind wandering during everyday driving: An on-road study. *Accident Analysis & Prevention* 122 (2019), 76–84.

[12] Jonathan SA Carriere, Paul Seli, and Daniel Smilek. 2013. Wandering in both mind and body: individual differences in mind wandering and inattention predict fidgeting. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale* 67, 1 (2013), 19.

[13] Stephen M Casner and Jonathan W Schooler. 2014. Thoughts in flight: Automation use and pilots' task-related and task-unrelated thought. *Human factors* 56, 3 (2014), 433–442.

[14] Jenova Chen. 2007. Flow in Games (and Everything Else). *Commun. ACM* 50, 4 (4 2007), 31–34. https://doi.org/10.1145/1232743.1232769

[15] Kalina Irving Christoff, Zachary C., Kieran C. R. Fox, R. Nathan Spreng, and Jessica R. Andrews-Hanna. 2016. Mind-wandering as spontaneous thought: a dynamic framework. *Nature Reviews Neuroscience* 17, 718 (2016). https://doi.org/10.1037/h0041846

[16] John Cohen, Charles Edward Mark Hansel, and JD Sylvester. 1956. Mind wandering. *British Journal of Psychology* 47, 1 (1956), 61.

[17] John W Creswell and Cheryl N Poth. 2016. *Qualitative inquiry and research design: Choosing among five approaches.* Sage publications, Chapter 5.

[18] Mihaly Csikszentmihalyi. 2009. *Flow: The psychology of optimal experience* (nachdr. ed.). Harper [and] Row, New York.

[19] Barry Dauphin and Grant Heller. 2010. Going to other worlds: The relationships between videogaming, psychological absorption, and daydreaming styles. *Cyberpsychology, Behavior, and Social Networking* 13, 2 (2010), 169–172.

[20] Kiret Dhindsa, Anita Acai, Natalie Wagner, Dan Bosynak, Stephen Kelly, Mohit Bhandari, Brad Petrisor, and Ranil R Sonnadara. 2019. Individualized pattern recognition for detecting mind wandering from EEG during live lectures. *PloS one* 14, 9 (2019), e0222276.

[21] Mariana Rachel Dias da Silva, Myrthe Faber, Diogo António de Andrade Branco, and Marie Postma. 2022. Mind and body: The manifestation of mind wandering in bodily behaviors. In *New Perspectives on Mind-Wandering*. Springer, 59–75.

[22] Henry W Dong, Caitlin Mills, Robert T Knight, and Julia WY Kam. 2021. Detection of mind wandering using EEG: Within and across individuals. *Plos one* 16, 5 (2021), e0251490.

[23] Anders Drachen, Pejman Mirza-Babaei, and Lennart Nacke (Eds.). 2018. *Games User Research.* New York, NY: Oxford University Press. https://doi.org/10.1093/oso/9780198794844.001.0001

[24] Sidney D'Mello, Kristopher Kopp, Robert Earl Bixler, and Nigel Bosch. 2016. Attending to Attention: Detecting and Combating Mind Wandering during Computerized Reading. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI EA '16)*. Association for Computing Machinery, New York, NY, USA, 1661–1669. https://doi.org/10.1145/2851581.2892329

[25] John Anders Eichenlaub, Gijs Huisman, and Haian Xue. 2023. Exploring Extended Mind-Wandering Through an Interactive Haptic Fidget Object. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference*. 2657–2671.

[26] Myrthe Faber, Kristina Krasich, Robert E Bixler, James R Brockmole, and Sidney K D'Mello. 2020. The eye–mind wandering link: Identifying gaze indices of mind wandering across tasks. *Journal of experimental psychology: human perception and performance* 46, 10 (2020), 1201.

[27] Carlo Fabricatore. 2007. Gameplay and game mechanics: a key to quality in videogames. (2007).

[28] Christopher J Ferguson and John Colwell. 2017. Understanding why scholars hold different views on the influences of video games on public health. *Journal of Communication* 67, 3 (2017), 305–327.

[29] Tom Foulsham, James Farley, and Alan Kingstone. 2013. Mind wandering in sentence reading: Decoupling the link between mind and eye. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale* 67, 1 (2013), 51.

[30] Kieran CR Fox, R Nathan Spreng, Melissa Ellamil, Jessica R Andrews-Hanna, and Kalina Christoff. 2015. The wandering brain: Meta-analysis of functional neuroimaging studies of mind-wandering and related spontaneous thought processes. *Neuroimage* 111 (2015), 611–621.

[31] Michael S Franklin, James M Broadway, Michael D Mrazek, Jonathan Smallwood, and Jonathan W Schooler. 2013. Window to the wandering mind: Pupillometry of spontaneous thought while reading.

[32] Michael S Franklin, Michael D Mrazek, Craig L Anderson, Jonathan Smallwood, Alan Kingstone, and Jonathan Schooler. 2013. The silver lining of a mind in the clouds: Interesting musings are associated with positive mood while mind-wandering. *Frontiers in psychology* 4 (2013), 583.

[33] Shelly L Gable, Elizabeth A Hopper, and Jonathan W Schooler. 2019. When the muses strike: Creative ideas of physicists and writers routinely occur during mind wandering. *Psychological science* 30, 3 (2019), 396–404.

[34] Amedeo Giorgi. 2009. *The descriptive phenomenological method in psychology: A modified Husserlian approach.* Duquesne university press.

[35] Romain Grandchamp, Claire Braboszcz, and Arnaud Delorme. 2014. Oculometric variations during mind wandering. *Frontiers in psychology* 5 (2014), 31.

[36] Muriel A Hagenaars, Emily A Holmes, Fayette Klaassen, and Bernet Elzinga. 2017. Tetris and Word games lead to fewer intrusive memories when applied several days after analogue trauma. *European Journal of Psychotraumatology* 8, sup1 (2017), 1386959.

[37] Johanna Hall, Ursula Stickler, Christothea Herodotou, and Ioanna Iacovides. 2020. Expressivity of creativity and creative design considerations in digital games. *Computers in Human Behavior* 105 (2020), 106206.

[38] R Scott HG Liddell and HS Jones. 1940. A greek-english lexicon. (1940).

[39] Karen Holtzblatt and Hugh Beyer. 1997. *Contextual design: defining customer-centered systems.* Elsevier.

[40] Yudai Iijima and Yoshihiko Tanno. 2012. The effect of cognitive load on the temporal focus of mind wandering. *Shinrigaku kenkyu: The Japanese journal of psychology* 83, 3 (2012), 232–236.

[41] Lalitha Iyadurai, Simon E Blackwell, Richard Meiser-Stedman, Peter C Watson, Michael B Bonsall, John R Geddes, Anna C Nobre, and Emily A Holmes. 2018. Preventing intrusive memories after trauma via a brief intervention involving Tetris computer game play in the emergency department: a proof-of-concept randomized controlled trial. *Molecular psychiatry* 23, 3 (2018), 674–682.

[42] Susan A Jackson and Robert C Eklund. 2002. Assessing flow in physical activity: The flow state scale–2 and dispositional flow scale–2. *Journal of Sport and Exercise Psychology* 24, 2 (2002), 133–150.

[43] Susan A Jackson and Herbert W Marsh. 1996. Development and validation of a scale to measure optimal experience: The Flow State Scale. *Journal of sport and exercise psychology* 18, 1 (1996), 17–35.

[44] Christina Yi Jin, Jelmer P Borst, and Marieke K van Vugt. 2019. Predicting task-general mind-wandering with EEG. *Cognitive, Affective, & Behavioral Neuroscience* 19, 4 (2019), 1059–1073.

[45] Michael J Kane, Bridget A Smeekens, Matt E Meier, Matthew S Welhaf, and Natalie E Phillips. 2021. Testing the construct validity of competing measurement approaches to probed mind-wandering reports. *Behavior Research Methods* 53, 6 (2021), 2372–2411.

[46] Matthew A Killingsworth and Daniel T Gilbert. 2010. A wandering mind is an unhappy mind. *Science* 330, 6006 (2010), 932–932.

[47] Madison Klarkowski, Daniel Johnson, Peta Wyeth, Simon Smith, and Cody Phillips. 2015. Operationalising and Measuring Flow in Video Games. In *Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction* (Parkville, VIC, Australia) *(OzCHI '15)*. Association for Computing Machinery, New York, NY, USA, 114–118. https://doi.org/10.1145/2838739.2838826

[48] Eric Klinger and W. Miles Cox. 1987. Dimensions of Thought Flow in Everyday Life. *Imagination, Cognition and Personality* 7, 2 (1987), 105–128. https://doi.org/10.2190/7K24-G343-MTQW-115V arXiv:https://doi.org/10.2190/7K24-G343-MTQW-115V

[49] Kristina Krasich, Greg Huffman, Myrthe Faber, and James R Brockmole. 2020. Where the eyes wander: The relationship between mind wandering and fixation allocation to visually salient and semantically informative static scene content. *Journal of Vision* 20, 9 (2020), 10–10.

[50] Juyoung Lee and Katrina Skewes McFerran. 2015. Applying interpretative phenomenological analysis to video data in music therapy. *Qualitative Research in Psychology* 12, 4 (2015), 367–381.

[51] Otto Lowenstein, Richard Feinberg, and Irene E. Loewenfeld. 1963. *Pupillary Movements During Acute and Chronic Fatigue: A New Test for the Objective Evaluation of Tiredness.* Federal Aviation Agency, Office of Aviation Medicine. Google-Books-ID: 030Z45MEbWoC.

[52] David Marcusson-Clavertz, Melina West, Oscar NE Kjell, and Eli Somer. 2019. A daily diary study on maladaptive daydreaming, mind wandering, and sleep disturbances: Examining within-person and between-persons relations. *PloS one* 14, 11 (2019), e0225529.

[53] Víctor Martínez-Pérez, Damián Baños, Almudena Andreu, Miriam Tortajada, Lucía B Palmero, Guillermo Campoy, and Luis J Fuentes. 2021. Propensity to intentional and unintentional mind-wandering differs in arousal and executive vigilance tasks. *PLoS one* 16, 10 (2021), e0258734.

[54] Malia F Mason, Moshe Bar, C Neil Macrae, et al. 2009. Exploring the past and impending future in the here and now: Mind-wandering in the default state. *Cognitive Science Compendium* 2 (2009), 143–162.

[55] Rebecca McMillan, Scott Barry Kaufman, and Jerome L Singer. 2013. Ode to positive constructive daydreaming. *Frontiers in psychology* 4 (2013), 626.

[56] Barbara Medea, Theodoros Karapanagiotidis, Mahiko Konishi, Cristina Ottaviani, Daniel Margulies, Andrea Bernasconi, Neda Bernasconi, Boris C Bernhardt, Elizabeth Jefferies, and Jonathan Smallwood. 2018. How do we decide what to do? Resting-state connectivity patterns and components of self-generated thought linked to the development of more concrete personal goals. *Experimental brain research* 236, 9 (2018), 2469–2481.

[57] Elisa D. Mekler, Ioanna Iacovides, and Julia Ayumi Bopp. 2018. "A Game That Makes You Question...": Exploring the Role of Reflection for the Player Experience. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play* (Melbourne, VIC, Australia) *(CHI PLAY '18)*. Association for Computing Machinery, New York, NY, USA, 315–327. https://doi.org/10.1145/3242671.3242691

[58] Caitlin Mills, Robert Bixler, Xinyi Wang, and Sidney K D'Mello. 2016. Automatic Gaze-Based Detection of Mind Wandering during Narrative Film Comprehension. *International Educational Data Mining Society* (2016).

[59] Benjamin W Mooneyham and Jonathan W Schooler. 2013. The costs and benefits of mind-wandering: a review. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale* 67, 1 (2013), 11.

[60] Lennart Nacke and Craig Lindley. 2008. Boredom, Immersion, Flow - A pilot study investigating player experience. In *Proceedings of Computer Graphics and Visualization 2008 and Gaming 2008: Design for Engaging Experience Soc. Interaction*. IADIS Press, Amsterdam, The Netherlands, 5. https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A836109&dswid=-5853

[61] Lennart Nacke and Craig A. Lindley. 2008. Flow and Immersion in First-Person Shooters: Measuring the Player's Gameplay Experience. In *Proceedings of the 2008 Conference on Future Play: Research, Play, Share* (Toronto, Ontario, Canada) *(Future Play '08)*. Association for Computing Machinery, New York, NY, USA, 81–88. https://doi.org/10.1145/1496984.1496998

[62] Lennart E. Nacke. 2017. Games User Research and Gamification in Human-Computer Interaction. *XRDS* 24, 1 (Sept. 2017), 48–51. https://doi.org/10.1145/3123748

[63] Susan Nolen-Hoeksema. 2000. The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of abnormal psychology* 109, 3 (2000), 504.

[64] Juan F Olaya-Figueroa, Younes Lakhnati, and Jens Gerken. 2021. MuseFlow: Facilitating Mind-Wandering Through Video Games. In *IFIP Conference on Human-Computer Interaction*. Springer, 126–135.

[65] Jacob L Orquin and Kenneth Holmqvist. 2019. A primer on eye-tracking methodology for behavioral science. In *A handbook of process tracing methods*. Routledge, 53–64.

[66] Michela Ott and Francesca Pozzi. 2012. Digital games as creativity enablers for children. *Behaviour & Information Technology* 31, 10 (2012), 1011–1019.

[67] Stefan Palan and Christian Schitter. 2018. Prolific.ac—A subject pool for online experiments. *Journal of Behavioral and Experimental Finance* 17 (2018), 22–27. https://doi.org/10.1016/j.jbef.2017.12.004

[68] Federica Pallavicini, Alessandro Pepe, Fabrizia Mantovani, et al. 2021. Commercial Off-The-Shelf Video Games for Reducing Stress and Anxiety: Systematic Review. *JMIR mental health* 8, 8 (2021), e28150.

[69] Claudia Pelagatti, Paola Binda, and Manila Vannucci. 2018. Tracking the dynamics of mind wandering: Insights from pupillometry. *Journal of Cognition* 1, 1 (2018).

[70] Natalie E Phillips, Caitlin Mills, Sidney D'Mello, and Evan F Risko. 2016. On the influence of re-reading on mind wandering. *Quarterly Journal of Experimental Psychology* 69, 12 (2016), 2338–2357.

[71] Giulia L. Poerio, Mladen Sormaz, Hao-Ting Wang, Daniel Margulies, Elizabeth Jefferies, and Jonathan Smallwood. 2017. The role of the default mode network in component processes underlying the wandering mind. *Social Cognitive and Affective Neuroscience* 12, 7 (2017), 1047–1062. https://doi.org/10.1093/scan/nsx041

[72] Halley M Pontes, Bruno Schivinski, Christopher Kannen, and Christian Montag. 2022. The interplay between time spent gaming and disordered gaming: A large-scale world-wide study. *Social Science & Medicine* (2022), 114721.

[73] Andrew K. Przybylski, C. Scott Rigby, and Richard M. Ryan. 2010. A motivational model of video game engagement. *Review of General Psychology* 14, 2 (2010), 154–166. https://doi.org/10.1037/a0019440

[74] Andrew K Przybylski, Netta Weinstein, Richard M Ryan, and C Scott Rigby. 2009. Having to versus wanting to play: Background and consequences of harmonious versus obsessive engagement in video games. *CyberPsychology & Behavior* 12, 5 (2009), 485–492.

[75] Quintilian. 1921. *Intitutes of Oratory*. Harvard University Press and William Heinemann, Ltd., London and Cambridge, Mass., Chapter VI.2.30. http://data.perseus.org/citations/urn:cts:latinLit:phi1002.phi0016.perseus-eng1:2 With An English Translation.

[76] Marcus E Raichle, Ann Mary MacLeod, Abraham Z Snyder, William J Powers, Debra A Gusnard, and Gordon L Shulman. 2001. A default mode of brain function. *Proceedings of the National Academy of Sciences* 98, 2 (2001), 676–682.

[77] Dennis Ramirez. [n. d.]. *Core Game Mechanics*. Video Game Workshop. https://www.videogameworkshop.com/game-design/Core-Game-Mechanics.html

[78] Leonard Reinecke, Jennifer Klatt, and Nicole C Krämer. 2011. Entertaining media use and the satisfaction of recovery needs: Recovery outcomes associated with the use of interactive and noninteractive entertaining media. *Media Psychology* 14, 2 (2011), 192–215.

[79] Matthew K Robison, Ashley L Miller, and Nash Unsworth. 2020. A multi-faceted approach to understanding individual differences in mind-wandering. *Cognition* 198 (2020), 104078.

[80] Steven V. Rouse. 2015. A reliability analysis of Mechanical Turk data. *Computers in Human Behavior* 43 (2015), 304–307. https://doi.org/10.1016/j.chb.2014.11.004

[81] Henrik Schoenau-Fog. 2011. The Player Engagement Process – An Exploration of Continuation Desire in Digital Games. In *DiGRA 2011 - Proceedings of the 2011 DiGRA International Conference: Think Design Play*, Vol. 6. DiGRA/Utrecht School of the Arts, Hilverson, The Netherlands, 18. http://www.digra.org/wp-content/uploads/digital-library/11307.06025.pdf

[82] Miguel Sicart. 2008. Defining game mechanics. *Game Studies* 8, 2 (2008), 1–14.

[83] Jerome L. Singer. 1974. Daydreaming and the Stream of Thought. *American Scientist* 62, 4 (1974), 417–425.

[84] Jerome L. Singer and John S. Antrobus. 1970. *Subscale keys: imaginal processes inventory*. Center for Research in Cognition and Affect Graduate Center, City University of New York.

[85] Eli Somer, Nirit Soffer-Dudek, and Colin A Ross. 2017. The comorbidity of daydreaming disorder (maladaptive daydreaming). *The Journal of Nervous and Mental Disease* 205, 7 (2017), 525–530.

[86] Maitta Spronken, Rob W Holland, Bernd Figner, and Ap Dijksterhuis. 2016. Temporal focus, temporal distance, and mind-wandering valence: Results from an experience sampling and an experimental study. *Consciousness and Cognition* 41 (2016), 104–118.

[87] David Stawarczyk, Helena Cassol, and Arnaud D'Argembeau. 2013. Phenomenology of future-oriented mind-wandering episodes. *Frontiers in Psychology* 4 (2013), 425.

[88] David Stawarczyk, Steve Majerus, Michalina Maj, Martial Van der Linden, and Arnaud D'Argembeau. 2011. Mind-wandering: Phenomenology and function as assessed with a novel experience sampling method. *Acta psychologica* 136, 3 (2011), 370–381.

[89] Angela Stewart, Nigel Bosch, Huili Chen, Patrick J Donnelly, and Sidney K D'Mello. 2016. Where's Your Mind At? Video-Based Mind Wandering Detection During Film Viewing. In *Proceedings of the 2016 conference on User Modeling*

Adaptation and Personalization. 295–296.

[90] Angela Stewart, Nigel Bosch, Huili Chen, Patrick J. Donnelly, and Sidney K. D'Mello. 2016. Where's Your Mind At? Video-Based Mind Wandering Detection During Film Viewing. In *Proceedings of the 2016 Conference on User Modeling Adaptation and Personalization* (Halifax, Nova Scotia, Canada) *(UMAP '16)*. Association for Computing Machinery, New York, NY, USA, 295–296. https://doi.org/10.1145/2930238.2930266

[91] Penelope Sweetser and Peta Wyeth. 2005. GameFlow: A Model for Evaluating Player Enjoyment in Games. *Comput. Entertain.* 3, 3 (July 2005), 3. https://doi.org/10.1145/1077246.1077253

[92] Ron Tamborini and Paul Skalski. 2006. The Role of Presence in the Experience of Electronic Games. In *Playing video games: Motives, responses, and consequences*. Lawrence Erlbaum Associates Publishers, Mahwah, NJ, US, 225–240.

[93] David R Thomson, Derek Besner, and Daniel Smilek. 2015. A resource-control account of sustained attention: Evidence from mind-wandering and vigilance paradigms. *Perspectives on psychological science* 10, 1 (2015), 82–96.

[94] TobiiAB. 20203. *Tobii Pro Lab*. Danderyd, Stockholm. http://www.tobii.com/

[95] Nash Unsworth, Gene A Brewer, and Gregory J Spillers. 2012. Variation in cognitive failures: An individual differences investigation of everyday attention and memory failures. *Journal of Memory and Language* 67, 1 (2012), 1–16.

[96] Nash Unsworth and Brittany D McMillan. 2017. Attentional disengagements in educational contexts: A diary investigation of everyday mind-wandering and distraction. *Cognitive research: Principles and implications* 2, 1 (2017), 1–20.

[97] Marieke K Van Vugt, Maarten van der Velde, and ESM-MERGE Investigators. 2018. How does rumination impact cognition? A first mechanistic model. *Topics in cognitive science* 10, 1 (2018), 175–191.

[98] Manila Vannucci, Claudia Pelagatti, and Igor Marchetti. 2022. Mind-wandering in adolescents: Evidence, challenges, and future directions. In *New perspectives on mind-wandering*. Springer, 43–58.

[99] E. R. Watkins. 2008. Constructive and unconstructive repetitive thought. *Psychological bulletin* 134, 2 (2008), 163–206. https://doi.org/10.1037/0033-2909.134.2.163

[100] Rina R Wehbe, Diane K Watson, Gustavo F Tondello, Marim Ganaba, Melissa Stocco, Alvin Lee, and Lennart E Nacke. 2016. Above water: An educational game for anxiety. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*. 79–84.

[101] Annett Welz, Iris Reinhard, Georg W Alpers, and Christine Kuehner. 2018. Happy thoughts: Mind wandering affects mood in daily life. *Mindfulness* 9, 1 (2018), 332–343.

[102] Erin C Westgate, Timothy D Wilson, Nicholas R Buttrick, Rémy A Furrer, and Daniel T Gilbert. 2021. What makes thinking for pleasure pleasurable? *Emotion* (2021).

[103] Kathryn JH Williams, Kate E Lee, Terry Hartig, Leisa D Sargent, Nicholas SG Williams, and Katherine A Johnson. 2018. Conceptualising creativity benefits of nature experience: Attention restoration and mind wandering as complementary processes. *Journal of Environmental Psychology* 59 (2018), 36–45.

[104] Xiaoxiao Xu, Hong Yuan, and Xu Lei. 2016. Activation and connectivity within the default mode network contribute independently to future-oriented thought. *Scientific reports* 6, 1 (2016), 1–10.

[105] M. R. Yanko and T. M. Spalek. 2014. Driving With the Wandering Mind: The Effect That Mind-Wandering Has on Driving Performance. *Human Factors* 56, 2 (2014), 260–269. https://doi.org/10.1177/0018720813495280

[106] Angela H Young, Andrew K Mackenzie, Robert L Davies, and David Crundall. 2018. Familiarity breeds contempt for the road ahead: The real-world effects of route repetition on visual attention in an expert driver. *Transportation research part F: traffic psychology and behaviour* 57 (2018), 4–9.

[107] Claire M Zedelius, John Protzko, James M Broadway, and Jonathan W Schooler. 2020. What types of daydreaming predict creativity? Laboratory and experience sampling evidence. *Psychology of Aesthetics, Creativity, and the Arts* (2020).

[108] Han Zhang, Nicola C Anderson, and Kevin F Miller. 2021. Refixation patterns of mind-wandering during real-world scene perception. *Journal of experimental psychology: human perception and performance* 47, 1 (2021), 36.

[109] Han Zhang, Kevin F Miller, Xin Sun, and Kai S Cortina. 2020. Wandering eyes: Eye movements during mind wandering in video lectures. *Applied Cognitive Psychology* 34, 2 (2020), 449–464.