VIDEO GAMES IN THE PRESENT MOMENT: FLOW, MIND-WANDERING, AND INTEROCEPTION

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ABSTRACT

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Flow theory of optimal experiences was first introduced by Csikszentmihalyi in 1975. It has been debated whether an individual's attention is focused or unfocused while in the flow state. Newer research suggests that attention is intensely focused during the flow state. This coincides nicely with another thread of attentional research: interoception. Interoception is the process of listening, understanding, and interpreting signals coming from the body. The opposite of interoception is mind-wandering. Together, interoception and mind-wandering are ways of characterizing quality of attention.

This manuscript looks to link quality of attention (interoceptive awareness and mind-wandering) while playing a video game with quality of experience (flow and spatial presence). Specifically, the study links classic flow theory and virtual worlds presence (another construct associated with optimal experiences in virtual worlds) with neuroscience research on interoception and mind-wandering. The study consists of a 2 (primed for interoceptive awareness or primed for mind-wandering) by 2 (virtual reality or high-definition television) between subject design. Gaming performance and virtual reality (VR) technologies are stereotypically masculine, while interoceptive awareness is stereotypically feminine. Interaction effects of gender were considered throughout the analysis.

Results confirm relationships between quality of attention and quality of experience. Specifically, interoceptive awareness while playing a video game had a positive relationship with both flow and spatial presence. The numerous significant interaction effects of gender illuminate

more detailed, complex understandings. Among males, using a virtual reality headset strongly resulted in much higher performance. But among females, display modality did not appear to impact game performance. Priming for interoceptive awareness was linked to higher performance among female players and lower performance among male players. Among females, priming interoceptive awareness increased mind-wandering during gameplay in VR and decreased mind-wandering during gameplay in HDTV.

This study served as a first step towards understanding relationships between quality of attention with quality of experience, indicating that the relationships may be moderated by gender.

"I know you got problems… hell, we all do. But you gotta understand that there ain't no gettin' offa this train we're on, till we get to the end of the line."

– Barret Wallace

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CHAPTER 1

INTRODUCTION

Over the last several decades video games have become ubiquitous in people's lives. It is estimated that by 2021 over 2.7 billion people worldwide will be actively playing video games (AAStocks, 2017). People play video games for a number of reasons and perhaps one of the more interesting aspects of video game play is many say it comes out of an intrinsic desire for a way to pass time. Of course, there is more going on, perhaps beneath an individual's level of consciousness as video games offer a landscape to satisfy basic needs (Mekler, Bopp, Tuch, Opwis, 2014; Tamborini et al., 2011). Another feature of digital games is the amount of variety in terms of not only genres (e.g., puzzle, role-playing, racing, action, etc.) but also difficulty. In fact, many games offer varying degrees of challenge that the user can select (e.g., easy, medium, hard) before starting out on their adventure. This combination of difficulty, skill, and choice provide an optimal landscape for people to enter a state of being known as flow. The idea of the flow state was developed by Csikszentmihalyi (1975, 1988, 1990) as a way to better understand optimal experiences, play, satisfaction, and motivation. Many aspects that make up the original flow theory have recently been validated by neural science (Klasen, Weber, Kircher, Mathiak, & Mathiak, 2011). A key element of flow is that the individual is "in the moment," in that they are fully engrossed with the activity at hand. At first researchers thought the person in the flow state was so involved in the flow state their attention did not need to be focused because their actions were taking place automatically (Swann, Keegan, Piggott, & Crust, 2012). However, some recent results suggest flow may require constant, purposeful focus but because the user is in a state of flow they do not realize their attention is focused (de Manzano, Theorell, Harmat, & Ullén, 2010; Harris, Vine, & Wilson, 2017a; 2017c).

Another growing body of research revolving around attention to the present moment is interoception. Put simply, interoception is the process of listening for, understanding, and interpreting present moment bodily sensations including sensations associated with feelings and thoughts (Craig, 2009; Craig, 2014; Farb et al., 2015; Heeter, 2016, Mahler, 2015; Mehling et al, 2012). Similar to flow, interoceptive awareness (directing attention to interoception) involves attention to the present moment. Individuals have different capacities and propensities for interoceptive awareness (Craig, 2014, Mehling et al, 2012).

There have not been any studies that link interoceptive awareness (IA) with flow. However, research by Day, Heeter, and Cherchiglia (2019) and Heeter, Day, and Cherchiglia (2020) examined interoceptive awareness during a virtual reality (VR) experience and the construct, State Interoceptive Awareness (State IA). Mehling et al. (2012) developed a scale for measuring propensity to engage in interoceptive awareness in daily life (the MAIA scale). Day, Heeter, and Cherchiglia (2019) and Heeter, Day, and Cherchiglia (2020) adapted the MAIA scale so that rather than asking about general propensity for interoceptive awareness in daily life, they asked about attention to interoceptive signals during a VR experience. They found that interoceptive awareness during a VR experience was a significant predictor of self-location spatial presence.

Mind-wandering (MW), known as the default neural network, is the opposite of focus on present moment awareness (Mittner et al., 2014; Mrazek, Phillips, Franklin, Broadway, Schooler, 2013). Mind-wandering refers to narrative self-talk, ruminating about the past, thinking about the future, daydreaming, etc. Research has not examined mind-wandering in relation to flow or spatial presence.

Flow is often talked about as a goal of video game design, mostly focused on the potential for games to offer just the right amount of challenge. Gameplay that is too difficult for the player can result in frustration and gameplay that is too easy can result in boredom. When challenge is balanced with the player's abilities the optimal "flow zone" is possible. However, challenge is only one factor that characterizes flow. Intriguingly, four of the other dimensions of flow potentially overlap with interoceptive awareness: 1) concentration on an immediate task, 2) merging of action and awareness, 3) loss of self-reflection, and 4) control over one's actions.

Virtual worlds and games are expected to be vivid and engaging. Interoceptive awareness, non-mind-wandering, flow, and presence are all expected to be associated with heightened experiences. The study will explore the extent to which interoceptive awareness and mind-wandering occur during gameplay, and whether quality of attention (interoceptive awareness and mind-wandering) relate to the experiences of flow and presence. The study will also test whether priming interoceptive awareness immediately before gameplay increases interoceptive awareness, non-mind-wandering, flow, and presence during video game play. Finally, the study will test whether VR gameplay increases interoceptive awareness, non-mind-wandering, flow, and presence compared to gameplay on a high-definition television (HDTV).

CHAPTER 2

LITERATURE REVIEW

Flow Theory and Video Games

Flow Theory provides an important framework from which researchers can begin to analyze and understand the causes and conditions that contribute to optimal experiences – a specific state of being. This state of being is called flow (Csikszentmihalyi, 1975, 1988, 1990, 1997). Through the years the construct of flow has been adapted to help account for the sense of enjoyment individuals feel when motivation comes from within (Nakamura & Csikszentmihalyi, 2002). In developing the theory, Csikszentmihalyi interviewed individuals across different activities and professions; some people were performing a task because it provided them with enjoyment (e.g., rock climbers, dancers, etc.) and others were performing a task because it was their job (e.g., surgeons). Thus Nakamura and Csikszentmihalyi (2002) came up with the following conditions of flow: 1) perceived challenges, or opportunities for action, that stretch (neither overmatching nor underutilizing) existing skills; a sense that one is engaging challenges at a level appropriate to one's capacities, and 2) clear proximal goals and immediate feedback about the progress that is being made.

While these conditions can occur during any activity, video games are an exceptionally good medium for providing these conditions (Sherry, 2004). First, video games typically present obstacles by scaffolding the challenge in that each new problem builds upon previous knowledge or skills. Thus, the game is not putting the player in a position where they feel overwhelmed. Second, video games are usually structured around proximal goals (e.g., I need to get my character across that pit) and immediate feedback (e.g., I did not press the button at the right time and my character feel into the pit, thus I died). Lastly the difficulty of a video game can usually be intentionally set by the player. This gives players the opportunity to choose a level of challenge that best suits their ability. Many games are designed to incrementally increase in challenge as the game is played, which helps to dynamically provide optimal levels of challenge.

Besides the two conditions mentioned above, there are other aspects that facilitate a flow state. Nakamura and Csikszentmihalyi (2002) outlined six characteristics that when met, create the flow experience: 1) intense and focused concentration on what one is doing in the present moment; 2) merging of action and awareness; 3) loss of reflective self-consciousness (i.e., loss of awareness of oneself as a social actor); 4) a sense that one can control one's actions; that is, a sense that one can in principle deal with the situation because one knows how to respond to whatever happens next; 5) distortion of temporal experience (typically, a sense that time has passed faster than normal); and 6) experience of the activity as intrinsically rewarding, such that often the end goal is just an excuse for the process.

Once again it is easy to see parallels between video game play and the state of flow. In order to progress in a video game, the player needs to stay focused on the task at hand; simultaneously being aware of what is happening within the game while also having dexterous motor control to manage the inputs necessary to navigate the game world. Additionally, playing video games is typically a voluntary leisure activity, so the motivation for playing is intrinsically driven. One of the intriguing aspects of Csikszentmihalyi's (1975) flow theory is that a task, however menial, can become intrinsically rewarding when there is a balance between individual skill and task difficulty; in fact, a facet of flow theory is that the individual performing the task is doing so in an autotelic manner. To summarize, video games provide an environment for a task to have a balance between challenge and ability, require continuous concentration, actions performed by an individual have immediate results/feedback (assuming the game is well designed), and are generally played by an individual because of an internal desire and curiosity. To that end, video games are a useful medium to study flow.

Flow and Attention

As mentioned previously, an aspect that makes video games likely to elicit flow is that games can dynamically adapt the difficulty (such as by changing the speed at which objects appear on the screen, or the number of objects, etc.) in response to player performance. Flow states can occur when the activities are neither too hard nor too easy, presenting just the right level of challenging. When a game is too hard it becomes frustrating and when a game is too easy it may become boring. Some video games can automatically adapt difficulty based on how well the player is doing. Other video games allow players to choose a difficulty level, or the difficulty in a game can become progressively more difficult as the player progresses. This is an important aspect of flow because the intermingling between challenge, skill, anxiety (or frustration), and boredom are pillars of the flow state (Csikszentmihalyi, 1990, Sharek & Wiebe, 2014; Sherry, 2004). Conversely, the discomfort of anxiety or boredom can distract from focus and pull people out of flow. Basically, the flow state may become active when the demands of a specific task and the skills of the individual are in balance. That being said, and perhaps the key factor that holds all of this together is the focused attention an individual is currently giving the present task (Nakamura & Csikszentmihalyi, 2014; Weber, Tamborini, Westcott-Baker, & Benjamin, 2009).

The connection between flow and attention has been extensively documented over the years (Bediou et al., 2018; Dietrich & Stoll, 2010; Harris, Vine, & Wilson, 2017a; 2017b; 2017c;

Poldrack et al., 2005). However, it is interesting because there is some disagreement about whether the flow state occurs because attention is effortless or because it is effortful. In the sports realm of flow research, early studies attribute attention becoming automatic and unforced as part of the flow state (Swann, Keegan, Piggott, & Crust, 2012). In other fields of flow research, studies found that when an individual is in the flow state their attention is highly focused and purposefully directed at points of interest (de Manzano, Theorell, Harmat, & Ullén, 2010). In fact, some of the recent flow studies based around sports and health sciences have found that it may have been an oversimplification to think that attention was effortless because they discovered that the flow state may require effortful attention, even if it feels effortless (Harris, Vine, & Wilson, 2017a; 2017c). In a way this makes a lot of sense because when you are in a state of flow the actions one makes feels automatic because they are happening in quick succession, but those actions are purposefully being selected by the user in some manner. For example, in a fast-paced puzzle video game, the player may feel like rotating the puzzle pieces is entirely automatic and yet the brain must constantly transmit signals to the hands and fingers to rotate each and every piece. Additionally, the individual playing the game needs to purposefully shift their attention to new information as it becomes available. Nakamura & Csikszentmihalyi (2014) also believe that focused attention on the present moment, an intense concentration on what is currently happening, is a requirement for flow to occur.

There is some new preliminary neurocognitive research being done that suggests the brain areas associated with higher-order attentional networks are active during the flow state (de Manzano et al., 2013; Harris, Vine, & Wilson, 2017c; Ulrich et al., 2014; Ulrich, Keller, Grön, 2016). Based on these newer study's findings it seems that flow is most likely not a passive state of being because the brain is highly active during flow. Anecdotally this all fits because to perform well at a task, especially one that is a balance between skill and difficulty, the player would have to be constantly shifting their attention to the utmost pertinent information currently being presented and absorbed. Now attention may feel automatic when someone is in the flow state as they are in sync with both the task and themself, but it seems logical that the body and brain are actually in a constant state of paying attention as new information becomes available. This line of thinking couples nicely with a growing corpus of research on the concept of interoceptive awareness (Craig, 2009; Craig, 2014; Farb et al., 2015; Heeter, 2016).

Interoceptive Awareness and Mind-Wandering

Interoception is the process of listening, understanding, and interpreting signals coming from the body (Craig, 2009; Craig, 2014; Farb et al., 2015; Heeter, 2016, Mahler, 2015). Interoception allows us, as humans, to experience life through our bodies; via different body states, from physical states like pain, hunger, and muscle tension to different emotional states, like happiness, anger, and excitement, to even the subtle hard to place feelings like trustworthiness. Most of the time interoception happens unconsciously, below our level of conscious awareness. We are unaware of feelings unless we actively pay attention to how we are feeling. Interoceptive awareness is the process of consciously directing attention to present moment bodily sensations, including sensations associated with feelings and thoughts. Interoceptive awareness is also a skill. Different individuals have different propensities and capacity for directing attention to present moment bodily sensations (Craig, 2014; Farb et al., 2015). Meditation training has been shown to increase propensity for interoceptive awareness (Bornemann, Herbert, Mehling, & Singer, 2015; Heeter, Lehto, Allbritton, Day, & Wiseman, 2017; Mehling et al., 2012).

If we think back to the first and second characteristic of Nakamura and Csikszentmihalyi (2002) flow theory, 1) intense and focused concentration on what one is doing in the present moment and 2) merging of action and awareness, interoceptive awareness appears to fit extremely well. Our body is constantly embodying how we are feeling. A major caveat of flow theory is that the individual is focused on the task at hand and able to filter out any non-pertinent information, both externally and internally. If an individual is able to parse through external data (e.g., what needs to be done to complete the next step) while also being aware of interoception (e.g., attending to relevant internal body states), one's ability to enter the flow state could be more attainable. It is interesting that both flow and interoceptive awareness are ongoing, continuous processes that are constantly being updated by the individuals' present moment interactions.

A study by Harris, Vine, and Wilson (2018) found that providing participants with an external focus during a driving simulation seemed to promote the flow state. It should be noted that in their study the difference between external and internal foci was for directing visual gaze (i.e., inside and outside of a vehicle while driving) not the current state of their body. Thus, it is of particular interest to this manuscript to consider whether priming a state of interoceptive awareness prior to a task can improve the likelihood of eliciting a flow state during the task. One of the highlights of Harris, Vine, and Wilson (2018) research is the suggestion that attention is important to the feeling of flow. This is especially thought-provoking because by definition interoceptive awareness is synonymous with being in the present moment and paying attention to the body's feelings. Therefore, interoceptive awareness may be a contributing factor to flow or a component of flow. Studying interoceptive awareness during gameplay could contribute to understanding how the flow state is achieved or maintained.

At first glance there is a possible disconnect between flow and interoceptive awareness because flow requires the loss of 'self,' and there are a number of studies that find flow is weakened when an individual is self-aware (Garrison et al., 2013; Harris, Vine, & Wilson, 2017c; Ulrich, Keller, & Grön, 2015). However, when those studies refer to thinking about the self, they associate the brain activity to mind-wandering and self-ruminative thought (e.g., worrying about the past or future). Both interoceptive awareness and flow are blocked or hindered if an individual's thoughts are not focused on the tasks at hand, if their minds are wandering. The default mode of the human brain is mind-wandering, when our attention is focused on things other than the present moment (Buckner, Andrews-Hanna, & Schacter, 2008; Killingsworth & Gilbert, 2010; Mittner et al., 2014; Mrazek, Phillips, Franklin, Broadway, Schooler, 2013). Another term for mind-wandering is "stimulus-independent thought" (Schooler et al., 2011). Our mind is typically in a state of jumping from though to thought thinking about a wide range of topics ranging from the past and future. In interoceptive awareness research mind-wandering is considered to be the opposite of paying attention to present moment bodily sensations, because either the mind is in the moment or it is wandering through other thoughts. If both interoception and flow require active attention to the present moment, then it is reasonable to suspect a connection between the two. In addition, if paying attention to interoception acts similarly to an external point of focus, although not visual, then perhaps interoceptive awareness will lead to stronger feelings of flow.

Another overlap between the two concepts of flow and interoceptive awareness that are particularly important to performing well in a video game is not second guessing oneself and *feeling* the moment. When playing a game there is a big difference between being in the moment, making swift and accurate movements than making movements but worrying about failing (e.g., am I doing the right *thing*; am I making a mistake?). Recall that interoceptive awareness means listening to your body, and when an individual is in the flow state they will be making decisions and movements in an almost automatic way based on what feels right, which, colloquially, is similar to a "gut feeling."

Interoceptive awareness is consistent with four of the six dimensions of flow Nakamura and Csikszentmihalyi (2002). Specifically, interoceptive awareness and flow occurs when there is: 1) intense and focused concentration on what one is doing in the present moment; 2) merging of action and awareness; 3) loss of reflective self-consciousness (i.e., loss of awareness of oneself as a social actor); and 4) a sense that one can control one's actions; that is, a sense that one can in principle deal with the situation because one knows how to respond to whatever happens next.

Presence

Flow has been associated with experiencing a sense of presence in virtual worlds (Jin, 2011; Michailidis, Balaguer-Ballester, & He, 2018). Although it is not the focus of this manuscript to define, or redefine, presence in and of itself, it is stimulating to think about how the field of neuroscience defines presence compared to virtual worlds. The main assumption of presence in virtual worlds research is that presence is the illusion of non-mediation (Lee, 2004; Lombard & Ditton, 1997). We can think about this definition as saying that humans when not in a mediated environment (i.e., going about regular life) are fully present (Heeter, 2016). However, we know now from the research mentioned previously that the default state of being is mind-wandering, or not being present in the moment. This is where the neuroscience definition of presence appears to fit in rather well because in that field, presence is: being aware of how you feel “now” (Craig, 2009, 2015; Mahler, 2015). In other words, interoceptive awareness may be useful to help media effects scholars better understand virtual world presence. Some preliminary research by Heeter, Day, and Cherchiglia (2020) found a connection between interoceptive awareness and feelings of spatial presence while experiencing a virtual reality meditation. It should be noted that spatial presence is defined as an individual’s sense of ‘being there’ in the virtual environment provided by a medium (Hartmann et al., 2016). While the context for the current research is quite different this paper will continue the trend of examining the connection between spatial presence and interoceptive awareness. Since the participants will be actively playing a video game rather than listening to a meditation it is unclear if interoceptive awareness will be positively related to feelings of spatial presence, but it may be reasonable to assume that there is a link.

According to a handful of studies, when an individual enters the flow state, they report higher feelings of presence (Jennett, 2008; Jin, 2011; Nacke & Lindley, 2008; Weibel & Wissmath, 2011; Weibel, Wissmath, Habegger, Steiner, & Groner, 2008). These findings occurred across several questionnaires designed to measure different aspects of presence (e.g., spatial presence, self-presence, etc.) and across different questionnaires designed to measure the same type of presence. The range of games utilized in the studies was varied, from driving to narrative-driven to side-scrolling action games. While, there is some research that questions if flow and presence measure the same properties (Michailidis, Balaguer-Ballester, & He, 2018), there is other research that emphatically states they are distinct constructs (Weibel & Wissmath, 2011). It is beyond the scope of this manuscript to address that particular wonderment and instead will stand on the ground that the two are separate, measurable ideas – especially because spatial presence is being examined which focuses on the feelings of being in a *place*.

Virtual Reality

It would be easy to assume that virtual reality would increase feelings of spatial presence because previous research has shown that certain technological advancements have improved a user's sense of presence such as: improved graphics or realism (Ivory & Kalyanaraman, 2007; Krcmar, Farra, & McGloin, 2011; McGloin et al., 2011), realistic game controllers (Kim & Sundar, 2013; McGloin et al., 2011; Schmierbach, Limperos, & Woolley, 2012; Skalski et al., 2011), and a larger screen size (Hou, Nam, Peng, & Lee, 2012; Kim & Sundar, 2013). While one study did seem to suggest that virtual reality lead to a higher sense of spatial presence (Day, 2016), however that may have been because of the specifics of the study (i.e., playing an atmospheric horror video game). Some research has proposed that individual differences and emotional responses lead to stronger feelings of presence (Gromer, Reinke, Christner, & Pauli, 2019; Weech, Kenny, & Barnett-Cowan, 2019). Interestingly, the simple puzzle video game *Tetris* played on a television screen has been shown to elicit feelings of presence (Ravaja et al., 2004). However, *Tetris* would not typically be considered a game to garner a high amount of *spatial* presence because the game design offers very limited control in the game world (moving blocks). The current study is specifically interested in feelings of spatial presence because we want to see if a game without intuitive motion controls along with simple game design in virtual reality can elicit those feelings. It is unknown whether playing a simple puzzle video game in virtual reality will change feelings of spatial presence.

In a parallel line of thinking virtual reality has been shown to impact feelings of flow but again those studies have examined instances where individuals have a higher emotional investment in the outcome or the experience is tailored to elicit an emotional response (Kim & Ko, 2019; Shin, 2018). There is a dearth of virtual reality research related to flow. Similarly, this paper is the first step towards connecting interoception to video game playing. The interaction of virtual reality with flow, spatial presence, and interoceptive awareness during gameplay is a mystery.

Finally, there is limited research looking at game performance comparing playing a video game in virtual reality and playing the same game without virtual reality. Virtual reality has shown positive effects when used by surgeons prior to performing surgery (da Cruz et al., 2016) so it can provide an environment for manual dexterity training. Perhaps because the virtual world provides an engaging distraction, individuals report feeling less pain (Matsangidou, Ang, Mauger, Otkhmezuri, & Tabbaa, 2017) and exercise longer (Matsangidou et al., 2019) when immersed in a virtual world, wearing a virtual reality headset. The underlying reasons of 'why' virtual reality affords those benefits are unknown but might have to do with the attentional resources available while using the headset. The idea is that people have a limited amount of attentional resources they can allocate at any given time and virtual reality requires a large amount of your attention. The brain might not be able to pay as much attention to 'pain' signals because the attention is on experiencing the virtual world. Furthermore, while wearing the headset the real world is not visible. In a situation where someone might feel watched or judged, wearing a virtual reality headset could lead to better performance because a) resources that might otherwise be used for negative or detrimental thoughts are being 'used up' by virtual reality, and b) having the real world blocked from view might heighten focus on the virtual space. Ultimately, in the case of the current study, wearing a virtual reality headset may affect game performance by removing environmental distractions and reducing awareness of the body in physical space (e.g., the usual visual cues of seeing hands and other body parts in one's peripheral vision are absent).

Gender-based differences in the experience of VR have been documented (Stanney, Fidopiastis & Foster, 2020; Statista, 2017). More males than females owned a VR or an augmented reality device in 2017 (57% to 43%) and an even higher gender disparity is seen with intent to purchase, with 69% of males intending to purchase a device compared to 31% of females (Statistica, 2017). It would seem that VR appeals more to males. Females are also more likely to experience cybersickness, driven in part by poorer fit of interpupillary distance between the eyes for female anatomy (Stanney, Fidopiastis & Foster, 2020).

Gender and Gaming

There are extreme gender differences abound in gaming, including time spent gaming, achievement orientation, and genre preferences. Men spend more time playing video games and they play for longer (Caywood & Heeter, 2006; Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010). Women and men have different genre preferences. For example, violent games such as action adventure and shooter games are more strongly preferred by men (Hartmann & Klimmt, 2006). Women expressed significantly less interest than men in 9 gaming uses and gratifications; among those most relevant to the present study women were less interested than men in competition, challenge, and arousal in games (Greenberg et al., 2010). Interestingly, puzzle games were the top-rated mobile game genre by women (Newzoo, 2017), hence the selection of *Tetris* for this study – it is a genre that is not predominantly male.

There is sizeable amount of research showcasing the differences between men and women's playstyles (e.g., men tend to favor playing fast whereas women tend to favor playing for exploration; on average men are more competitive than women; women tend to play slower than men and tend to make more errors) (Heeter, Lee, Medler, & Magerko, 2011; Heeter &

Winn, 2008; Klawe, Inkpen, Phillips, Upitis, & Rubin, 2002; Yee, 2006). Interestingly, there is some research that suggests when men and women's performance are compared across players with similar amount of experience with an online role-playing game, they have similar performance (Shen, Ratan, Cai, & Leavitt, 2016). Another study also found that while women are capable of performing at a similar level to men, female players are more likely to conform to gender stereotypes and take on helping and healing roles (Ratan, Taylor, Hogan, Kennedy, & Williams, 2015). Both of those previous studies revolved around gameplay in an online, competitive situation and the current study has neither of those aspects. In fact, the current research specifically emphasized to participants that their performance is not critical to success prior to playing in the sense that they are not being judged on how well they play the video game. Since this an exploratory study where the game being utilized is a single player puzzle game without any references to how other participants play, gender is a variable of interest but the specifics of the outcome are unknown.

Some research has found that there are gender differences relating to flow (Chang, 2017; Yang & Quadir, 2018) and other studies did not find any differences (Bressler & Bodzin, 2013; Sharp, Coatsworth, Darling, Sumsille, & Ranieri, 2007). Also, research has pointed towards gender differences in experiences eliciting presence (Felnhofer et al., 2014; Oh, Bailenson, & Welch, 2018). Thus, it is clear gender is an important construct to measure and we posit several questions that will continue to shed some light on this particular topic. In a similar line of thought, past studies have shown that women report higher feelings of interoceptive awareness than men (Grabauskaitė, Baranauskas, & Griškova-Bulanova, 2017), but the current study is focused on a new measure of interoceptive awareness that has only been utilized in one other paper (Heeter, Day, & Cherchiglia, 2020). Therefore, we set out to explore if there are any gender differences utilizing this new interoceptive awareness scale.

Individual Differences

The majority of the constructs in this study are known to involve large individual differences. For example, interoceptive awareness is a skill; an individual's ability to be aware of and receive signals coming for their body can differ drastically from person to person (Craig, 2014; Farb et al., 2015). Similarly, while a wandering mind is our brains default resting state some individuals more easily maintain focus on a task than others. These individual characteristics are important because the exact same virtual experience can produce individually unique experiences, which can lead to distinct feelings of interoceptive awareness, mind-wandering, flow, and spatial presence. Part of the unique experiences stem from the fact that we all have individual propensities and considerations for how we self-analyze feelings. Another part of the unique experiences is how the specific virtual world or game is designed to enhance or maximize those feelings. In this study we look at whether priming interoceptive awareness can lead to long lasting increase in feelings of interoceptive awareness, flow, and spatial presence. We also look at whether playing a puzzle video game in virtual reality can strengthen feelings of interoceptive awareness, flow, and spatial presence.

CHAPTER 3

HYPOTHESES AND RESEARCH QUESTIONS

Based on the literature review we have several proposed hypotheses. First, we are mainly interested in the relationships between quality of attention (measured by interoceptive awareness and mind-wandering) during gameplay and quality of experience in virtual world gameplay (measured by flow and spatial presence). To our knowledge this is a new area of research that might help to further expand understanding of the mechanisms that influence flow and spatial presence. We are also interested in whether priming interoceptive awareness versus priming mind-wandering might influence quality of attention during gameplay. Regardless of whether quality of attention is influenced by priming, there is reason to believe that higher interoceptive awareness experienced while playing might be associated with a stronger sense of flow and spatial presence because of the connection between engaged attention and one's state of being. There is reason to believe that higher mind-wandering while playing might lead to a weaker sense of flow and spatial presence because the mind is not focused on the present moment experience.

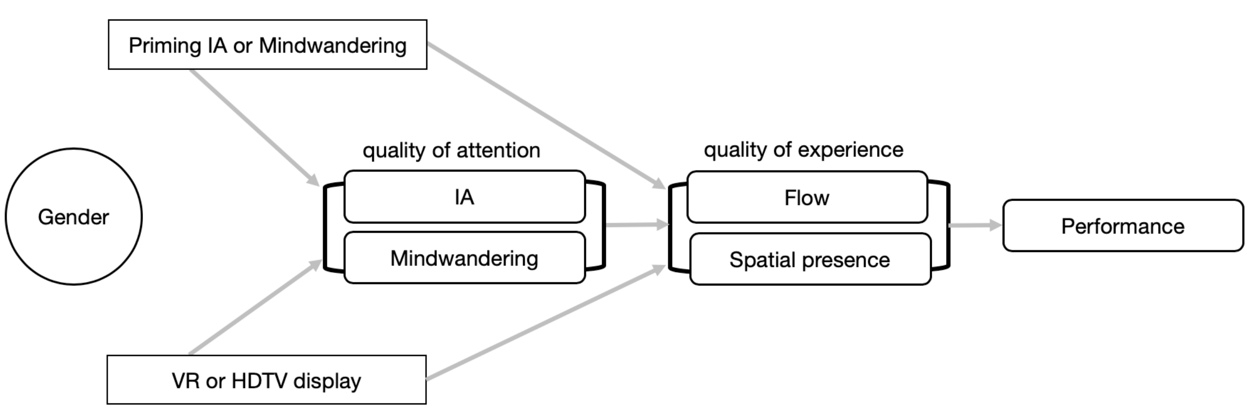

Figure 1: Theoretical Model

The primary goal of this research is to test a hypothesized relationship between quality of attention and quality of experience while playing a video game. Specifically, higher interoceptive awareness and lower mind-wandering are predicted to be associated with more flow and more spatial presence.

Experimental manipulations were designed to try to influence quality of attention during gameplay. Half of study participants were primed to activate interoceptive awareness and half were primed to activate mind-wandering. Half of study participants played the video game wearing a VR headset (to increase immersion and limit visual distractions outside of the game) and half played the game on a high-definition television.

Gaming performance is also examined as an outcome, with the caveat that not all players are motivated to achieve high scores (i.e., performance reflects quality of experience for achievement-motivated players).

Because there are documented gender differences in interoceptive awareness (on average, females report higher interoceptive awareness in daily life), technology (VR is a stereotypically masculine technology), and playstyle (males play faster and are more achievement oriented) moderating and mediating roles for gender are examined.

Direct Effects of Experimental Manipulations on Quality of Attention

The first two hypotheses propose direct effects of the experimental manipulations on quality of attention. Research questions consider a moderating role for gender.

H1: Participants who are primed for interoceptive awareness prior to playing a video game will report higher quality of attention, specifically a) more interoceptive awareness and b) less mind-wandering during video game play than participants who are primed for mind-wandering.

RQ1: Does gender moderate the effect of attentional priming on quality of attention, specifically a) interoceptive awareness or b) mind-wandering?

When someone plays a game on a high-definition television screen, the distractions in the world around them are still visible. When someone plays a game wearing a VR headset, they only see the virtual world, and perhaps the outlines of the headset. The technology limits visual distractions and supports focused attention on the screen. On the other hand, where attention focuses within the display is not restricted in either form of display. Even in VR, attention can be directed toward core gameplay or toward movement, objects, and special effects on the display. The question of whether playing the puzzle game in VR compared to playing on a high-definition television impacts quality of attention is addressed in H2.

H2: Playing a video game in VR will result in better quality of attention — specifically, a) interoceptive awareness and b) mind-wandering compared to playing the same game on a high definition television.

RQ2: Does gender moderate the effect of display modality (i.e., virtual reality or high-definition television) on quality of attention, specifically a) interoceptive awareness and b) mind-wandering?

Effects of Experimental Manipulations on Quality of Experience

Hypotheses 3 and 4 propose direct effects of the experimental manipulations on quality of experience. Research questions consider a moderating role of attentional priming, display modality, and gender.

Attentional priming (interoceptive awareness or mind wandering) may have short term or subtle longer-term effects on quality of experience even if quality of attention during gameplay is not measurably different. The next hypothesis predicts an effect of attentional priming on quality of experience.

H3: Participants who are primed for interoceptive awareness prior to playing a video game will report better quality of experience, specifically higher a) flow, and b) spatial presence during video game play than participants who are primed for mind-wandering.

Because VR is more immersive than a high-definition television, playing a video game in VR is expected to increase spatial presence compared to playing the same game on a high-definition television. VR also may facilitate some of the qualities of flow (such as high levels of concentration, melting together actions and consequences, and a fulfilling activity) beyond what occurs when playing on a high-definition television.

H4: Participants who play a video game in virtual reality will report higher quality of experience — specifically, higher a) flow, and b) spatial presence — during video game play than participants who play the same game on a high definition television.

RQ3: Do display modality (i.e., virtual reality or high-definition television) or gender moderate the effect of attentional priming (i.e., interoceptive awareness or mind-wandering) on a) flow and b) spatial presence?

RQ4: Do attentional priming (i.e., interoceptive awareness or mind-wandering) or gender moderate the effect of display modality (i.e., virtual reality or high-definition television) on a) flow and b) spatial presence?

Effects of Quality of Attention on Quality of Experience

Mind-wandering implies lack of focus on the present moment, whereas interoceptive awareness implies focus on present moment bodily sensations. Mind-wandering ought to impede flow and spatial presence, while interoceptive awareness ought to support those experiences. Interoceptive awareness should be associated with higher quality of experience.

Hypothesis 5 proposes direct effects of quality of attention on quality of experience. Research question 5 explores a moderating role of attentional priming, display modality, and gender.

H5: Participants who report experiencing a) higher interoceptive awareness and b) less mind-wandering while playing a video game will report higher quality of experience, specifically higher 1) flow, and 2) spatial presence during video game play.

RQ5: Do attentional priming (i.e., interoceptive awareness of mind-wandering), display modality (i.e., virtual reality or high-definition television), or gender moderate the effect of quality of attention (i.e., interoceptive awareness of mind-wandering) on a) flow and b) spatial presence?

Game Performance, Quality of Attention, and Quality of Experience

Research Question 6 explores whether and how gaming performance is influenced by gender, attentional priming, display modality, quality of attention, and quality of experience.

RQ6: How do gender, attentional priming (interoceptive awareness or mind-wandering), use of virtual reality versus a high-definition television, quality of attention (interoceptive awareness and mind-wandering), and quality of experience (flow and spatial presence) influence participants' game performance.

Moderated Mediation

Hypothesis 6 proposes gender moderates the relationship between quality of attention (interoceptive awareness or mind-wandering) on quality of experience (flow and spatial presence).

H6: Gender moderates the mediating effect of quality of attention on quality of experience.

CHAPTER 4

METHODS

Participants

This study consisted of 129 college students from a large Midwest University in the United States. Participants were recruited through SONA, which is an online system hosted by the College of Communication Arts and Sciences of said Midwest University. As compensation for participation participants were offered bonus credit for a college course of their choosing. College students were sampled for this study for two reasons: a) availability, and b) they are likely to have played or currently play video games as per the United States demographics show that a majority of video game players are under the age of 35 (Entertainment Software Association, 2019).

Participant age ranged between 17 and 25 with an average age of about 20. Of those 129 participants 70 (54.3%) described themselves as female, 58 (45.0%) described themselves as male, and 1 (~0.8%) choose not to answer. Regarding Race/Ethnicity, 82 (63.6%) identified as Caucasian/White, 24 (18.6%) identified as Asian, 16 (12.4%) identified as Black or African American, 5 identified as Hispanic or Latino (3.9%), 1 (~0.8%) identified as Middle Eastern, and 1 (~0.8%) identified as Other. See Table 2 for a breakdown of demographic information by condition.

Materials

The video game, *Tetris Effect* (2018) was selected for the puzzle game stimulus. *Tetris Effect* is a game where the player strategically rotates, moves, and drops falling blocks

(Tetriminos) to create horizontal lines without any missing spaces; those gapless lines are then cleared from the screen. If the blocks are placed incorrectly and the screen is filled with un-cleared lines, the game will end. When a player successfully clears a line, they are awarded points. Additionally, after a certain number of total lines are cleared the speed of the game increases (e.g., 10 lines = 1 additional "speed").

Tetris Effect was selected for specific reasons. First, while the study is primarily interested in individuals who play video games *Tetris Effect* does not require extensive tutorials to begin playing so it should be accessible, perhaps not at a high level of skill, to most individuals comfortable with holding a video game controller. In the same line of thinking, *Tetris Effect* was selected because *Tetris* (Pajitnov, 1984) is one of the longest running game series in existence and has seen numerous iterations of the original game, from computers to consoles to cell phones, all around the world so that increases the probability of participants having played the game before. Second, due to the unique nature for an individual to enter the flow state (i.e., the balance between skill and ability; a wide variance among individuals; individual preferences and ability to focus) *Tetris Effect* will be mentioned by name in the SONA description so that participants know ahead of time what to expect from the gameplay experience and hopefully will attract people who may already enjoy playing thus increasing their likelihood of being able to enter the flow state. Third, *Tetris Effect's* difficulty slowly gets more difficult as the player clears lines. Hopefully, this type of progression will assist participants in finding that balance between skill and ability. And finally, we are curious to see how the dimension of spatial presence is internalized since *Tetris* is not a game that would typically be associated with high feelings of presence because the gameplay is simply connecting blocks to clear lines.

The video game console PlayStation® 4 along with the PlayStation® VR (PSVR), a virtual reality headset (See Appendix A), was utilized to run the puzzle game. A computer along with a device to capture console gameplay (e.g., an Elgato Capture Card – See Appendix A) was used, along with a pair of headphones. Finally, a recording was designed, written, and recorded by Dr. Carrie Heeter to prime interoceptive awareness (See Appendix B for the full script). Lastly, a room where the participants could comfortably play *Tetris Effect* without being disturbed by other people is essential.

Study Design

The study consists of a 2 (primed for interoceptive awareness x primed for mind-wandering) by 2 (virtual reality x no virtual reality) between subject design (See Table 1). The four randomly assigned groups had roughly the same number of participants: primed for interoceptive awareness with virtual reality ($n = 36$); primed for interoceptive awareness without virtual reality ($n = 31$); primed for mind-wandering with virtual reality ($n = 33$), and primed for mind-wandering without virtual reality ($n = 29$). See Table 1. One of the main interests of this research is to see if interoceptive awareness has a connection to flow and spatial presence, two important virtual worlds measures. Thus, participants were randomly assigned between two conditions; in one condition the participants had their interoceptive awareness primed by way of the audio recording, and in the other condition the participants were primed for mind-wandering by having them sit in a room with no access to their phones and nothing to do for 3 minutes (the same time duration as the priming for interceptive awareness audio). All participant's mobile devices were collected and stored in a box in the room with the researcher until that person finished participating in the study. Additionally, the participants either played *Tetris Effect* using the PSVR or on a standard 40" high-definition television.

Table 1: Study Conditions and Sample Size

	Primed for Interoceptive Awareness	Primed for Mind-Wandering
VR Tetris Effect	*n* = 36	*n* = 33
HDTV Tetris Effect	*n* = 31	*n* = 29

It should be noted that the gameplay and controls in the virtual reality and high-definition television conditions were identical. The major differences between the two is that: 1) in the virtual reality conditions participants can look up and down and it appears that they are floating in space, 2) the participants' field-of-view of the game world and 3) visibility of the external world. While using the virtual reality headset, what participants could see was only the game world. Participants using the high-definition television could look around the physical room in addition to looking at the television. Even with attention focused on the monitor, the external world was visible in their peripheral vision. Thus, while player's in game field-of-view is quite similar in terms of size and scope their peripheral vision is very different. See Appendix A for a comparison between the gameboard size in virtual reality versus a high-definition television.

Table 2: Basic Demographic Characteristics by Condition

	Prime IA + VR	**Prime IA + No VR**	**Prime MW + VR**	**Prime MW + No VR**
Age Band				
≤ 17	2.9% (*n* = 1)	0% (*n* = 0)	0% (*n* = 0)	0% (*n* = 0)
18-21	88.6% (*n* = 31)	83.9% (*n* = 26)	86.2% (*n* = 25)	87.9% (*n* = 29)
22-25	8.6% (*n* = 3)	16.1% (*n* = 5)	13.7% (*n* = 4)	9.1+% (*n* = 3)
≥ 26	0% (*n* = 0)	0% (*n* = 0)	0% (*n* = 0)	3% (*n* = 1)
Gender				
Women	61.1% (*n* = 22)	46.7% (*n* = 14)	48.5% (*n* = 16)	62.1% (*n* = 18)
Men	38.9% (*n* = 14)	53.3% (*n* = 16)	51.5% (*n* = 17)	37.9% (*n* =11)

Table 2 (cont'd)				
<u>Ethnicity</u>				
Caucasian/ White	55.6% (*n* = 20)	51.6% (*n* = 16)	69.7% (*n* = 23)	79.3% (*n* = 23)
Hispanic or Latino	5.6% (*n* = 2)	6.5% (*n* = 2)	0% (*n* = 0)	3.4% (*n* = 1)
Asian	22.2% (*n* = 8)	22.6 % (*n* = 7)	18.2% (*n* = 6)	10.3% (*n* = 3)
Middle Eastern	2.8% (*n* = 1)	0% (*n* = 0)	0% (*n* = 0)	0% (*n* = 0)
Black or African American	13.9% (*n* = 5)	16.1% (*n* = 5)	12.1% (*n* = 4)	6.9% (*n* = 2)
Other	0% (*n* = 0)	3.2% (*n* = 1)	0% (*n* = 0)	0% (*n* = 0)
<u>*Tetris* Experience</u>				
Yes	83.3% (*n* = 30)	71.0% (*n* = 22)	84.8% (*n* = 28)	79.3% (*n* = 23)
No	16.7% (*n* = 6)	29.0% (*n* = 9)	15.2% (*n* = 5)	20.7% (*n* = 6)

Procedure

Before a participant arrived at the study, they were randomly placed into one of the four conditions: Priming for Interoceptive Awareness – Yes/No by Virtual Reality – Yes/No. Upon arrival to the experiment participants were given an IRB-approved consent which they verbally provided their consent if they wished to continue. It was made clear that participation could be stopped at any time for any reason without consequence. Participants were asked to turnoff or silence their cellphones and/or smart devices and place them either inside their own bag or in a container provided by the researcher.

After providing consent the participant completed a presurvey. If the participant was assigned to the primed for interoceptive awareness condition, the participant listened to a 3-minute priming for interoceptive awareness audio recording by meditation expert Dr. Carrie Heeter which used techniques to encourage the individual to direct attention to present moment sensations including breath and other bodily sensations. If the participant was assigned to the primed for mind-wandering condition, after the participant finishes the pre survey the researcher asked them stay in the room and to not use their smart device until they come back in about 3 minutes, which is the same length as the primed for interoceptive awareness audio.

If the participant was in the virtual reality condition the researcher explained how the headset worked and assisted in putting on the equipment if necessary. The researcher then went over the basics of how to play the video game *Tetris Effect*, followed by the participant immediately playing *Tetris Effect*. The participant played the game for about 7 minutes. While playing if the participants screen filled up with Tetriminos they were instructed to select the "Start Over" option and continue playing for the full 7 minutes. Afterwards the participant completed a post questionnaire.

If the participant was assigned to the primed for mind-wandering condition, after the participant finishes the pre survey the researcher asked them stay in the room and to not use their smart device until they come back in about 3 minutes. All participant's mobile devices were collected and stored in a box in the room with the researcher until study that person finished participating in the study. After the 3 minutes the researcher follows the same protocol as above depending on if the participant is in the virtual reality condition or not.

Measures

Interoceptive Awareness for Virtual Worlds. See Appendix C for a full inventory of scale items. Interoceptive awareness was measured using a modified Multidimensional Assessment of Interoceptive Awareness (MAIA) scale (Mehling, 2014; 2018). The original scale measures general propensity toward eight dimensions of interoceptive awareness with a total of 37 questions from the following subscales: 1) Noticing, 2) Not-Distracting, 3) Not-Worrying, 4) Attention Regulation, 5) Emotional Awareness, 6) Self-Regulation, 7) Body Listening, and 8)

Trusting. Some example questions include, “When I am tense I notice where the tension is located in my body” and “I can refocus my attention from thinking to sensing my body.” Items were rated on a 6-point Likert scale from 0 “Never” to 5 “Always.”

A previous study (Heeter, Day, & Cherchiglia, 2020) developed and tested a scale that modified MAIA questions to refer to a virtual reality experience participants had just completed, instead of general daily life propensities; specifically the scale measured an individual’s state interoceptive awareness and was composed by 17 items. The current study uses the same methodology to attain the 17 items; the full MAIA scale was presented in the post-survey and from there the specific 17 items from the Heeter, Day, and Cherchiglia (2020) study were utilized to create a new measure of interoceptive awareness. From this point on this scale will be called Interoceptive Awareness for Virtual World’s (IAVW). See Appendix C for all items in the MAIA scale along with the specific IAVW 17-item scale. The IAVW scale was utilized on the post-test to assess feelings of interoceptive awareness during *Tetris Effect* gameplay. Utilizing the new Interoceptive Awareness for Virtual Worlds scale our data yielded the following statistics: $\alpha = 0.91$; $M = 2.94$; $SD = 0.76$. The IAVW scale was administered in the post-survey, following 7 minutes of *Tetris Effect* play.

Mind-Wandering for Virtual Worlds. Mind-wandering was measured using the Mind-Wandering Questionnaire (Mrazek, Phillips, Franklin, Broadway, & Schooler, 2013). The Mind-Wandering Questionnaire (MWQ) was designed to measure trait mind-wandering and for this study was adapted to measure state mind-wandering. Specifically, rather than referring to general propensity for mind-wandering, each of the five questionnaire items were changed to specifically refer to mind-wandering during the experience of recently playing a video game. This paper is the first usage of the adapted scale and will be referred to as the Mind-Wandering for Virtual

Worlds (MWVW) scale going forward. Table 3 below as well as Appendix C lists the original scale items followed by the adapted scale items.

Table 3: Adapting the MWQ into the MWVW

Mind-Wandering Questionnaire	Mind-Wandering for Virtual Worlds
1. I have difficulty maintaining focus on simple or repetitive work.	1. I had difficulty maintaining focus on the game.
2. While reading, I find I haven't been thinking about the text and must therefore read it again.	2. During gameplay, I had trouble maintaining my attention on what I needed to pay attention to.
3. I do things without paying full attention.	3. I played the game without paying full attention.
4. I find myself listening with one ear, thinking about something else at the same time.	4. I found myself playing and thinking about something else at the same time.
5. I mind-wander during lectures or presentations.	5. My mind wandered while playing.

Items were rated on a 6-point Likert Scale from 0 "Almost Never" to 5 "Almost Always." Utilizing the new Mind-Wandering for Virtual Worlds scale our data yielded the following statistics: $\alpha = 0.83$; $M = 1.86$; $SD = 0.82$. The MWVW was administered in the post-survey, following 7 minutes of *Tetris Effect* play.

Short Flow Scale. Flow was measured using the Short Flow Scale (Rheinberg, Vollmeyer, & Engeser, 2003; Engeser & Rheinberg, 2008). Table 4 below has a full list of the items as well as Appendix C. Items were rated on a 7-point Likert scale from 1 "not at all" to 7 "very much." The short flow scale was selected because it is well validated and used in many studies (Engeser & Rheinberg, 2008; Montull, Vázquez, Rocas, Hristovski, and Balagué, 2020; Schüler, 2007; Schüler & Brunner, 2009), and the questions are applicable to virtual reality and non-virtual reality *Tetris Effect*.

Table 4: Short Flow Scale
1. I felt just the right amount of challenge.
2. My thoughts/activities ran fluidly and smoothly.
3. I did not notice time passing.
4. I had no difficulty concentrating.
5. My mind was completely clear.
6. I was totally absorbed in what I was doing.
7. The right thoughts/movement occurred of their own accord.
8. I knew what I had to do each step of the way.
9. I felt that I have everything under control.
10. I was completely lost in thought.

Utilizing the Short Flow Scale our data yielded the following statistics: $\alpha = 0.77$; $M = 5.21$; $SD = 0.84$. The Short Flow Scale was administered in the post-survey, following 7 minutes of *Tetris Effect* play.

Spatial Presence Experience Scale. The Spatial Presence Experience Scale (SPES) (Hartmann et al., 2016) was used to measure spatial presence. The SPES measures self-location and possible actions. Table 5 below has a full list of the items as well as Appendix C. Some example questions include, "It was as though my true location had shifted into the environment in the presentation" and "The objects in the presentation gave me the feeling that I could do things with them." Items were rated on a 5-point Likert scale from 1 "I do not agree at all" to 5 "I fully agree."

Table 5: Spatial Presence Experience Scale
1. I felt like I was actually there in the environment of the presentation. 2. It seemed as though I actually took part in the action of the presentation. 3. It was as though my true location had shifted into the environment in the presentation. 4. I felt as though I was physically present in the environment of the presentation. 5. The objects in the presentation gave me the feeling that I could do things with them. 6. I had the impression that I could be active in the environment of the presentation. 7. I felt like I could move around among the objects in the presentation. 8. It seemed to me that I could do whatever I wanted in the environment of the presentation.

Utilizing the Spatial Presence Experience Scale our data yielded the following statistics: $\alpha = 0.89$; $M = 3.45$; $SD = 0.83$. The Spatial Presence Experience Scale was administered in the post-survey, following 7 minutes of *Tetris Effect* play.

Game Metrics. As previously mentioned, *Tetris Effect* has several different variables that could theoretically be used to measure an individual's progress during gameplay. For the purposes of this study "Score" was omitted because there are many variables that influence the number of points a player receives. Performance was measured based on Total Lines Cleared which is an aggregate of the total number of lines the player cleared even if they needed to reset the game due to filling up the screen with Tetriminos (e.g., during the first 3 minutes of gameplay the player cleared 14 lines and then reset. During the next 4 minutes of gameplay the player cleared 16 lines. The total number of lines cleared would be 30 lines). Performance (total lines cleared) is a measure with strong external validity because the number of lines cleared between a skilled *Tetris* player and a new *Tetris* player would be vastly different. Gameplay was recorded and after each participant the researcher catalogued the appropriate game metrics. See Table 6 for mean and standard deviations of gameplay metrics by condition.

Table 6: Gameplay Metrics by Condition

	Prime IA + VR	**Prime IA + No VR**	**Prime MW + VR**	**Prime MW + No VR**
Performance				
Mean	28.69	19.07	25.85	19.48
Std. Deviation	30.85	15.12	21.51	13.38

Interoceptive Awareness Manipulation Check. Anecdotal observations of participants in the study suggest that those primed for interoceptive awareness were very relaxed after the audio recording. On several occasions when the researcher returned to the room to start the game the participants would comment about how relaxed they felt and in a couple of cases were sound asleep or were startled by the door opening rustling them from a light slumber. On the other hand, participants in the priming for mind-wandering condition appeared and responded in a predictably more agitated manner.

It should be reiterated that we did not measure interoceptive awareness or mind-wandering immediately after priming, as that would have interfered with the priming. We did measure several factors (i.e., the scales above) immediately after 7 minutes of *Tetris Effect* play which could conceivably have been affected by the priming.

CHAPTER 5

RESULTS

Direct Effects of Experimental Manipulations on Quality of Attention

In order to examine H1a (Priming interoceptive awareness is associated with more interoceptive awareness during gameplay), RQ1a (Does gender moderate the effects of attentional priming on interoceptive awareness during gameplay?), H2a (VR display modality is associated with higher interoceptive awareness during gameplay), and RQ2a (Does gender moderate the effects of display modality on interceptive awareness during gameplay?), we conducted an analysis of variance (ANOVA) with attentional priming (i.e., interoceptive awareness or mind-wandering) and display modality (i.e., VR or HDTV) as the manipulated independent variables, gender as a fixed factor, and interoceptive awareness during gameplay as the outcome variable.

No main effects of the manipulated independent variables were significant, and none of the interaction effects were significant. Therefore, these results inform H1a, RQ1a, H2a, and RQ2a, offering no evidence that attentional priming, VR display modality, or gender impact interoceptive awareness during gameplay.

In order to examine H1b (Priming mind-wandering is associated with more mind-wandering during gameplay), RQ1b (Does gender moderate the effects of attentional priming on mind-wandering during gameplay?), H2b (VR display modality is associated with less mind-wandering during gameplay), and RQ2b (Does gender moderate the effects of display modality on mind-wandering during gameplay), we conducted an analysis of variance (ANOVA) with attentional priming (interoceptive awareness or mind-wandering) and display modality (VR or

HDTV) as the manipulated independent variables, gender as a fixed factor, and mind-wandering during gameplay as the outcome variable.

No main effects of the manipulated independent variables were significant. However, two of the interaction effects were significant and a third interaction effect approached significance.

*Modality*Priming Interaction:* A significant interaction effect was found for display modality (VR or HDTV) by attentional priming (mind-wandering or interoceptive awareness) conditions, $F(7, 120) = 4.311$, $p < 0.040$, $\eta_p^2 = 0.04$ (see Figure 2).

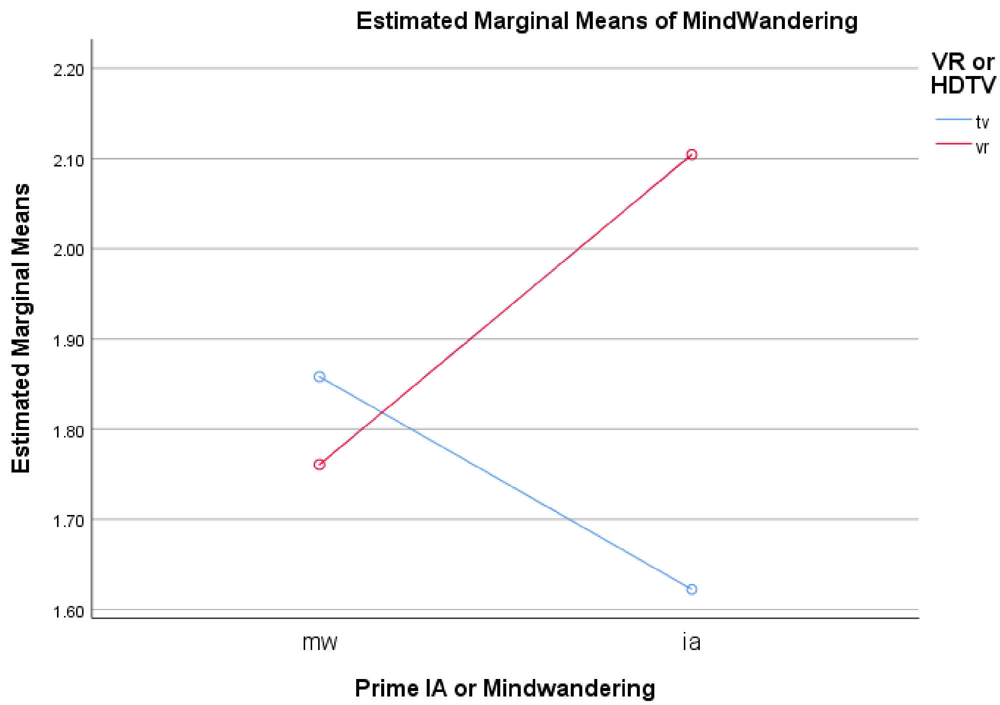

Figure 2: Mind-Wandering: Interaction Effect for Display Modality by Attentional Priming

For participants in the VR condition, priming interoceptive awareness increased mind-wandering during gameplay ($M = 2.11$, $SE = 0.13$), while priming mind-wandering decreased mind-wandering during gameplay ($M = 1.76$, $SE = 0.14$), but for participants in the HDTV condition, there was a smaller difference between priming interoceptive awareness and priming mind-wandering and that difference was in the opposite direction than what was found for VR display modality. For HDTV players, mind-wandering was lower when interoceptive awareness was primed (M = 1.62, SE = 0.14) and mind-wandering was higher when mind-wandering was primed (M = 1.86, SE = 0.15).

*Modality*Gender Interaction:* There was a significant interaction effect for gender and display modality for mind-wandering, $F(7, 120) = 9.071$, $p < 0.003$, $\eta_p^2 = 0.04$. Males in the VR condition reported lower mind-wandering during gameplay (M = 1.73, SE = 0.14), than did males in the HDTV condition (M = 1.96, SE = 0.15), but the results for females were opposite, with females in the VR condition reporting higher mind-wandering during gameplay (M = 2.14, SE = 0.13) than females in the HDTV condition (M = 1.52, SE = 0.14). See Figure 3.

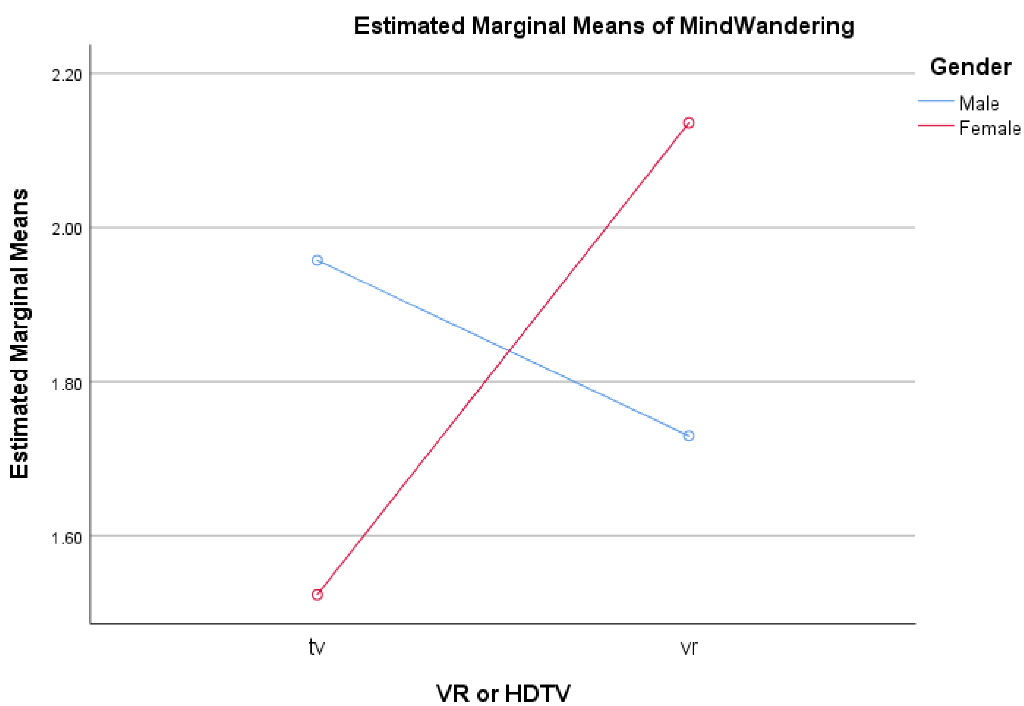

Figure 3: Mind-Wandering: Interaction Effect for Gender and Display Modality

*Modality*Priming*Gender*: the three-way interaction effect also approached significance, $F(7, 120) = 3.191$, $p < 0.077$, $\eta_p^2 = 0.04$. Among males, mind-wandering was always higher when playing in HDTV (primed for MW: $M = 1.93$, $SE = 0.23$; primed for IA: $M = 1.99$, $SE = 0.19$), than when playing in VR (primed for MW: $M = 1.66$, $SE = 0.19$; primed for IA: $M = 1.80$, $SE = 0.21$). See Figure 4. Among females, priming interoceptive awareness increased mind-wandering in VR (primed for MW: $M = 1.86$, $SE = 0.19$; primed for IA: $M = 2.41$, $SE = 0.17$), but had negligible impact on mind-wandering in the HDTV modality (primed for MW: $M = 1.79$, $SE = 0.18$; primed for IA: $M = 1.26$, $SE = 0.21$). See Figure 5.

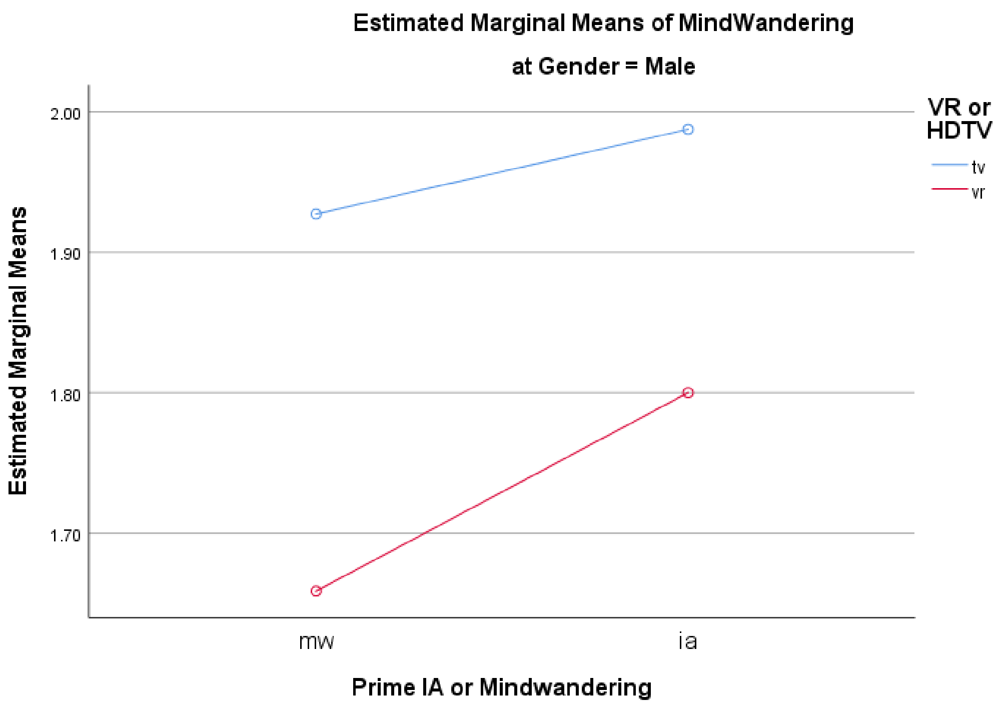

Figure 4: Mind-Wandering: 3-Way Interaction Between Display Modality and Priming by Gender for Males Only

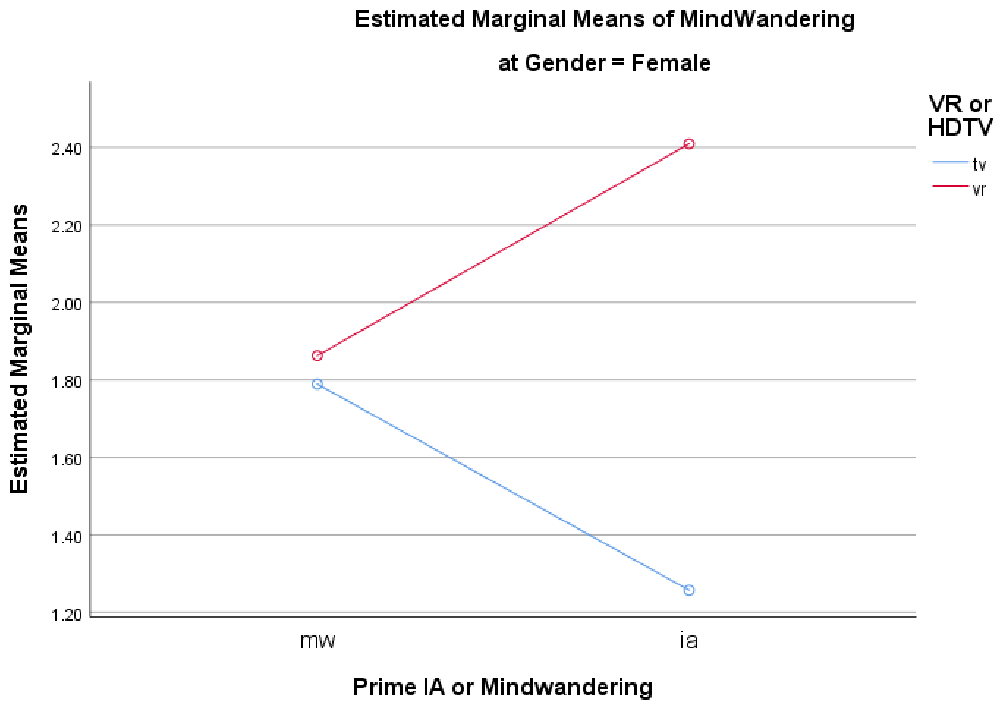

Figure 5: Mind-Wandering: 3-Way Interaction Between Display Modality and Priming by Gender for Females Only

Effects of Experimental Manipulations on Quality of Experience

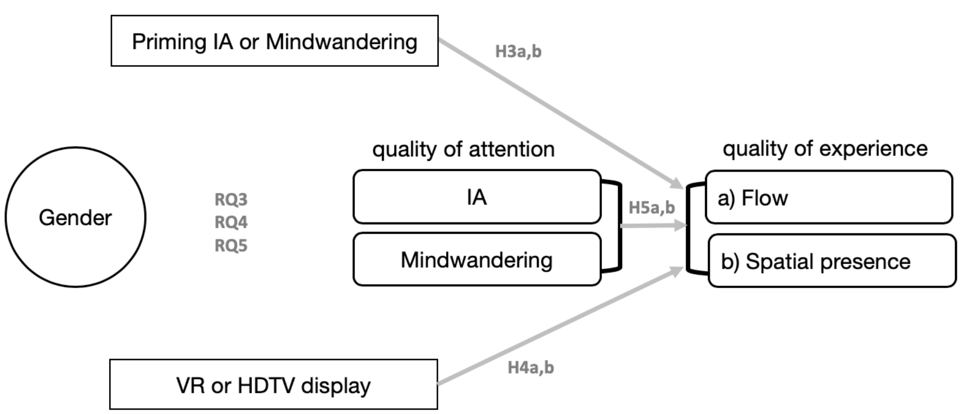

Figure 6: Visualizing Hypotheses and Research Questions

In order to examine H3a (Priming interoceptive awareness increases flow during gameplay), RQ3a (Do playing on a VR display or gender moderate the effects of attentional priming on flow during gameplay?), H4a (Playing a video game on a VR display increases flow during gameplay compared to playing on an HDTV monitor), RQ4a (Do attentional priming or gender moderate the effects of VR display on flow during gameplay?), H5a (More interoceptive awareness and less mind-wandering during gameplay are associated with higher flow), and RQ5a (Do playing on a VR display, attentional priming, or gender moderate the effects of quality of attention (interoceptive awareness and mind-wandering) on flow during gameplay?) we conducted an analysis of variance (ANOVA) with attentional priming (interoceptive awareness or mind-wandering) and display modality (VR or HDTV) as the manipulated independent variables, and flow as the outcome variable. Gender was included as a fixed factor. Quality of attention (mind-wandering and interoceptive awareness during gameplay) and spatial presence were included as co-variates.

The overall model for flow was significant: $F(10, 117) = 4.653$, $p < 0.000$. The direct effect for attentional priming on flow was not significant. The direct effect for VR display modality approaches significance: $F(10, 117) = 3.589$, $p < 0.061$, with participants in the VR display condition reporting more flow ($M = 5.30$, $SD = 0.87$) than those in the HDTV display condition ($M = 5.10$, $SD = 0.81$). Interoceptive awareness during gameplay shows a significant direct effect on flow: $F(10, 117) = 4.349$, $p < 0.039$, as does mind-wandering during gameplay: $F(10, 117) = 25.081$, $p < 0.000$. The association of spatial presence with flow approaches significance: $F(10, 117) = 3.652$, $p < 0.058$. None of the interaction effects were significant. Thus, playing Tetris Effect in VR, experiencing higher interoceptive awareness, experiencing less mind-wandering, and experiencing more spatial presence while playing are linked to a stronger experience of flow in *Tetris Effect*.

In order to examine H3b (Using a VR display increases spatial presence during gameplay), RQ3b (Do attentional priming or gender moderate the effects of display modality on spatial presence during gameplay?), H4b (Playing a video game on a VR display increases spatial presence during gameplay compared to playing on an HDTV monitor), RQ4b (Do attentional priming or gender moderate the effects of VR display on flow during gameplay?), and H5b (More interoceptive awareness and less mind-wandering during gameplay are associated with higher spatial presence), and RQ5b (Do playing on a VR display, attentional priming, or gender moderate the effects of quality of attention (Interoceptive awareness and mind-wandering) on spatial presence during gameplay?) we conducted an analysis of variance (ANOVA) with attentional priming (interoceptive awareness or mind-wandering) and display modality (VR or HDTV) as the manipulated independent variables, and spatial presence as the outcome variable. Gender was included as a fixed factor. Quality of attention (mind-wandering and interoceptive awareness during gameplay) and flow were included as co-variates.

The overall model for spatial presence was not significant, nor were any of the interaction effects. Only one variable, interoceptive awareness during gameplay emerged as significantly associated with spatial presence: $F(9, 118) = 10.384$, $p = 0.002$. Higher interoceptive awareness and higher flow were linked to more spatial presence.

Game Performance, Quality of Attention, and Quality of Experience

We conducted an analysis of variance (ANOVA) in order to examine RQ6 (How do gender, attentional priming (interoceptive awareness or mind-wandering), use of virtual reality versus a high-definition television, quality of attention (interoceptive awareness and mind-wandering), and quality of experience (flow and spatial presence) influence participants' game performance?). The dependent variable was game performance. Attentional priming (interoceptive awareness or mind-wandering) and display modality (VR or HDTV) were included as the manipulated independent variables. Gender was included as a fixed factor. Quality of attention (mind-wandering and interoceptive awareness during gameplay), spatial presence, and flow were included as co-variates.

The overall model for gaming performance is significant: $F(11, 115) = 4.183$, $p < 0.000$). Neither of the manipulated independent variables had a direct effect on gaming performance. The direct effect for gender was significant: $F(11, 115) = 18.127$, $p < 0.000$; covariates appearing in the model were evaluated at the following values: Mind-Wandering = 1.8740, IA = 2.9333, Spatial Presence = 3.4646, Flow = 5.1992. Males scored higher ($M = 30.2$, $SD = 22.0$) than females ($M = 17.3$, $SD = 14.9$). Mind-wandering during gameplay was a significant covariate with game performance ($F(11, 115) = 6.390$, $p < 0.013$), and higher flow was associated with higher scores ($F(11, 115) = 14.352$, $p < 0.000$). Interoceptive awareness during gameplay and spatial presence were not significant covariates. There was a significant interaction effect between gender and display modality: $F(11, 115) = 5.336$, $p < 0.023$. Males in the HDTV condition scored lower ($M = 23.41$, $SD = 15.99$) than males in the VR condition ($M = 36.09$, $SD = 24.99$) whereas for females there was negligible game performance differences between the HDTV condition ($M = 16.10$, $SD = 11.61$) and the VR condition ($M = 18.26$, $SD = 17.30$). See Figure 7.

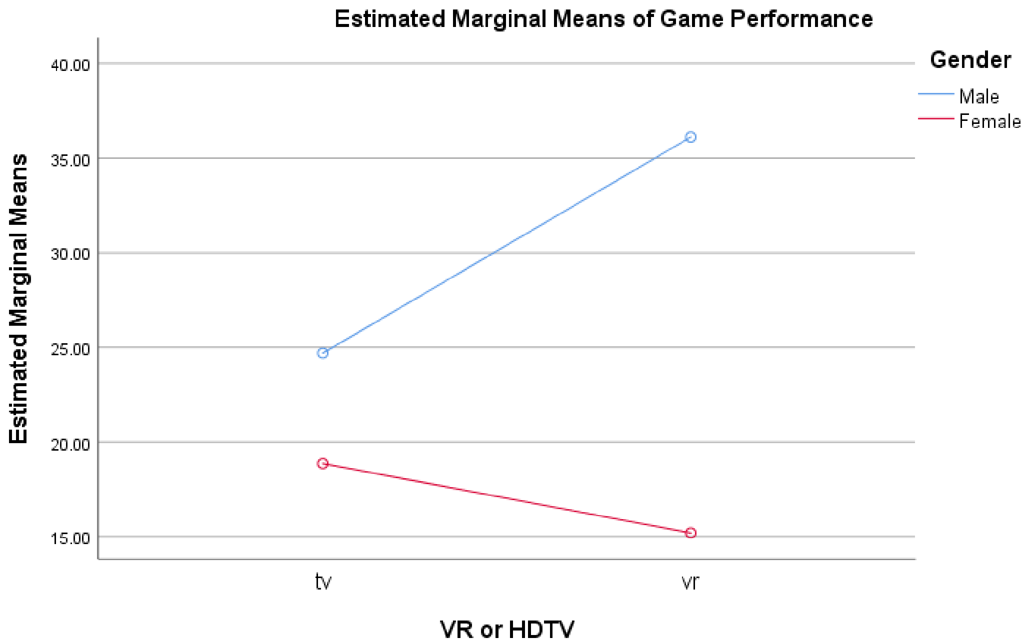

Figure 7: Game Performance: Interaction Effect Between Gender and Display Modality

The interaction between gender and attentional priming approached significance: $F(11,115) = 2.964$, $p < 0.088$; covariates appearing in the model were evaluated at the following values: Mind-Wandering = 1.8740, IA = 2.9333, Spatial Presence = 3.4646, Flow = 5.1992. Males primed for mind-wandering scored higher ($M = 33.61$, $SD = 19.39$) than males primed for interoceptive awareness ($M = 26.99$, $SD = 24.16$), whereas females primed for mind-wandering scored lower ($M = 14.03$, $SD = 11.56$) than females primed for interoceptive awareness ($M = 20.46$, $SD = 17.21$). In other words, playing in VR was beneficial for male game performance but had little impact on female game performance. Priming for interoceptive awareness was beneficial for female player performance and detrimental for male player performance. See Figures 8 and 9.

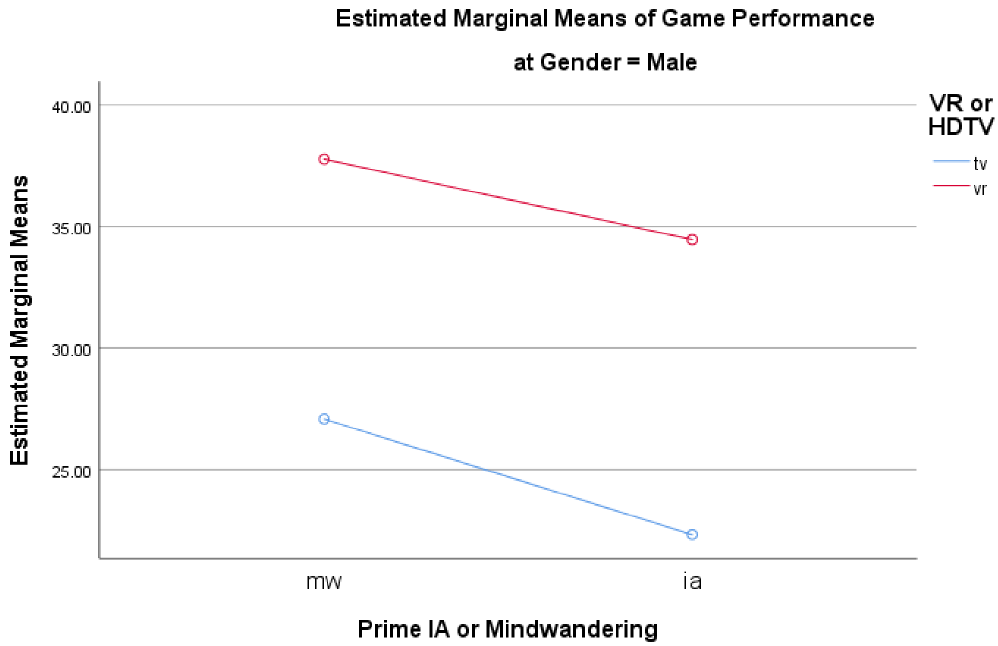

Figure 8: Game Performance: Interaction Between Display Modality and Priming by Gender for Males Only

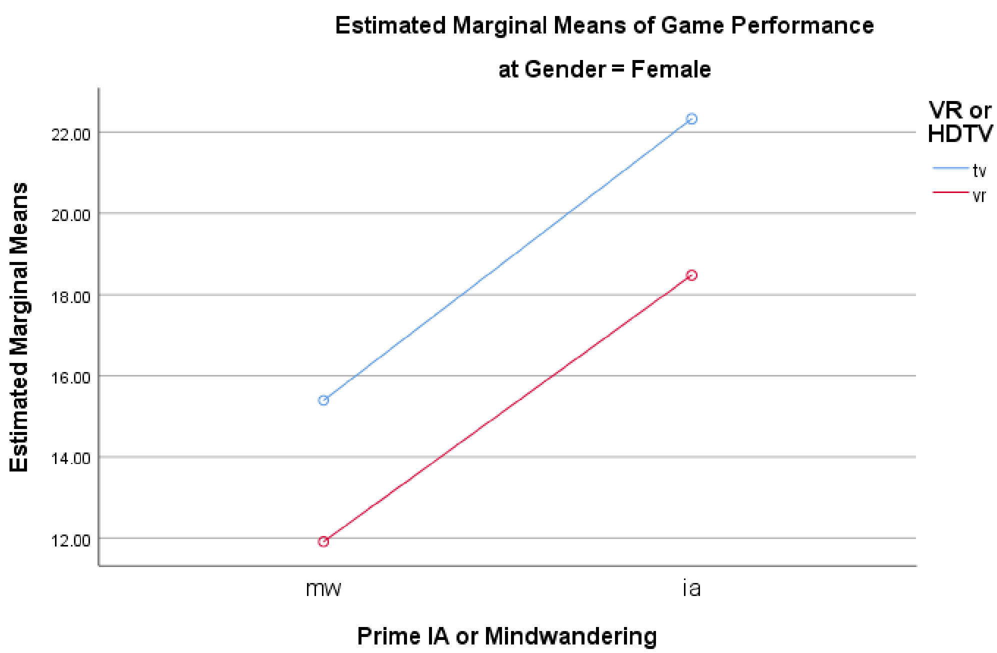

Figure 9: Game Performance: Interaction Between Display Modality and Priming by Gender for Females Only

Mediated Moderation

The preceding analyses point to interactions of gender with both display modality in relation to flow. The possible role of gender in a moderated mediation was examined.

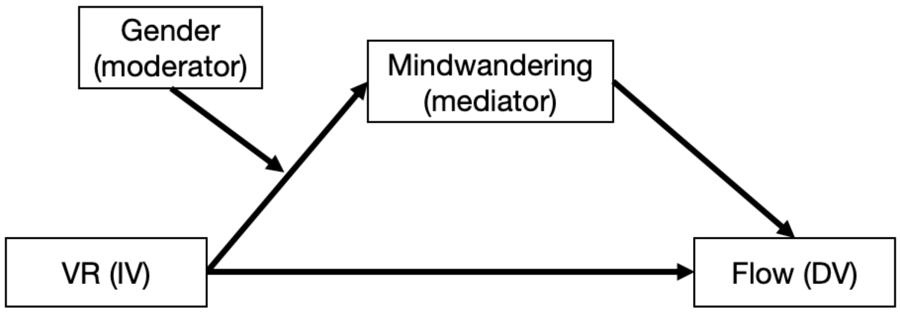

Figure 10: Gender as a Moderator

We tested the expectation for moderated mediation suggested by the results from H4 (The effect of VR display modality on flow — moderated by gender — is mediated by mind-wandering) by conducting a moderated mediation analysis (Hayes PROCESS, Model 7, 10000 bootstrapped samples) with flow as the outcome, VR display modality as the predictor, gender as the moderator, mind-wandering as the mediator, and attentional priming and interoceptive awareness as covariates. The index of moderated mediation was significant [LLCI: -0.64, ULCI: -0.14], with mind-wandering significantly mediating the effect of VR display on flow among females [LLCI: -0.47, ULCI: -0.09], but not among males [LLCI: -0.06, ULCI: 0.27]. Thus, H6 was supported for females but not males.

CHAPTER 6

DISCUSSION

The main goal of this manuscript was to establish relationships between traditional virtual worlds' quality of experience measures (flow and spatial presence) with quality of attention measures (interoceptive awareness and mind-wandering). The study was inspired by new research suggesting that flow state requires active attention (de Manzano et al., 2013; Harris, Vine, & Wilson, 2017c; Ulrich et al., 2014; Ulrich, Keller, Grön, 2016) and neuroscience research describing the active attention required for interoceptive awareness (Craig, 2009; Craig, 2014; Farb et al., 2015; Heeter, 2016; Heeter, Day, & Cherchiglia, 2020).

Interaction effects of gender were considered throughout the analysis, given the numerous gaming differences between males and females in previous literature (e.g., time spent playing, achievement orientation, genre preferences, playstyles; Caywood & Heeter, 2006; Greenberg et al., 2010; Hartmann & Klimmt, 2006; Heeter et al., 2011; Heeter & Winn, 2008; Klawe et al., 2002; Newzoo, 2017; Yee, 2006), and research's findings that gaming performance and virtual reality (VR) technologies are stereotypically masculine (Stanney, Fidopiastis & Foster, 2020), while interoceptive awareness is stereotypically feminine (Grabauskaitė, Baranauskas, & Griškova-Bulanova, 2017).

A relationship between flow, interoceptive awareness, and spatial presence was detected. Interoceptive awareness had a positive relationship with both flow and spatial presence, casting some light into the relationship between quality of attention and quality of experience. Specifically, higher interoceptive awareness and higher flow were related to more spatial presence in a play session of *Tetris Effect*, a puzzle video game. This is exciting because it seems like some of the underlying mechanisms that can enhance spatial presence are flow and interoceptive awareness. Moreover, if we can better understand what leads to increased spatial presence or flow, we can better facilitate the desirable experience of presence when playing a video game. The finding that increased feelings of interoceptive awareness were associated with higher feelings of spatial presence mirrors the only other study examining these two constructs (Heeter, Day, & Cherchiglia, 2020). The fact that both studies have found similar results using two different stimuli (i.e., a meditative virtual experience versus a puzzle game) does suggest that interoceptive awareness may be a meaningful facet of spatial presence. Neither study was designed to test whether the relationship is causal or correlational. The relationship between interoceptive awareness and spatial presence seems especially interesting in the current study considering that the stimuli, *Tetris Effect*, is a fairly simple puzzle game with no opportunities for the player to interact with the game environment. We do not know whether that relationship would be found in a game that included player interactions with the environment. Ultimately, if interoceptive awareness can bolster an individual sense of spatial presence, virtual designers and developers could use that knowledge to create a more engrossing experience.

Continuing to integrate a neuroscience perspective into virtual worlds' research, we found an exciting relationship between interoceptive awareness, mind-wandering, spatial presence, and flow. Specifically, experiencing higher interoceptive awareness, experiencing less mind-wandering, and experiencing more spatial presence while playing in VR are linked to a stronger experience of flow in *Tetris Effect*. Moreover, participants in the VR display condition reported more flow than those in the HDTV display condition. This finding supports the proposition that quality of attention should be incorporated as a possible aspect of flow theory, and provides more evidence that the state of flow requires purposeful, active attention even though it might feel effortless (de Manzano et al., 2010; Harris, Vine, & Wilson, 2017a; 2017c).

Diving into game performance, higher experience of flow was associated with better game performance in *Tetris Effect*; this was expected because flow has been reported to be conducive to high levels of performance across a variety of activities (Bakker, Oerlemans, Demerouti, Slot, & Ali, 2011; de Manzano et al., 2013; Fullagar, Knight, & Sovern, 2013; Perry, 1999; Nakamura & Csikszentmihalyi 2014; Sawyer, 1992). It should be noted that, up to a certain game speed, better performance does not necessarily mean being better at *Tetris Effect*, it simply means playing faster. This is important because participants only had seven minutes to play so some of the slower participants may have actually performed much higher given the benefit of time.

Gender was pivotal to understanding game performance differences observed among the study conditions. The findings are aligned with previous studies (Chang, 2017; Yang & Quadir, 2018). When considering display modality, playing in VR was beneficial for male game performance but had little impact on female game performance. One explanation is that the VR display limited visual distractions and provided the chance to try VR technology, and either or both factors may have helped boost male game performance. However, females may have found the VR display uncomfortable, nauseating, or distressing, interfering with game performance.

When considering attentional priming conditions, priming for interoceptive awareness was beneficial for female player performance and detrimental for male player performance. Gender stereotypes offer a possible explanation. For men, the interoceptive awareness priming condition might have been cognitively agitating, with the unintended effect of increasing mind-wandering (rumination). Males stereotypically focus attention externally, not on how they are feeling emotionally or physically. Maybe this form of mind-wandering prior to playing *Tetris Effect* is beneficial to men because it allows them to "set the stage" to perform at a higher level, since some of their minds might have been wandering about how to play *Tetris Effect*, remembering past experiences while playing, etc. For females, priming interoceptive awareness might have had a calming effect which in turn increased game performance, as the activity of focusing on their bodies and emotions allowed them to be in a more comfortable and safe space.

Curiously, when analyzing the direct effects of experimental manipulations on quality of attention, there was an unexpected finding in the VR condition. Priming interoceptive awareness increased mind-wandering during gameplay, while priming mind-wandering decreased mind-wandering during gameplay, which was opposite from our expectations and in contrast to the HDTV condition (i.e., for HDTV players, mind-wandering was lower when interoceptive awareness was primed and mind-wandering was higher when mind-wandering was primed). Interaction effects help explain these findings.

When looking through the lens of gender, females follow the same pattern as above, but for males it is even more confusing because mind-wandering is increased when priming for IA regardless of display modality. It appears that there are gender differences when considering display modality and priming for interoceptive awareness or priming for mind-wandering. Noting that females primed for interoceptive awareness reported more mind-wandering, they may have been more aware of their physical or emotional discomfort in VR, which may have triggered rumination (a form of mind-wandering), whereas females who were primed for mind-wandering were less aware of physical or emotional discomfort. On the other hand, paying attention to present moment emotions and bodily sensations may have been unfamiliar or uncomfortable for males, triggering mind-wandering.

Interestingly, considering only gender and display modality, overall males in the VR condition reported lower mind-wandering during gameplay than males in the HDTV condition, while females in the VR condition reported higher mind-wandering during gameplay than females in the HDTV condition. Perhaps virtual reality causes males to focus more on the gameplay because the external distractions are removed thus reinforcing the stereotypical desire to play games for achievement and eliminating unnecessary mind-wandering. Given that interoceptive awareness is a more feminine trait, perhaps priming interoceptive awareness in VR for females made them hyper aware of their body: greater sensitivity to bodily sensations in VR might have helped females notice how uncomfortable they were feeling, which then triggered mind-wandering about how uncomfortable VR feels, in turn causing them to mind-wander away from thoughts of the game. There could also be other complications that the researcher had not foreseen such as the VR headset smudging make-up or disrupting jewelry and hair accessories, which might have led to mind-wandering while using the VR headset.

Moderated mediation analysis confirmed and clarified the results discussed in the preceding paragraphs. Gender mediated the effect of VR display on flow. Specifically, mind-wandering significantly moderated the effect of VR display on flow among females but not among males.

Limitations & Future Research

This study does not come without limitations. One key limitation of this research is that the manipulations (both attentional priming and display modality) often had limited or no measurable impact. The current study was the first time this method of priming interoceptive awareness and priming mind-wandering was used. By definition, priming is supposed to happen immediately prior to the experience the priming is intended to influence – in this case, playing *Tetris Effect*. In hindsight, it would have been useful to conduct a pretest measuring the immediate effects of priming. In other words, what were the IAVW and MWVW scores immediately after priming? And if the expected increases occurred, how long did they last? Perhaps the priming should be repeated halfway through gameplay. These are important considerations for future studies that include priming quality of attention. In also seems prudent for designers and researchers to be more considerate of the unique nature of both genders and delve deeper into the affordances that different display technologies offer to both males and females. Perhaps the priming experience itself needs to be gender specific as well or carefully designed in such a way to elicit a positive response for both genders by focusing in different cues.

The nature of *Tetris Effect* may have mitigated quality of attention and quality of experience outcomes. VR and HDTV conditions differed only in whether participants wore a VR headset or looked at an HTDV monitor. This in itself may have been a limitation when considering aspects of virtual worlds research. The most glaring feature of *Tetris Effect* is that it offers almost zero player interactivity which could have impacted the spatial presence findings. Also, the field-of-view for *Tetris Effect* in VR is almost identical to non-VR which might have also influenced spatial presence. Future research could utilize a game more likely to elicit a strong spatial presence response.

An important limitation is that all of the constructs were measured using pre-post self-report data (except game performance) and multiple points of data collection were not used for each one of the constructs. It would be fascinating to collect physiological data during gameplay (e.g., fMRI, EEG) to be able to observe neural network activation throughout gameplay.

Physiological data would provide much more detail about player experiences and also could be compared to self-report measures.

CHAPTER 7

FINAL REMARKS

The current study sought to determine if there is a connection between quality of attention and quality of experience. Interoceptive awareness, mind-wandering, flow, and virtual world's spatial presence were studied in the context of a digital video game. Specifically, the project sought to better understand the mechanisms that underly entering the flow state and how attentional priming and quality of attention can impact feelings of flow and spatial presence. Two new scales were designed and utilized to measure the recalled experience of interoceptive awareness and mind-wandering while playing a digital video game.

Our results suggest that higher interoceptive awareness and higher flow are linked to more spatial presence. The VR condition was able to elicit higher feelings of flow when compared to the HDTV display condition. Also, playing *Tetris Effect* in VR, experiencing higher interoceptive awareness, experiencing less mind-wandering, and experiencing more spatial presence while playing are linked to a stronger experience of flow in *Tetris Effect*. Gender interactions were found, providing insight into how men and women approach playing video games in VR and non-VR environments, how they perceive flow and spatial presence, and how they are influenced by interoceptive awareness and mind-wandering. Game performance was higher for men in VR, while for women priming for interoceptive awareness was able to boost their game performance.

This research is the first step towards introducing interoceptive awareness and mind-wandering into both flow theory and virtual world studies. The encouraging results indicate value in continuing to research quality of attention and its relationship to quality of experience.

APPENDICES

APPENDIX A: PS4, PSVR, TETRIS EFEECT & GAME CAPTURE CARD

The PlayStation® 4 video game console coupled with the PlayStation® VR headset was utilized to play the video game *Tetris Effect*. The participants that played the game without a virtual reality headset used a standard 42” high-definition television.

Figure 11: PlayStation® 4 Console

Figure 12: PlayStation® VR Headset

Figure 13: *Tetris Effect* Game Box

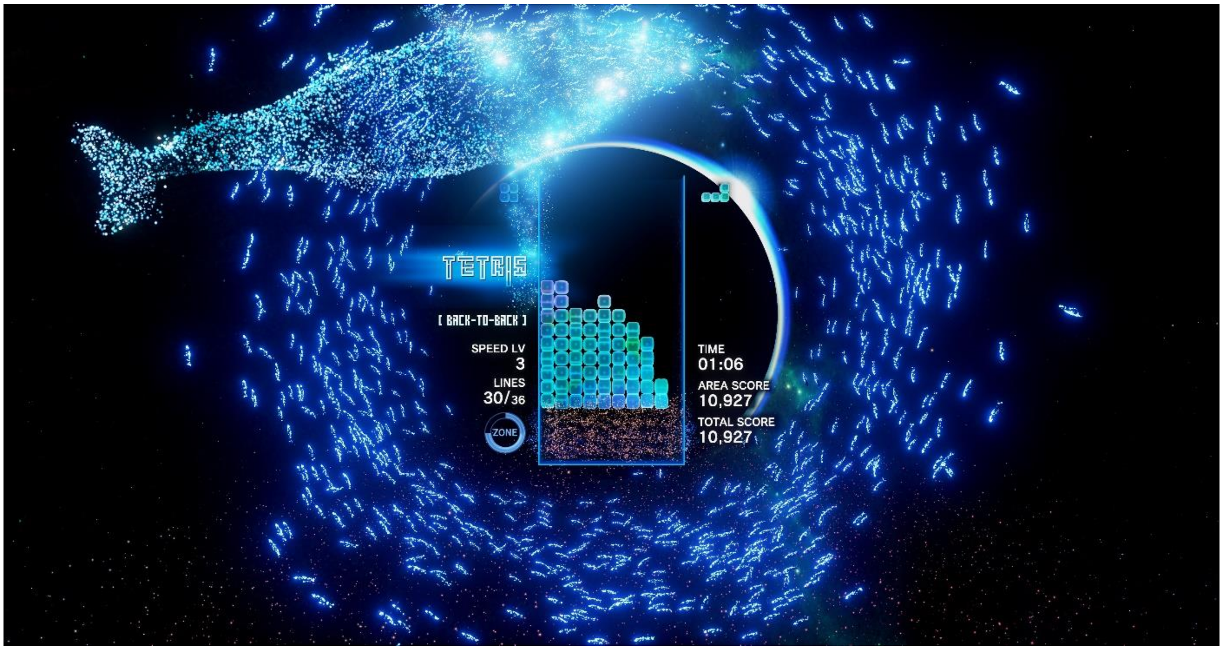

Figure 14: *Tetris Effect* Gameplay

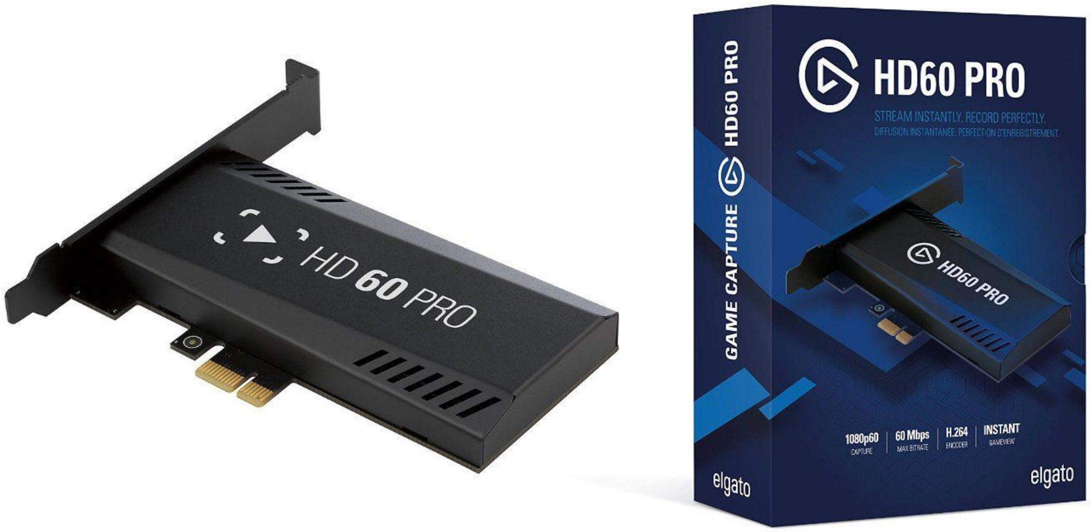

Figure 15: Elgato Capture Card

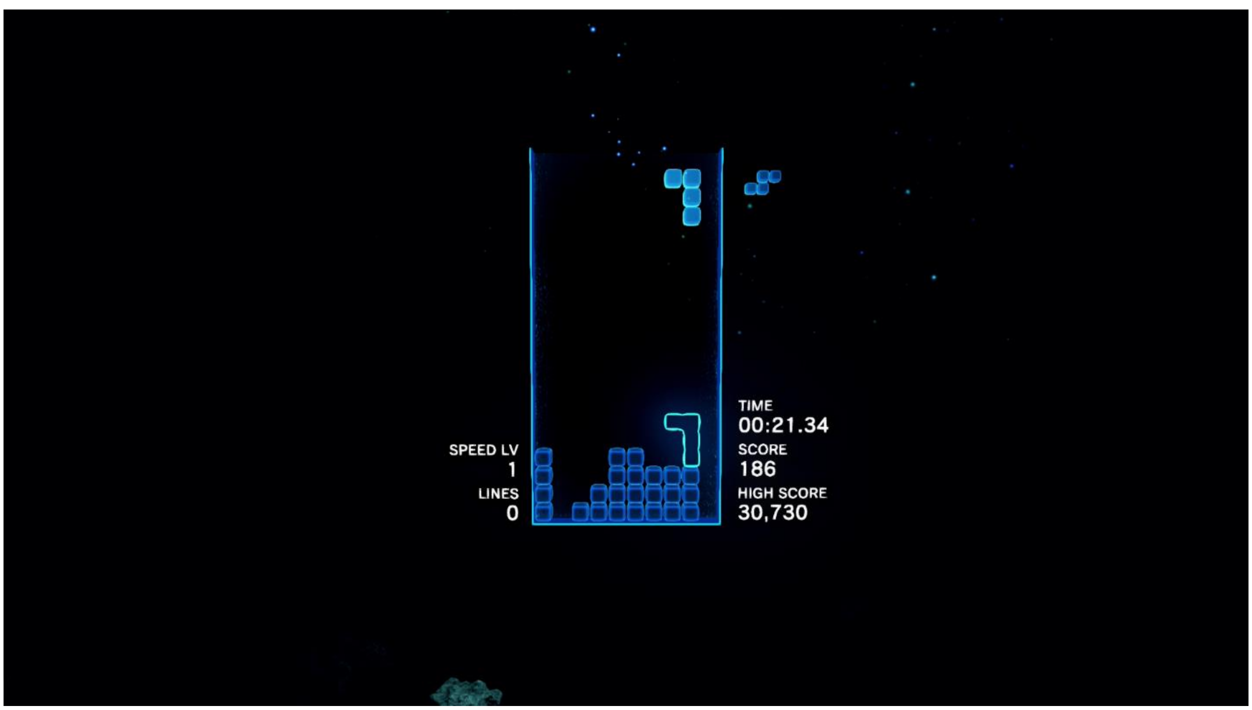

Figure 16: *Tetris Effect* Gameboard with HDTV

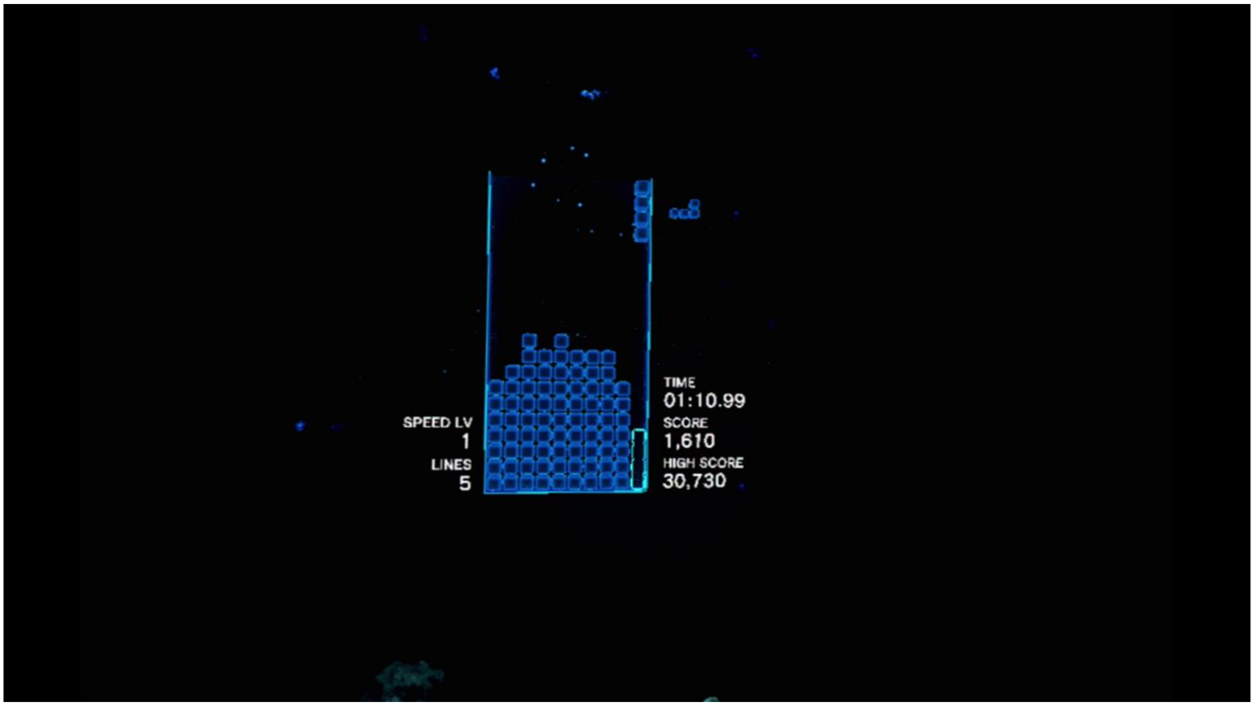

Figure 17: *Tetris Effect* Gameboard with VR

APPENDIX B: PRIMING IA SCRIPT

We're going to take 3 minutes to relax before you start playing the game.

Sit comfortably with your hands resting in your lap, palms down.

Have your eyes closed.

Bring your attention to your body.

Notice how you feel.

Bring your attention to your shoulders.

Gently raise your shoulders, then lower them.

Feel your hands where they are resting.

Feel where your legs are touching the chair.

Feel your feet resting on the floor.

Lean a little bit forward, then a little bit back.

Continue to move gently back and forth to find the point where you feel the most stable.

Lean a little bit left, then a little bit right.

Continue to move gently to either side to find the point where you feel the most stable.

Now bring your attention to your breathing.

Notice how you feel as you inhale.

And as you exhale.

Exhale here.

As you inhale, bring your hands into a gentle fist.

As you exhale, relax your hands.

Inhale, bring your hands into a gentle fist.

Exhale, relax your hands.

Notice how you feel.

Gently bring your awareness back.

Gently open your eyes.

Imagine or have a sense that you are holding onto a mug or a cup with both hands. The cup is full of kindness. It's the perfect temperature.

Have a sense of how it feels to hold the cup in your hands.

Now hold the cup near your face.

Inhale kindness. Pause.

Exhale, kindness spreads throughout your system. Pause.

Total length: ~ 3 minutes

APPENDIX C: SCALES

Flow Short Scale

Items from the 7-point Likert FSS (Engeser & Rheinberg, 2008).

Items were rated from 1 “not at all” to 7 “very much.”

1. I felt just the right amount of challenge.
2. My thoughts/activities ran fluidly and smoothly.
3. I did not notice time passing.
4. I had no difficulty concentrating.
5. My mind was completely clear.
6. I was totally absorbed in what I was doing.
7. The right thoughts/movement occurred of their own accord.
8. I knew what I had to do each step of the way.
9. I felt that I have everything under control.
10. I was completely lost in thought.

The Spatial Presence Experience Scale

Items from the 5-point Likert SPES (Hartmann et al., 2016).

Items were rated from 1 “I do not agree at all” to 5 “I full agree.”

1. I felt like I was actually there in the environment of the presentation.
2. It seemed as though I actually took part in the action of the presentation.
3. It was as though my true location had shifted into the environment in the presentation.
4. I felt as though I was physically present in the environment of the presentation.
5. The objects in the presentation gave me the feeling that I could do things with them.
6. I had the impression that I could be active in the environment of the presentation.
7. I felt like I could move around among the objects in the presentation.
8. It seemed to me that I could do whatever I wanted in the environment of the presentation.

Interoceptive Awareness for Virtual Worlds

Items from the 6-point Likert MAIA-2 (Mehling, 2018).

Items were rated from 0 "Never" to 5 "Always."

Items 5, 6, 7, 8, 9, 10, 11, 12, and 15 are reverse scored.

Items marked with [IAVW] make up the singular IA scale informed by previous research (Heeter, Day, & Cherchiglia, 2020).

1. When I was tense I noticed where the tension was located in my body.
2. I noticed when I was uncomfortable in my body.
3. I noticed where in my body I was comfortable.
4. I noticed changes in my breathing, such as whether it slowed down or sped up. [IAVW]
5. I ignored physical tension or discomfort.
6. I distracted myself from sensations of discomfort.
7. When I felt pain or discomfort, I tried to power through it.
8. I tried to ignore pain.
9. I pushed feelings of discomfort away by focusing on something.
10. When I felt unpleasant body sensations, I occupied myself with something else so I didn't have to feel them.
11. When I felt physical pain, I became upset.
12. I stated to worry that something was wrong if I felt any discomfort.
13. I noticed an unpleasant body sensation without worrying about it.
14. I stayed calm and didn't worry when I had feelings of discomfort or pain.
15. When I was in discomfort or pain I couldn't get it out of my mind.
16. I paid attention to my breath without being distracted by things happening around me.

17. I maintained awareness of my inner bodily sensations.
18. I paid attention to my posture. [IAVW]
19. I returned awareness to my body when I got distracted. [IAVW]
20. I refocused my attention from thinking to sensing my body. [IAVW]
21. I could maintain awareness of my whole body even when a part of my is in pain or discomfort. [IAVW]
22. I was able to consciously focus on my body as a whole. [IAVW]
23. I noticed how my body changed during the activity. [IAVW]
24. I could feel in my body when something was wrong. [IAVW]
25. I noticed my body felt different after the activity. [IAVW]
26. I noticed that my breathing became free and easy. [IAVW]
27. I noticed how my body changed when I felt positive emotions. [IAVW]
28. If I felt overwhelmed, I could find a calm place inside. [IAVW]
29. When I brought awareness to my body I felt a sense of calm. [IAVW]
30. I used my breath to reduce tension. [IAVW]
31. When I got caught up in thoughts, I calmed my mind by focusing on my body/breathing. [IAVW]
32. I listened for information from my body about my emotional state. [IAVW]
33. I took time to explore how my body felt. [IAVW]
34. I listened to my body to inform me about what to do.
35. I was at home in my body.
36. I felt my body was a safe place.
37. I trusted my body sensations.

Mind-Wandering for Virtual Worlds

Items from the 6-point Likert MWQ (Mrazek, Phillips, Franklin, Broadway, & Schooler, 2013). Items were rated 0 “Almost Never” to 5 “Almost Always”

6. I have difficulty maintaining focus on simple or repetitive work.
7. While reading, I find I haven’t been thinking about the text and must therefore read ita gain.
8. I do things without paying full attention.
9. I find myself listening with one ear, thinking about something else at the same time.
10. I mind-wander during lectures or presentations.

The MWQ was modified to create the Mind-Wandering for Virtual Worlds (MWVW) scale:

6. I had difficulty maintaining focus on the game
7. During gameplay, I had trouble maintaining my attention on what I needed to pay attention to.
8. I played the game without paying full attention.
9. I found myself playing and thinking about something else at the same time.
10. My mind wandered while playing.

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