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All or Nothing: The influence of hyperactivity and inattention on perceived flow engagement and time distortion during video game play.

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Thesis Declaration

This Thesis is entirely my own work, and has not been previously submitted to this or any other third level institution.

Signed:

Date:

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I would thank my main supervisor, Dr Liam Challenor, for assisting me in the most professional way and providing support that made me feel safe and empowered. Any future student to have Liam in as their supervisor can consider themselves lucky. Second, I want to thank my co-supervisor Dr Tom Burke for providing invaluable input, especially in the early stages of the study which helped shape various parts of the experimental design.

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Abstract

ADHD has long been associated with negative aspects of daily functioning, and few investigations have investigated the potentially positive aspects of the neurological condition. However, studies suggest individuals with ADHD tendencies are better are dealing with urgent threats, possess increased sensitivity for sound-colour impressions, and are inclined to enter a state hyper focus in situations that interest them or capture their full attention. Specifically, self-reported ADHD symptoms have been associated with self-reported scores of hyper focus scales. In turn, hyper focus is a concept closely related to flow theory; rationalizing an investigation into the relationship between ADHD and flow engagement. ADHD has furthermore been associated with increased screen-time and amplified risk for video game addiction. Hence, this study aimed to investigate the influence of hyperactivity/impulsivity and inattention (components of ADHD) on self-reported flow and time distortion. Forty-eight (N = 48) adult participants were recruited online for the purpose of completing an ASRS Scale, play Tetris during three temporally separated intervals, estimate the amount of time played they had played after each interval, and complete the Flow Short scale. Two independent t-tests indicated no significant effects of hyperactivity/impulsivity or inattention on self-reported flow, but significant effects on time distortion. Similarly, two Mann Whitney U tests indicated no significant effects on self-reported flow, but significant effects on time distortion. Conclusively, the findings suggested that, during video game play, hyperactivity/impulsivity and inattention significantly distort our capacity for temporal estimation, which is a key component of flow. However, no significant differences were found in relation to self-reported flow scores. Future studies of similar nature are recommended to employ a sample size of N = +100, conduct the study offline in a controlled environment, and include additional outcome variables such as eye-tracking for increased inter-rater reliability.

Introduction

Background and rationale for research

The video game industry grows exponentially each year, and accounted for $43.8 Bn global revenue in 2018 (Baltezarević, Baltezarević, & Baltezarević, 2018). One reason behind the popularity of video games springs from their capacity to induce flow states (Admiraal, Huizenga, Akkerman, & Ten Dam, 2011; Cowley, Charles, Black, & Hickey, 2008a; Sherry, 2004), and satisfy psychological needs (Ryan, Rigby, & Przybylski, 2006). Up to 23% of people who play video games report symptoms of addiction, but individuals diagnosed with the neurodevelopmental condition ADHD have been found to be at increased risk for developing problematic play behaviours (Mathews, Morrell, & Molle, 2019). Cognitive impairments such as behavioural inhibition, self-regulation, and self-control commonly found with ADHD-diagnosed individuals may be causal factors driving this increased risk for addiction. However, research further states that ADHD-diagnosed individuals are able to hyper focus if interested in something, causing increased levels of concentration and focus. In addition, hyper focus can be argued as similar to flow (Csikszentmihalyi, 1997a; Nakamura & Csikszentmihalyi, 2014), and flow is regarded as an intrinsically motivating psychological experience. Hence, perhaps individuals with ADHD symptoms tend to experience flow states more intensely than people without; making relevant an investigation into the relationship between ADHD symptomatology and video game flow states.

Attention-Deficit Hyperactivity Disorder (ADHD)

Attention Deficit-Hyperactivity Disorder is a relatively common neurodevelopmental condition stemming from genetic predisposition, associated with multiple cognitive impairments and difficulties in daily functioning (Makris, Biederman, Monuteaux, & Seidman, 2009). Adults with ADHD, compared to healthy individuals, have been found to reveal significant differences in selective attention (L Tucha et al., 2008),

divided attention (Woods, Lovejoy, & Ball, 2002), sustained attention (Johnson et al., 2001; Lara Tucha et al., 2017), working memory (Alderson, Kasper, Hudec, & Patros, 2013), planning and problem solving (Lara Tucha et al., 2011), cognitive flexibility (Halleland, Haavik, & Lundervold, 2012), inhibition and impulse control (Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010). Meta-analysis found inhibition, working memory, cognitive flexibility, and fluency skills to be the most impaired of cognitive abilities (Alderson et al., 2013; Boonstra et al., 2010). Individuals with ADHD have furthermore been associated with functional impairments in social functioning, academic achievements, occupational attainment, self-concept, quality of life, and wellbeing (Agarwal, Goldenberg, Perry, & Ishak, 2012; Canu & Carlson, 2007; Diamantopoulou, Rydell, Thorell, & Bohlin, 2007; Fergusson, Lynskey, & Horwood, 1997; Kok, Groen, Fuermaier, & Tucha, 2016; Kooij et al., 2010).

Based on a systematic review of geo-targeted studies, the worldwide prevalence of ADHD is 5.29% (95% CI = 5.01 – 5.56); growing yearly but with large geographical variation (Polanczyk, De Lima, Horta, Biederman, & Rohde, 2007). Hence, an investigation into not only the negative aspects of ADHD, but also the positive aspects, could be motivated to provide a more balanced understanding of the condition.

As suggested, a majority of ADHD research to date has been focused on investigating and outlining the negative impact on daily functioning. However, an old study by Glickman & Dodd (1998) found that individuals with ADHD are better at dealing with urgent tasks. Findings such as these have led to suggestions genetic predispositions to ADHD evolved due to a superiority in dealing with immediate threat and danger, leading to an increased chance for survival (Hartmann, 1997). Further research suggests that ADHD-diagnosed individuals show heightened awareness of incoming stimuli such as sound and colour (Ruel, 1997), leading improved capacity for detecting threat, but also to a potentially increased sensitivity to the abundance of sound-colour impressions in video games. Research suggests that ADHD-diagnosed individuals consume significantly more screen-time than non-ADHD peers (Acevedo–Polakovich, Lorch, & Milich, 2005; Swing, Gentile, Anderson, & Walsh, 2010). One

reason for this may be that ADHD-populations experience more positive affect while playing video games than non-ADHD populations, as found via both self-report measures and eye-tracking studies (Milman, 2017). It may also be connected to Ruel's (1997) theory of increased sensitivity for sound-colour impressions. Research has also shown that inattentive and hyperactive ADHD populations score higher in self-reported video game usage compared to non-diagnosed populations, (Yoo et al., 2004).

Hyper focus

Research also suggests that, although often struggling with concentration difficulties, individuals with ADHD are able to attain extremely high levels of concentration if they engage in something they find interesting (Hansen, 2017). This type of concentration is referred to as hyper focus, and is argued to be highly context-dependent, especially concerning individuals that display ADHD symptoms (Hupfeld, Abagis, & Shah, 2019). A working definition of hyper focus based on interviews with ADHD-diagnosed persons, is described as: "*A state of heightened, intense focus of any duration, which most likely occurs during activities related to one's school, hobbies, or "screen time" (i.e., television, computer use, etc.); this state may include the following qualities: timelessness, failure to attend to the world, ignoring personal needs, difficulty stopping and switching tasks, feelings of total engrossment in the task, and feeling "stuck" on small details*'' (Hupfeld et al., 2019, p. 2). The definition sounds similar to the concept of flow; aligning in areas such as timelessness, lack of attention to physical surroundings, and immersive aspects (Csikszentmihalyi, 1997a; Jackson & Marsh, 1996; Klinger, 1978; Nah, Eschenbrenner, Zeng, Telaprolu, & Sepehr, 2014; Nakamura & Csikszentmihalyi, 2014; Sherry, 2004). Hence, one may begin to wonder if hyper focus and flow overlap significantly in its psychological effect and experience. The study by Hupfeld et al (2019) found self-reported ADHD symptoms to be significantly associated with self-reported scores in hyper focus questionnaires. This suggests that ADHD-diagnosed individuals may be more inclined to enter a state of hyper focus than non-diagnosed individuals. Perhaps, a similar

effect would occur when associating ADHD symptoms with flow engagement in a context that most people find intrinsically motivating - such as a video game.

Flow Theory

Flow theory was first developed in an attempt to investigate why some people tend to engage so intensely in projects or activities without any external rewards as the main goal. The sensation of flow was conceptualized by Csikszentmihalyi (1992, 1997b) as the key driver of intrinsic motivation that caused people to work so passionately on their hobbies/activities/professions. Part of Csikszentmihalyi's theory were nine components: (1) Balance between the perception of capacity/skill to perform the task, and the challenge of the task; (2) Intuitive awareness and action; (3) Clear goals; (4) Immediate and clear feedback on progress; (5) High degree of concentration; (6) Positive feeling of being in control (7) Loss of self-awareness; (8) Altered time-perception; (9) Autotelic experience (Csikszentmihalyi, 1997a; Nakamura & Csikszentmihalyi). The theory has, however, been built on since its original development. The components have been divided into categories of pre-conditions and psychological outcomes (Csikszentmihalyi & Hunter, 2014; Hamari & Koivisto, 2014); some required to facilitate the flow experience (1, 2, and 4) and others regarded as psychological outcomes resulting from the facilitation of flow (3, 5, 6, 7, and 8).

Subjective measurement of flow

Quantitative measurement of flow has been attempted using validated and tested self-report scales, such as the Flow State Scale (Jackson & Marsh, 1996), The Activity Flow State Scale (Payne, Jackson, Noh, & Stine-Morrow, 2011), the Dispositional Flow Scale-2 (Jackson & Eklund, 2002), and finally the Flow Short Scale (Rheinberg, Vollmeyer, & Engeser, 2003); all of which have propelled academic understanding of which activities that typically create flow states.

These measurement tools contain the same limitation that most self-report surveys struggle with; response bias. This includes biases such as social desirability (Arnold, 1981; Van de Mortel, 2008), and order effects (Strack, 1992). Luckily, techniques have been developed to deal with these biases. Social desirability can be counteracted by using lie scales, as in the case of Eysenck's original study of personality traits (Eysenck & Eysenck, 1984). In addition, order effects can be counteracted through counterbalancing (Bradley, 1958). Another limitation of using self-report measurement is that the measurement normally must be conducted after the activity itself, and not during. Hence, the sensation of e.g. flow may become distorted and misrepresented by the participant.

Objective measurement of flow

Because of the aforementioned limitations, studies have attempted to obtain objective measures of flow, as a complement to the subjective measures. A smart way to attain this is to attempt measuring a capacity that is hampered or enhanced due to flow, leading to reliance on capacity, which is less biased than self-perceived flow. For example, one component indicates that people immersed in flow tend to experience an altered perception of time, leading to a difficulty estimating how long they have been engaging in the activity. A study by Tucha et al (2008) found that participants immersed in flow tended to estimate time spent in the activity as less than it actually was. Hence, using this technique, one could then attempt to correlate self-reported flow with the difference between Estimated Time and Actual Time, leading increased inter-rater reliability and potentially a triangulated outcome. This technique would require the participant to be unaware of the actual time that has passed; therefore, participants must be instructed not to look at their clock or have their clock removed from them.

Temporal estimation

The underlying area of research for a temporal estimation task resides in time perception; a human ability largely unaffected by sensory modalities and heavily influenced by cognitive processes such as memory and attention (Roeckelein, 2008). Studies have been using temporal estimation tasks to investigate attention and memory processes in Parkinson's disease (Pastor, 1992) and schizophrenia (Davalos, Kisley, & Ross, 2003). Csikszentmihalyi's 8th component, altered time perception, is argued by various researchers as multi-faceted and can be influenced by a variety of activity factors such as pleasantness, degree of urgency, variety of the task (Soltanlou, Nazari, Vahidi, & Nemati, 2020), and how busy the person is (Seya & Mori, 2018). Furthermore, prior experience has suggested as a key influence on time perception, as a study found expert gamers to be more accurate in estimating time than novice gamers (Rau, Peng, & Yang, 2006). Another study recently also found that time perception can be influenced by prior task experience (Tobin & Grondin, 2015), in support of the study by Rau et al (2006).

Conclusively, time estimation tasks have been involved in multiple accredited clinical studies for evaluating differences in distorted time perception, and hence one may regard the task as a suitable objective measurement for the 8th component in Csikszentmihalyi's Flow Theory. Furthermore, literature suggests prior activity experience to be a key influence on degree of distorted time perception (Rau, Peng, & Yang, 2006; Tobin & Grondin, 2015).

Video games

Video games have been known for their capacity to create immersive, flow-facilitative experiences. They have also been strongly associated with the concept of flow for many years, and researchers believe it to be a potent vice for generating flow states (Chen, 2007; Cowley, Charles, Black, & Hickey, 2008b; Lee, Aiken, & Hung, 2012; Sherry, 2004). Furthermore, video games are known to satisfy most

components of flow; as they are often designed to balance the skill-challenge equilibrium, provide feedback on progress, maintain concentration levels, and create an interesting virtual environment to play around in. The popularity of video games has not only been connected to concepts such as flow, but also the satisfaction of psychological needs (Ryan, Rigby, & Przybylski 2006).

Video games appear to be especially attractive for individuals that show ADHD symptoms. Perhaps this is due to their lack of behavioural self-control; but another factor may be a difference in the intensity of flow engagement experienced by individuals with ADHD symptoms compared to those with less symptoms.

Rationale

As suggested in earlier paragraphs, hyper focus has been associated with ADHD tendencies (Hupfeld et al., 2019). In addition, and considering the abundant similarities between flow and hyper focus - perhaps flow has a similar connection to ADHD tendencies. In addition, flow sensations elevate dopamine levels in the brain (de Manzano et al., 2013), similar to the effect of ADHD medicine (Volkow et al., 2012).

Hence, one may argue that flow states, ubiquitously associated with video games, may act as a temporary remedy for attention difficulties.

Conclusively, we do not know enough about the connection between ADHD and flow states, although there are hints from evolutionary research (Glickman & Dodd, 1998; Hartmann, 1997; Ruel, 1997), hyper focus research (Hupfeld et al, 2019), screen-time research (Acevedo–Polakovich, Lorch, & Milich, 2005; Swing, Gentile, Anderson, & Walsh, 2010; Milman, 2017; Yoo, 2014) and neurological reports (de Manzano et al., 2013; Hansen, 2017). In addition, video games are known for their ability to induce flow states (Chen, 2007; Cowley, Charles, Black, & Hickey, 2008b; Lee, Aiken, &

Hung, 2012; Sherry, 2004). This adds a convincing rationale for an investigation into ADHD symptomatology, flow theory, and gaming.

Based on the theoretical foundation proposed, this study aimed to investigate the influence of Hyperactivity/Impulsivity and Inattention on perceived flow engagement and time distortion. Forty-eight (N = 48) participants were recruited online, and directed to a Microsoft Forms link where all the required information (consent, information sheet, test material, debrief) was located. Hyperactivity/Impulsivity & Inattention was measured using the ASRS Scale (Kessler, 2005), perceived flow engagement was measured using the Flow Short Scale (Rheinberg, 2003), and time distortion was derived using a time estimation task that will be detailed in the materials section. The hypotheses are stated below.

Hypothesis 1

Individuals who score highly in Hyperactivity/Impulsivity will produce significantly higher mean self-reported flow scores, than low scoring individuals.

Hypothesis 2

Individuals who score highly in Inattention will produce significantly higher mean self-reported flow scores, than low scoring individuals.

Hypothesis 3

Individuals who score highly in Hyperactivity/Impulsivity will produce significantly less seconds estimated on average than low scoring individuals.

Hypothesis 4

Individuals who score highly in Inattention will produce significantly less seconds estimated on average than low scoring individuals.

Method

Design

This study was conducted using an experimental between-groups design aimed to investigate the effect of Hyperactivity/Impulsivity (HI) and Inattention (IA) on perceived flow engagement and time distortion. Specifically, the study compared differences between high-scoring individuals and low-scoring HI and IA on self-reported flow scores and differences in number of seconds estimated in the Time Estimation Task. The differences were statistically investigated using an independent samples t-test and a Mann-Whitney U test.

The independent variables (IV's) were HI and IA, each containing two levels (High, Low), obtained from self-reported scores in the ADHD Self-Report Scale (Kessler et al., 2005). Participants scoring above the median of the variable in question were allocated to the high-scoring group, and participants scoring below the sample median will be allocated to the low-scoring group. Hence, there were four IV levels under investigation: HI High, HI Low, IA High, and IA Low.

The dependent variables (DV's) were self-reported flow scores in the Flow Short Scale (Rheinberg, 2003) and number of seconds estimated in the Time Estimation Task.

Participants

Forty-eight (N = 48) participants were recruited from online sources such as Steam Forum, Facebook, LinkedIn, and from the Institute of Art, Design, and Technology. All participants stated their age as above 18 years. No vulnerable populations were deliberately included.

Materials

The ASRS Scale

The ASRS scale was be used (Kessler et al., 2005) to assess ADHD tendencies (Appendix E). The scale had previously passed a KMO test (0.75) and Bartlett test ($p < 0.05$), indicating that application of a factorial analysis is adequate. Factorial analysis revealed two clear factors with adjusted construct validity: inattention (9 items) and hyperactivity/impulsiveness (9 items), together explaining 67.7% of the variance in responses. In this study, the scale attained sufficiently high alpha scores (IA = 0.80, HI = 0.89, Overall = 0.92).

According to Ron Kessler (2005), NCSR general population surveys indicate the following distributional characteristics of the ASRS.

Table 1. Distributional characteristics of the ASRS.

	Range	Mean	Median	Error	Skewness	Kurtosis	25th	75th	95th
	0-72	17.19	17	1.43	0.72	2.74	13	17	33

The Flow Short Scale

The Flow Short Scale (Rheinberg et al., 2003) was be used to measure perceived flow engagement (Appendix F). The scale had previously been validated with success and utilized in multiple experimental and correlational, achieving internal consistencies for flow (alpha = 0.92). For this study, the scale attained an alpha of 0.77.

The Temporal Estimation Task

The Temporal Estimation Task was administered during three intervals of the experimental game session; after 2.5 minutes, after 5 minutes, and after 7.5 minutes. In each of the intervals, the game was paused and the participant was

instructed to estimate how long it had been since the last interval (with exception to the first interval, where participants were asked to estimate time since the start of the game).

By the end of the experimental session, each participant had estimated three sets of time, which was used to create an average number of seconds estimated per participant. This average was used as the outcome variable in measuring time distortion, theoretically suggested to become hampered during intense flow states.

The Experimental Game

Tetris (Appendix H) was used to facilitate the flow experience. The game was chosen due to its synchronisation with flow principles, such as balance between perception of skill and challenge. Tetris is designed so that one plays until reaching a point where the game is too difficult, creating a way for every participant to reach their skill threshold.

Procedure

The participants were recruited via online sources and presented with a Microsoft Forms link which included all necessary information and in the following order: information sheet (Appendix B), consent form (Appendix C), the ASRS Scale (Kessler, 2005), the experimental game (Appendix H), the Flow Short Scale (Appendix F), and the debrief sheet (Appendix D). During the experimental session, each participant played during three 150-second-long intervals and were asked directly after each interval (Appendix G) to estimate how long they had been playing for. No serious outliers were detected, but two participants (1 and 39) were removed due to insufficient or incorrect information.

Ethics

The study made use of the ASRS scale (Kessler, 2005), which is aimed to measure tendencies of Attention Deficit-Hyperactive Disorder (Appendix E). No participants were informed of their scores in the ASRS Scale. However, participants were informed of available psychological assistance, were signs psychological distress to arise during or after any of the experimental sessions. The ethics application form can be found in Appendix A.

Results

A Levene's test of normality indicated normal distribution in Inattention ($p > 0.05$), but not in Hyperactivity/Impulsivity ($p = 0.001$). Hence, t-tests were conducted to investigate mean differences in self-reported flow engagement and mean differences in seconds estimated across the high-scoring and low-scoring groups in Inattention, and Mann Whitney U test was conducted to investigate mean differences in self-reported flow engagement and mean differences in seconds estimated across the high-scoring and low-scoring groups in Hyperactivity/Impulsivity.

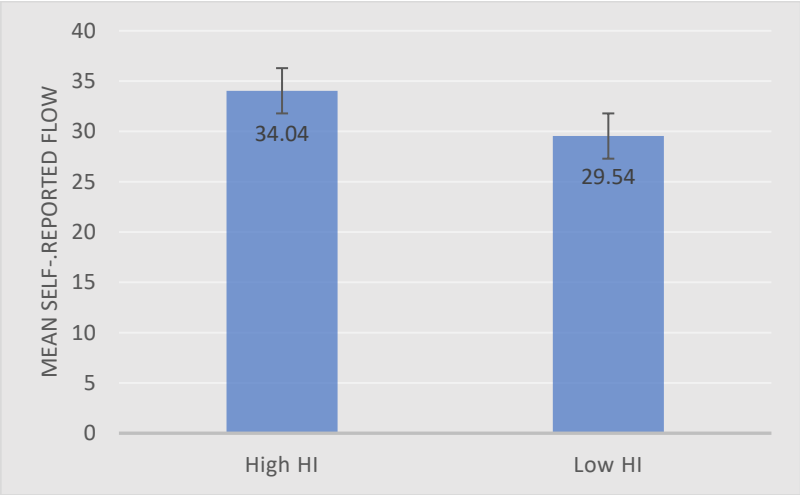
IV 1 - Hyperactivity/Impulsivity

Flow engagement

A Mann-Whitney U Test revealed significant differences in the number of seconds estimated by group High HI (*Md* = 34, *n* = 48) and Low HI (*Md* = 31, *n* = 48), *U* = 381.5, *z* = 1.932, *p* = .045, *r* = 0.28.

Figure 1

Hyperactivity/Impulsivity - Perceived Flow



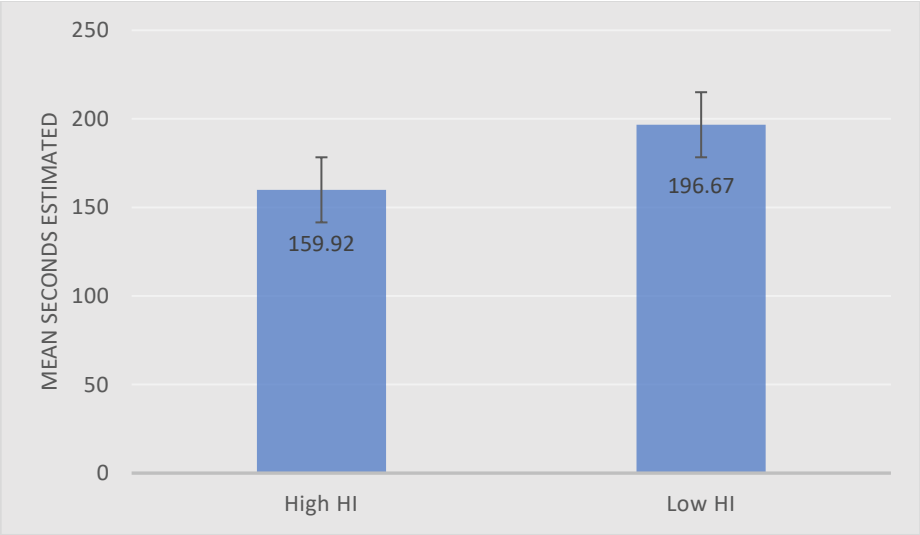
Note. The illustration presents mean self-reported flow score, categorised into the two High/Low groups of Hyperactivity/Impulsivity (HI).

Time Estimation Task

A Mann-Whitney U Test revealed no significant differences in the number of seconds estimated by group High HI (*Md* = 160, *n* = 48) and Low HI (*Md* = 199, *n* = 48), *U* = 191, *z* = –2.008, *p* = .053, *r* = 0.29.

Figure 2

Hyperactivity/Impulsivity - Temporal Estimation



Note. The illustration presents the mean number of seconds estimated across the three temporal intervals, categorised into the two High/Low groups of Hyperactivity/Impulsivity (HI).

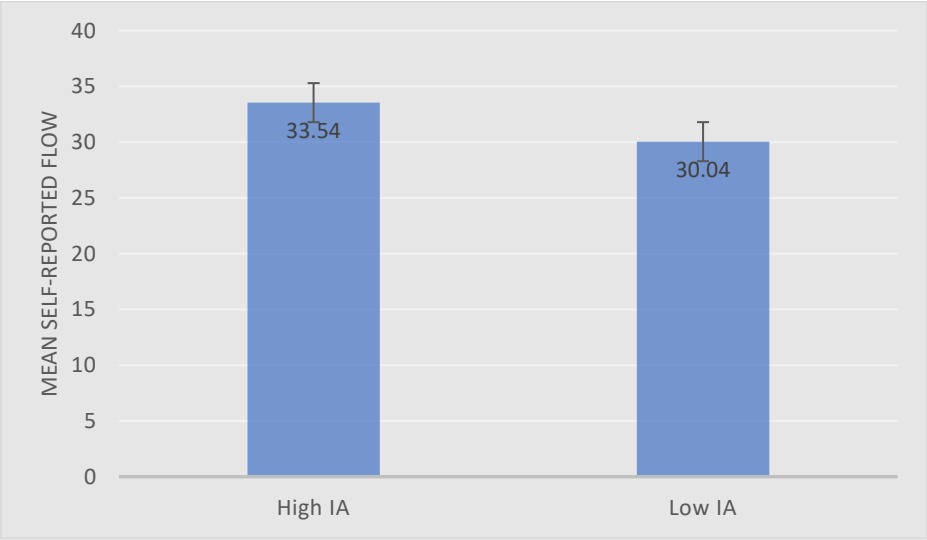
IV 2 – Inattention

Flow engagement

An independent-samples t-test was conducted to compare the self-reported flow engagement scores for group High IA and group Low IA. There were no significant differences in scores for group High IA (*M* = 33.54, *SD* = 7.39) and group Low IA (*M* = 30.04, *SD* = 7.28); *t* (24) = -1.653, *p* = 0.105, two-tailed). The magnitude of the differences in the means (mean difference = -3.50, 95% *CI*: -7.762 to 0.762) was moderate (*eta squared* = 0.067).

Figure 3

Inattention - Perceived Flow



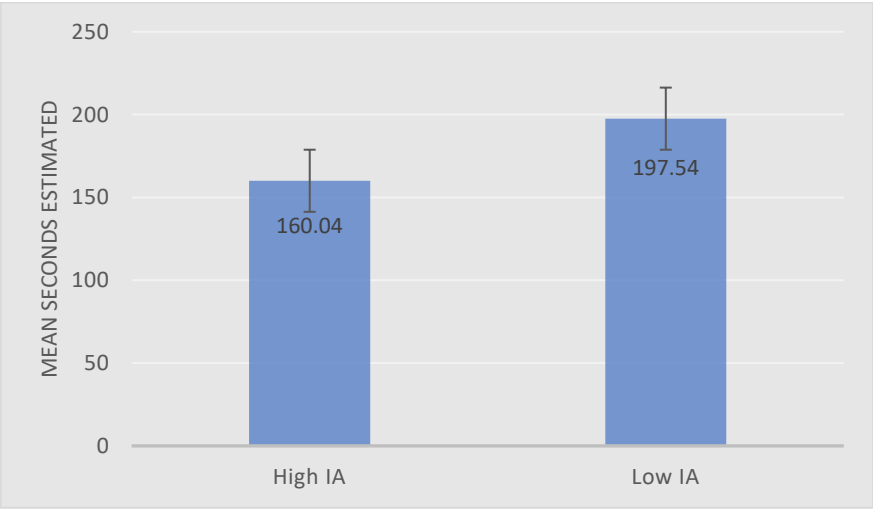
Note. The illustration presents mean self-reported flow score, categorised into the two High/Low groups of Inattention (IA).

Time Estimation Task

An independent-samples t-test was conducted to compare the average number of seconds estimated by group High IA and group Low IA. Significant differences were found for group High IA (*M* = 160.04, *SD* = 52.88) and group Low IA (*M* = 197.54, *SD* = 62.495); *t* (24) = 2.244, *p* = 0.030, two-tailed). The magnitude of the differences in the means (mean difference = 37.50, 95% *CI*: 3.864 - 71.136) was moderate to large (*eta squared* = 0.117).

Figure 4

Inattention - Temporal Estimation



Note. The illustration presents the mean number of seconds estimated across the three temporal intervals, categorised into the two High/Low groups of Inattention (IA).

Discussion

The results produced mixed, but clear outcomes in regards to the hypotheses formulated a priori. Two of the formulated hypotheses were supported and two were rejected.

Practical implications

Hypothesis 1 stated that high-scoring HI individuals would achieve significantly higher mean self-reported flow scores. The hypothesis was not supported, and the *null hypothesis retained*.

Hypothesis 2 stated that high-scoring IA individuals would achieve significantly higher mean self-reported flow scores compared to low-scoring IA individuals. The hypothesis was not supported, and the *null hypothesis retained*.

Hypothesis 3 stated that high-scoring HI individuals would achieve significantly less seconds estimated on average, than low-scoring HI individuals. The hypothesis was supported, and the *null hypothesis rejected*.

Hypothesis 4 stated that high-scoring IA individuals would achieve significantly less seconds estimated on average, than low-scoring IA individuals. The hypothesis was supported, and the *null hypothesis rejected*.

Theoretical implications and limitations.

Perceived flow

Using self-reported flow engagement as the guiding metric, the results suggest that neither hyperactivity/impulsivity nor inattention has a significant influence on the intensity of flow states during video game play, in contrast to previous research (Hartmann, 1997; Ruel, 1997; Glickman & Dodd, 1998; de Manzano et al., 2013; Hansen, 2017, Hupfeld et al., 2019).

Measurement of self-reported perceived flow engagement contains limitations in the form of response biases; such as social desirability (Arnold, 1981; Van de Mortel, 2008). No lie-scales (Eysenck & Eysenck, 1984) or reverse scoring practices were employed in the scoring, making reliability for the scores questionable. In addition, the scores are collected after the experience itself, and the more time there is in between the more misrepresented sensation is likely to reported. Nonetheless, alpha scores were more than sufficient (0.80 – 0.92), indicating internal scale consistency.

Temporal estimation

Using temporal estimation as the guiding metric, the results suggested that both hyperactivity/impulsivity and inattention has an influence on time distortion during video gameplay, in accordance with previous research (Hartmann, 1997; Ruel, 1997; Glickman & Dodd, 1998; de Manzano et al., 2013; Hansen, 2017, Hupfeld et al., 2019).

One may ponder, however, is hampered time estimation truly a valid measure of flow in all its diversity? Using time distortion, the 6th component of Csikzentmihalyi's Flow Theory (Csikszentmihalyi, 1997a; Nakamura & Csikszentmihalyi, 2014), the answer is yes. However, there are 7 more components. One may argue this objective measure as inadequate in its validity of measuring a varied construct such as flow, making inferences based on these results arguably parochial. In addition, previous

research in temporal estimation has suggested controlling for prior task experience (Rau, Peng, & Yang, 2006; Tobin & Grondin, 2015), which was not controlled for in this study. However, Tetris is a widely known game and one may argue that most people are aware of its main mechanics, making prior experience control less of a necessity. Finally, the lack of physical presence made it hard for the researchers to control for participants looking at the time when estimating the time intervals. However, this sort of variance does not influence in any particular direction and is therefore regarded as non-systematic noise.

Conclusively, the limitations of the study were diverse but manageable. Despite alpha scores being more than sufficient, the reliability of the study was hampered due to the lack of reverse scoring in the scales used. In addition, the time estimation task only answered a small fraction of the components included as part of flow theory, making the face validity of the measure questionable. Furthermore, the size of the sample (N = 48) injured the statistical power of the study, inducing ambiguity as to whether the insignificant influence of ADHD tendencies on perceived flow were due to a missing true effect, or a weak statistical power.

Strengths

Despite ADHD and flow research both having been given a great deal of attention by the academic community separately, they have been underserved as a joint subject. Adding the video game component makes this study even more unique, interesting and relevant. As mentioned in the introduction, the video game industry is growing and is bound to become more relevant over the coming years (Baltezarević, Baltezarević, & Baltezarević, 2018), and perhaps even more able to induce flow states (Admiraal, Huizenga, Akkerman, & Ten Dam, 2011; Cowley, Charles, Black, & Hickey, 2008a; Sherry, 2004) and satisfy psychological needs such as relatedness, competence, and autonomy (Ryan, Rigby, & Przybylski, 2006). However, if ADHD tendencies truly influence the capacity or likelihood of entering flow states during video game play, this could also be applicable to other activities that are aligned with flow principles. Hence, a core strength of this study was the relevance of the

knowledge gap it investigated. In addition, the augmentation of the second dependent variable was a good response to the limitations of self-report measures, and also a method of gaining more precision and security in our conclusions.

Conclusion

The study resulted in a non-triangulated outcome where the two dependent variables produced differing statistical conclusions. Self-reported perceived flow did not suggest significant influence from hyperactivity/impulsivity or inattention, in contrast to time distortion which showed significant differences between the high vs low scoring groups. Nonetheless, it is worth pointing out that their results point in the same direction, although to a varying degree. Perhaps, a study containing a larger sample size with more statistical power would result in a triangulated and more conclusive outcome. In addition, it would be interesting to make use of a different game with more diverse and immersive capacity; although still adhering to flow principles. Although temporal estimation holds value, it arguably lacks face validity in regards to flow; as it does not encapsulate all components of the construct. Hence, eye-tracking and galvanic skin response tests could be added as a third measure to capture positive affect, concentration, and intuitive awareness (Knierim, Rissler, Dorner, Maedche, & Weinhardt, 2018); incorporating a more complete picture of objective flow engagement.

The study ended up with two supported hypotheses stating that individuals with higher perceived hyperactivity/impulsive and inattentive tendencies experience more intense time distortion than those with those with lower perceived tendencies. This is not only a valuable takeaway, but also an interesting area for future research. Perhaps not all flow components are enhanced for individuals with ADHD tendencies, but rather some components more than others. Hopefully these findings will add to the currently body of knowledge concerning the relationship between ADHD, Flow, and video games.

Future research

Any future research aiming to conduct a similar study is recommended to plan ahead and make sure to attain a sufficiently large sample size (preferably with *N* = 100+). Furthermore, usage of a more diverse and immersive game is recommended if conditions allow it. It is also recommended to conduct the study in physical presence with the participant in order to control the experimental environment as much as possible, and also reduce financial costs of using a more immersive game that aligns with flow principles.

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Appendices

Appendix A

DEPARTMENT OF TECHNOLOGY AND PSYCHOLOGY
ETHICAL APPROVAL FORM B*

Three printed copies of this form should be submitted to the chair of the ethics committee

Title of project: All or nothing: The influence of hyperactivity/impulsivity and inattention on video game flow engagement.

Name of researcher: Love Mosse Torsten Sahlstroem

Email contact: N00190108@student.iadt.ie

Name of supervisor: Liam Challenor

		Yes	No	N/A
1	Will you describe the main research procedures to participants in advance, so that they are informed about what to expect?	X		
2	Will you tell participants that their participation is voluntary?	X		
3	Will you obtain written consent for participation (through a signed or 'ticked' consent form)?	X		
4	If the research is observational, will you ask participants for their consent to being observed?			X
5	Will you tell participants that they may withdraw from the research at any time and for any reason?	X		
6	With questionnaires, will you give participants the option of omitting questions they do not want to answer?	X		
7	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	X		
8	Will you debrief participants at the end of their participation (i.e., give them a brief explanation of the study)?	X		
9	If your study involves people between 16 and 18 years, will you ensure that passive consent is obtained from parents/guardians, with active consent obtained from both the child and their school/organisation?			X
10	If your study involves people under 16 years, will you ensure that active consent is obtained from parents/guardians and that a parent/guardian or their nominee (such as a teacher) will be present throughout the data collection period?			X
11	Will your project involve deliberately misleading participants in any way?		X	
12	Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?	X		

13	Does your project involve work with animals?			X	
14	Do you plan to give individual feedback to participants regarding their scores on any task or scale?			X	
15	Does your study examine any sensitive topics (such as, but not limited to, religion, sexuality, alcohol, crime, drugs, mental health, physical health)			X	
16	Is your study designed to change the mental state of participants in any negative way (such as inducing aggression, frustration, etc.)			X	
17	Does your study involve an external agency (e.g. for recruitment)?			X	
18	Do participants fall into any of the following special groups?	People with learning or communication difficulties		X	
		Patients (either inpatient or outpatient)		X	
		People in custody		X	

If you have ticked **No** to any of questions 1 to 10, or **Yes** to any of questions 11 to 18 you should refer to the PSI Code of Professional Ethics and BPS Guidelines. There is an obligation on the lead researcher to bring to the attention of the Department of Technology and Psychology Ethics Committee (DTPEC) any issues with ethical implications not clearly covered by the above checklist.

* This Ethics B form should be completed by researchers whose studies involve any ethically questionable practices.

I consider that this project **may** have ethical implications that should be brought before the DTPEC. 1. **Purpose of project with very clear and specific justification for the study [its potential benefits], given the acknowledged sensitivity of the topic of study or the methods used (approximately 100 words)** The proposed study aims to investigate the influence of ADHD tendencies/symptoms in the form of 1) hyperactivity/impulsivity and 2) inattention on video game flow engagement. This study will add to the body of knowledge concerning the relationship between Attention-Hyperactive Deficit Disorder, Flow Theory, and the contextual environment of a video games; an industry in exponential growth. In addition to supervisor Liam Channelor, Dr Tom Burke (PhD) will be an available resource as an advisor. 2. **Proposed methodology (approximately 300 words). This must include:** a. **Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria.** b. **Brief description of methods and measurements.** Sixty (*N* = 60) participants will be recruited online and via the Institute of Art, Design, and Technology. Online recruitment will occur using a geo-targeted strategy toward Dublin residents, most likely via Reddit and Facebook. The only restriction for participant will be that the participant is of an adult age (18 years plus). The online experiment will require the participant to use their own computer, as there will be no physical contact between the researcher and the participant. Participants will be invited into an approximate 30-minute session, in which the participants will read an information sheet concerning the study, after which an online consent form will be signed. Thereafter, participants will complete an ASRS scale (Kessler et al., 2005) which is constructed to uncover behavioural ADHD tendencies. The scale scores participants on two components of ADHD: inattention, and hyperactivity/impulsivity. These scores will be used to divide the participants into four groups; Inattention High (IH), Inattention Low (IL), Hyperactivity/Impulsivity (HIH), Hyperactivity/Impulsivity (HIL). Subsequently, participants will be invited to share their screen via an online conference call (which will be recorded) and click on a link leading to the experimental game. In this phase, they will start playing a trial run to understand how Tetris works, and subsequently the experimental round will begin. The game will continue until the participant can no longer withstand the tempo/difficulty of the game (which increases with time). Directly after the game session has finished, the participant will complete an online version of the Flow Short Scale (Rheinberg, Vollmeyer, & Engeser, 2003); constructed to gather subjective data regarding flow experiences attained during the video game play. In addition, a temporal estimation task will be included; where participants are asked estimate how long it has been since the researcher primed them approximately 10	☐

minutes earlier (read more in the Materials section). This part of the experiment is aimed to uncover an objective statement of flow engagement based on the idea that flow engagement distorts time perception. Similar forms of cognitive appraisal surveying has been tested in previous literature (Tucha et al., 2008). It is expected that people in the IH group and the HIH group will score significantly higher in mean self-reported flow engagement (Figure F1) and significantly less accurate in temporal estimation task (Figure F2).	
3. A clear but concise statement of the ethical considerations raised by the project and how you intend to deal with them (approximately 100 words). The study makes use of the ASRS scale, which is aimed to measure tendencies of Attention Deficit-Hyperactive Disorder. The research will add knowledge to understanding why individuals with ADHD tendencies may enjoy video games more than others; knowledge that can help in the treatment of video game addiction. If a participant chooses to contact the researcher about concerns or complaints, the supervisor will be an available resource for consultation. Furthermore, participants will be informed of available psychological assistance, were signs psychological distress to arise during or after any of the experimental sessions. **4. Copies of all materials to be used in your study should be attached to this form. This must include consent and participant information arrangements and debrief forms. It should also include copies of all standardized and/or non-standardized questionnaires and instruments, as well as any interventions and/or audio-visual materials which will be used. Please note that these materials will not be returned to you, so you should ensure that you retain a copy for your own records. All loose materials (such as DVDs, handouts etc.) should be clearly labeled with your name. There is no word count limit on appendices, but no appendices should be included that will not be used as materials in your study.** Three copies of this form, along with all materials to be used in your study, should be submitted to the DTPEC for consideration. ***If any of the above information is missing, your application will not be considered at the DTPEC meeting, and your research may be significantly delayed.***	

I am familiar with the PSI Code of Professional Ethics and BPS Guidelines (and have discussed them with the other researchers involved in the project). I have read and understood the specific guidelines for completion of Ethics Application Forms.

Signed _____ Print Name _____ Date _____
Applicant

Signed _____ Print Name _____ Date _____
Supervisor

Appendix B

Figure B1

Information Sheet

Information sheet

My name is Love Mosse Sahlstroem and I am a postgraduate student at the Institute of Art, Design, and Technology. As part of my final year course requirements, I am conducting research relating to the connection between attention and flow engagement while playing a video game. As a participant, you will complete three surveys, and play a game of Tetris.

Research Team

Researcher: Love Mosse Sahlstroem
Supervisor: Liam Challenor

Clinical Research Support: Dr Tom Burke
Research Submission Date: 14th March 2020

The current study

All participants will be invited to a 20-minute online session. The procedure will involve completion of two self-report scales and playing a game of Tetris.

Who can participate?

Participation has no requirements, except being of adult age (18+ years).

Do I have to take part?

You do not have to take part in this study, and doing so will not affect your career or academic results in any way. You can change your mind about taking part at any point until your data has been anonymously coded after the debrief.

Confidentiality and information storage

No identifying information such as the name of individual participants will be retained or published in any subsequent research article. All data points will be anonymously coded. Participation is voluntary and participants may withdraw at any stage until the data has been coded.

Note. Screenshot 1/2 of the Information Sheet.

Figure B2

Information Sheet

What does participation involve?

Where: Institute of Art, Design, and Technology.
When: February 2020 – March 2021.
What: The 20-minute session will start with you completing a consent form, and then an attention-related survey (approximately 4 minutes), after which you will be playing the experimental game (Tetris) for a relatively short amount of time. After this has been completed, you will complete the Engagement scale (approximately 3 minutes). Finally, you will receive a debrief sheet explaining all areas of the study.
How long: The experiment will take approximately 20 minutes.

Potential risk

The study involves answering questions related to your attention. You do not need to answer any questions you do not wish to answer. Contact details to counselling services are provided below, along with contact information to the researcher and the supervisor, should participants require further information. In the event that participants should require counselling, IADT Health Centre is an available resource for IADT students, and non-students will be provided an alternative if requested.

Address: IADT Health Centre
Phone: 01239 4760

Potential gains

Your participation will provide further insight into the study of flow and how gaming can support concentration.

Data rights

Under the EU General Data Protection Regulation (GDPR) the legal basis for collecting data for scholarly research is that of public interest. The regulations regarding the protection of your data will be followed. Only data which is needed for analysis will be collected. By giving your consent to take part in the study you are consenting to the use of your data as detailed in this information sheet.

Ethics approval
This study has been approved by the IADT Ethics Committee. Approval was granted on 29th of October, 2020.

Note. Screenshot 2/2 of the Information Sheet.

Appendix C

Figure C1

Consent Form

Consent Form

1. I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions. *

   - Yes
   - No

2. I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions. *

   - Yes
   - No

3. I understand that my participation is voluntary and that I am free to withdraw at any time. *

   - Yes
   - No

4. I agree to take part in this study. *

   - Yes
   - No

Note. Screenshot 1/2 of Participant consent form.

Figure C2

Consent Form

5. I understand that data collected about me during this study will be anonymised before it is submitted for publication. *

- Yes
- No

6. I agree to allow the data collected to be used for future research projects. *

- Yes
- No

7. I agree to be contacted about possible participation in future research projects. *

- Yes
- No

8. I confirm that I am above 18 years of age. *

- Yes
- No

Note. Screenshot 2/2 of Participant consent form.

Appendix D

Figure D1

Debrief sheet

Section 7 ...

Debrief Sheet

On behalf of everyone involved in this study, we thank you for your participation! This leaflet will provide you with any additional details about the purpose of the experiment. Feel free to keep a copy and ask any questions about the study.

Design of the study

Do people with a tendency toward Inattention and Impulsivity/Hyperactivity experience more intense flow states than people without it? This study was created to investigate the connection between attention flow engagement measured via self-report metrics and a temporal estimation task.

Why is this study important?

Little research has been aimed at an association between flow, video games, and psychological tendencies. Individually, these topics have been given large amounts of spotlight. But put together, they have not been given the same amount of attention. Hence, this study adds to the body of knowledge concerning three relevant but unconnected research areas.

What if I no longer wish to participate?

You are free to withdraw at any time. If you decide to withdraw now, we will destroy all records of your participation. You will not be penalized if you withdraw.

How to contact the researcher

This study is being conducted within IADT Department of Technology and Psychology for Love Torsten Mosse Sahlstroem's final year project, enrolled in the MSc Cyberpsychology programme.

If you would like to contact the researcher, he is available at: N00190108@student.iadt.ie.

If you would like to contact the supervisor, he is available at liam@challenor@iadt.ie.

In case of psychological distress
In the event that you experience any distress as a result of participating in this study please contact the IADT Health Centre for support if you are and IADT student, and if you are a non-student we will arrange for an external third party to assist you.

Additional Supports:
Find a psychologist in your area: https://www.psychologicalsociety.ie/footer/PSI-Chartered-Psychologist-Online-Directory
HSE Mental Health Resources: https://www2.hse.ie/mental-health/?gclid=CjwKCAjwIID8BRAFEiwAnUoK1T-9BP-5MZVJrXmwuXfFBDgI_0GTn74n8IFcEze1aO-TE_OLm4_CLhoCqfAQAvD_BwE&gclsrc=aw.ds

Note. Screenshot of the Debrief sheet.

Appendix E

Figure E1

Attention Survey

Attention Survey

Please answer the following questions as accurately as possible, and then continue with the Experimental Game Session.

10. *

	Never	Rarely	Sometimes	Often	Very often
How often do you make careless mistakes when you have to work on a boring or difficult project?	○	○	○	○	○
How often do you have difficulty keeping your attention when you are doing boring or repetitive work?	○	○	○	○	○
How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?	○	○	○	○	○
How often do you have trouble wrapping up the fine details of a project, once the challenging parts have been done?	○	○	○	○	○
When you have a task that requires a lot of thought, how often do you avoid or delay getting started?	○	○	○	○	○

Note. Screenshot 1/3 of the ASRS Scale.

When you have a task that requires a lot of thought, how often do you avoid or delay getting started?					
How often do you misplace or have difficulty finding things at home or at work?					
How often are you distracted by activity or noise around you?					
How often do you have problems remembering appointments or obligations?					
How often do you fidget or squirm with your hands or your feet when you have to sit down for a long time?					
How often do you leave your seat in meetings or other situations in which you are expected to remain seated?					
How often do you feel restless or fidgety?					
How often do you have difficulty unwinding and relaxing when you have time to yourself?					
How often do you feel overly active and compelled to do things, like you were driven by a motor?					

Note. Screenshot 2/3 of the ASRS Scale.

How often do you have difficulty waiting your turn in situations when turn-taking is required?					
How often do you interrupt others when they are busy?					

Note. Screenshot 3/3 of the ASRS Scale.

Appendix F

Figure F1

Flow Short Scale

Engagement Survey

Please answer the following questions as accurately as possible, after playing the game

11. Engagement 1 *

	Not at all				Very much
I feel just the right amount of challenge.	○	○	○	○	○
My thoughts/activities run fluidly and smoothly.	○	○	○	○	○
I do not notice time passing.	○	○	○	○	○
I have no difficulty concentrating.	○	○	○	○	○
My mind is completely clear.	○	○	○	○	○
I am totally absorbed in what I am doing.	○	○	○	○	○
The right thoughts/movements occur of their own accord.	○	○	○	○	○
I know what I have to do each step of the way.	○	○	○	○	○

Note. Screenshot 1 of the Flow Short Scale.

Figure F2

Flow Short Scale

I feel that I have everything under control.					
I am completely lost in thought.					
Something important to me is at stake here.					
I must not make any mistakes here.					
I am worried about failing.					

Note. Screenshot 2 of the Flow Short Scale.

Appendix G

Figure G1

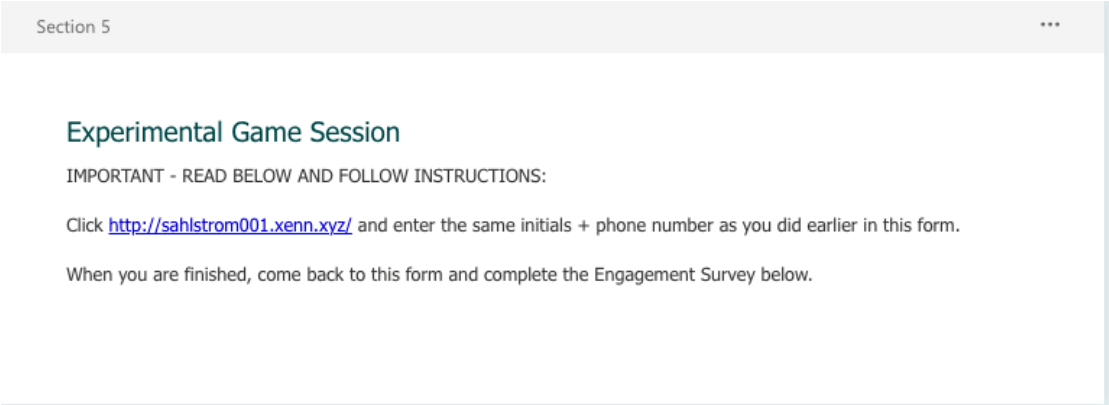
Time Estimation Task

Note. Screenshot of interval 1 in the Temporal Estimation Task.

Appendix H

Figure H1

The Experimental Game



Note. The Experimental game and its hosted link http://sahlstrom001.xenn.xyz/.