An Exploration of the Correlates and Causes of Boredom

by

Jhotisha Mugon

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Psychology

Waterloo, Ontario, Canada, 2020

Examining Committee Membership

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

External Examiner	Dr. Andreas Elpidorou Associate Professor Department of Philosophy University of Louisville
Supervisor	Dr. James Danckert Professor and Cognitive Neuroscience Research Area Head Department of Psychology University of Waterloo
Internal Member(s)	Dr. Evan Risko Associate Professor and Cognitive Research Area Head Department of Psychology University of Waterloo
	Dr. Abigail Scholer Associate Professor and Social Research Area Head Department of Psychology University of Waterloo
Internal-external Member	Dr. Jesse Hoey Associate Professor David R. Cheriton School of Computer Science University of Waterloo

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Boredom has been defined as self-regulatory signal which tells us that whatever we are currently doing is failing to keep us engaged, pushing us to seek out more satisfying alternatives. It is a negatively valenced experience associated with a wide range of negative consequences ranging from problem gambling to depression and poor academic performance. The pervasiveness of boredom points to the need to better understand the various contingencies that lead to it. As such, the goal of this thesis was to explore some of the lesser studied correlates and causes of boredom. Chapter 2 explored the relationship between boredom and willingness to engage in various tasks. Results showed that the less willing one is to engage in a task, the more bored they are likely to be. Chapter 3 investigated the relationship between boredom and effort regulation with results indicating that those who are less willing to expend effort are more likely to be bored. Chapter 4 examined the role of autonomy on boredom and demonstrated that control by itself does not differentiate between different levels of state boredom when tasks are boring. Finally, Chapter 5 explored whether having control over the challenge level of a task influenced boredom. Here too, results showed that the different manipulations of control over challenge did not influence boredom. The challenge of isolating individual factors that lead to boredom, highlighted across all the studies presented here, suggests that boredom arises from complex interactions of multiple variables. The last chapter discusses the possible interactions that can give rise to boredom.

Acknowledgements

I would like to begin by thanking my supervisor, Dr. James Danckert, for all your support, guidance and humour throughout my academic career. I started working with you as an undergraduate research assistant and little did I know then that I would have the opportunity to complete my PhD under your supervision. I am incredible grateful for all the research and professional development opportunities that you have given me. You have helped me grow not only as a researcher, but also as a person and an educator.

To Dr. Abigail Scholer, thank you for being my mentor throughout my graduate career. Your constructive feedback, attention to detail and support has been invaluable. I would also like to thank my thesis committee, Dr. Evan Risko, Dr. Jesse Hoey and Dr. Andreas Elpidorou for agreeing to read my thesis. Your time and effort is deeply appreciated.

To Dr. John Eastwood, under whose guidance and mentorship I co-authored a book chapter on boredom and learning, thank you for guiding my thinking and encouraging me to consider different perspectives. To the present/past members of the Danckert lab, thank you for your years of advice, feedback and camaraderie. I would particularly like to thank my good friend and collaborator, Dr. Andriy Struk, for his coding and statistical analysis help and for the many stimulating discussions we had. Your patience, friendship and support has allowed me to persevere through difficult times.

To my mum, Indranee, and my sisters, Ganga, Gomti and Anju, thank you for emotionally and financially supporting me throughout these years. This journey would not have been possible without you all. Finally, to all research participants, thank you for your time and contributions in shaping this thesis.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

Boredom is a pervasive human experience. Using an experience sampling approach to capture in-the-moment assessments of boredom, Chin and colleagues (2016) found that within 30-minute wakefulness windows, boredom was reported approximately 2.8% of the time in a large representative sample of U.S. adults. Furthermore, boredom was the seventh most commonly reported emotion of the seventeen captured (Chin, Markey, Bhargava, Kassam, & Loewenstein, 2016). Previous research has also found that high-school students in Germany experience some level of boredom 36% of the time during learning activities (Goetz et al., 2014) and that 91% of North American youth experience some level of boredom (The National Center on Addiction and Substance Use, 2003). Clearly, boredom is prevalent in Western society. The state of boredom is characterized as a negatively valenced, aversive state in which individuals want to engage with their environment but fail to do so (Eastwood, Frischen, Fenske, & Smilek, 2012). In other words, the state of boredom signals that what we are doing now is failing to satisfy our needs and goals in some important way, pushing us to explore alternative options for engagement (Elpidorou, 2014b, 2018b).

Those who fail to respond well to the state signal are said to be trait boredom prone (Farmer & Sundberg, 1986; Mugon, Struk, & Danckertb, 2018; Struk, Carriere, Cheyne, & Danckert, 2017). Unpublished data from our lab suggests that highly boredom prone individuals tend to experience the state of boredom more frequently and intensely. Across many large samples, participants were asked about how frequently and intensely they experienced boredom. Both frequency and intensity were positively correlated with the boredom proneness scale (SBPS) with the association consistently stronger for frequency (across the three terms of Fall 2017 and 2018 and Winter 2018, with an average n=2,161, intensity correlations with the SBPS ranged from 0.45 – 0.49, while for frequency the range was 0.63 – 0.64). Trait boredom proneness has been associated with a plethora of negative consequences ranging from increased levels of depression and anxiety (Goldberg, Eastwood, Laguardia, & Danckert, 2011; Lepera, 2011; Sommers & Vodanovich, 2000), problem gambling (Blaszczynski, Mcconaghy, & Frankova, 1990; Mercer & Eastwood, 2010; Neighbors, Lostutter, Cronce, & Larimer, 2002), increased absenteeism and decreased job satisfaction (Kass, Vodanovich, & Callender, 2001), to poor academic achievement (Mann & Robinson, 2009; Tze, Daniels, & Klassen, 2016).

There are many factors associated with the state of boredom, the most studied being monotony, lapses of attention and a lack of meaning (Damrad-Frye & Laird, 1989; Hunter & Eastwood, 2018; O'Hanlon, 1981; Thackray, Bailey, & Mark Touchstone, 1977; Van Tilburg & Igou, 2012). This thesis will explore some of the lesser studied contingencies that lead to state boredom. However, before doing so, it is worthwhile to highlight current findings on the circumstances known to be associated with boredom. Among the most prominent causes of state boredom is monotony, which has been defined as repetitive or uniform environments with little to no change (O'Hanlon, 1981; Smith, 1981; Thackray, 1981). Early evidence suggests that employees engaged in repetitive work are more likely to experience boredom (Caplan, Cobb, Franch, Harrison, & Pinneau, 1975; Münsterberg, 1913; Wyatt, 1929). Furthermore, Perkins and Hill (1985) found that those who reported a task as being subjectively monotonous also reported higher levels of boredom than those who experienced the same task to be interesting. In addition, some environments or circumstances are not only monotonous, but also entail a need for vigilance or sustained attention, either because individuals must make continual, repetitive decisions (e.g., assembly line work), or because they must monitor their environment for infrequent, salient events (e.g., Air-traffic controllers; O'Hanlon, 1981; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997; Smith, 1981). Johansson and colleagues (1978) found that employees whose jobs combined highly repetitive circumstances with a need to be vigilant reported experiencing higher levels of state boredom than those whose jobs were less repetitive and more autonomous. Within a laboratory setting, Thackray and colleagues (1977) had participants monitor changes on a simulated radar display for a prolonged period of time and found that compared to those who reported low levels of state boredom, highly bored participants took longer to respond to changes and reported decreased attentiveness.

In addition to monotony, lapses in attention have also been linked to the experience of boredom. Previous research suggests that lapses in everyday attention (e.g., pouring orange juice on cereal) are not only a cause but also a consequence of state boredom (Carriere, Cheyne, & Smilek, 2008; Cheyne, Carriere, & Smilek, 2006; Cumings, Gao, & Thornburg, 2015). Damrad-Frye and Laird (1989) found that participants who attributed their attentional lapses to the material they were working on reported higher levels of state boredom than those who did not experience attentional lapses. More recently, Hunter and Eastwood (2018) had participants complete a Sustained Attention to Response Task (SART; Robertson et al., 1997). The task presents participants with single digits and requires them to press a key for every number, withholding responses for one number. Results showed that participants who committed more commission errors (i.e., pressing the space bar when a withhold response was required) reported higher levels of boredom following that block of trials compared to boredom levels prior to the start of the block. The authors concluded that attention failures of this kind function as a cause of state boredom. Trait boredom proneness has also been related to attention failures such that highly boredom prone individuals experience higher rates of attention failures and exhibit poor performance on laboratory tests of sustained attention (Carriere et al., 2008; Cheyne et al., 2006; Kass, Vodanovich, Stanny, & Taylor, 2001; Malkovsky et al., 2012; Wallace, Vodanovich, & Restino, 2003).

State boredom has also been associated with perceived lack of meaning. van Tilburg and Igou (2012) found that retrospective evaluations of a boring situation led participants to judge the situation to be meaningless and unchallenging compared to situations in which participants felt sad, angry or frustrated. Furthermore, van Tilburg and Igou (2011) demonstrated that when bored, participants were more likely to engage in behaviours that favor their group identity (such as liking an in-group name more than an outgroup name or assigning less punishment to an in-group member compared to an outgroup member). There is an important distinction to be made here between in-the-moment judgements of meaning (i.e., situational meaning – for example, waiting in line is meaningless) and life meaning (i.e., feeling that one's life lacks purpose; Fahlman, Mercer, Gaskovski, Eastwood, & Eastwood, 2009). Previous research has found a negative relationship between boredom proneness and life meaning (Fahlman et al., 2009; MacDonald & Holland, 2002; Melton & Schulenberg, 2007; Weinstein, Xie, & Cleanthous, 1995). Fahlman and colleagues (2009) have also found that boredom proneness is uniquely associated with life meaning even when controlling for other negative affective states such as anxiety and depression. Furthermore, the authors manipulated meaning and found that compared to participants in the high meaning condition, those in the low meaning condition reported higher levels of state boredom, which provides evidence for the causal relationship between meaning and boredom.

The pervasiveness of both state and trait boredom point to the need to better understand the various contingencies that lead to the experience. Monotony, attentional failures and lack of meaning, may be the most prominent causes investigated to date, but they are unlikely to be the only causes of boredom. The essential conundrum of boredom is that it signals the desire to engage in something, coupled with a belief that none of the currently available options will satisfy (Danckert, Mugon, Struk, & Eastwood, 2018). Understanding the full suite of contingencies that lead to this conundrum may help address its negative outcomes. Chapter 2 investigates an individual's willingness to engage in activities. If state boredom is in part related to a belief that nothing will satisfy the desire to be mentally occupied, then higher levels of boredom should be related to a reduced willingness to engage. The conundrum of state boredom may also arise when tasks are perceived to be too effortful, a hypothesis explored in Chapter 3.

Boredom often arises in situations of constraint, when we feel obliged to do something we would rather not do (Fenichel, 1953; Geiwitz, 1966; O'Hanlon, 1981). This hints at a role for boredom (both state and trait) in our sense of agency, the feeling that our actions originate from our desires and that we control those actions – in other words, that we are the authors of our own lives (Snibbe & Markus, 2005). Chapter 4 examines whether a sense of autonomy or control over a given task has any influence on perceived state boredom. Finally, boredom may arise when we fail to achieve an appropriate skill-challenge fit (Csikszentmihalyi, 1975; Daschmann, Goetz, & Stupnisky, 2011). Chapter 5 gave participants the opportunity to control the challenge levels of a game-like task to examine the relation between boredom, varying levels of challenge and the capacity to autonomously change those challenge levels. Boredom ought to be minimal when people are free to find the appropriate challenge level for their own skill level. Chapter 6 concludes with a discussion of the implications of the current research and highlights the need to contextualize boredom to better understand the self-regulatory function of this ubiquitous experience. While the main focus of this thesis is on state boredom, exploratory analyses examined the association between trait boredom proneness and the constructs of interest in order to better understand the factors that influence boredom.

1.1 General methods

Participants in all studies completed the shortened Boredom Proneness Scale (SBPS; Struk et al., 2017; Appendix A) either at the end of the study (studies 2.1 and 2.2) or as part of the institutional on-line testing that students take at the beginning of each term. The SBPS is an 8-item questionnaire designed to assess one's proneness to experience boredom. Sample items include “I find it hard to entertain myself” measured on a Likert scale ranging from 1 “strongly disagree” to 7 “strongly agree” with high scores reflecting a high propensity to be bored. Struk and colleagues (2017) report an internal consistency of 0.88.

1.2 General data analysis

All data analyses were conducted in R (R Core Team, 2015). Shapiro-Wilks tests of normality (Shapiro & Wilk, 1965) was calculated for all study variables in each study. Where results of this test indicated that assumptions of normality were violated non-parametric analyses were adopted.

Given the potential for type II errors when using a Bonferroni correction on multiple correlations, previous research suggests focusing only on associations related to the constructs of interest (Curtin & Schulz, 1998). As such, Bonferroni corrections were applied to correlations involving state boredom and the number of corrections for each study is stated in each results section.

Chapter 2: Exploring the relationship between boredom and willingness to engage

2.1 Introduction

Boredom as a state signal is perhaps best characterized as a "call to action" (Bench & Lench, 2013; Danckert, 2019; Danckert et al., 2018; Elpidorou, 2014, 2018). That is, boredom highlights that we are disengaged from our current task for whatever reason and that we need to find an alternative for engagement (Mugon, Danckert, & Eastwood, 2018a). Highly boredom prone individuals are more likely to experience the boredom signal (Farmer & Sundberg, 1986) and yet they fail to head it effectively (Danckert et al., 2018; Mugon et al., 2018a). This represents a kind of conundrum for the highly boredom prone, who recognize the desire to act in some purposeful way, but fail to launch into any action that would satisfy that urge. In a direct evaluation of this conundrum, Mugon and colleagues (2018b) examined the relationship between boredom proneness and different modes of goal pursuit. Regulatory mode theory (Kruglanski et al., 2000) distinguishes between a 'locomotion' mode which focuses on a tendency for action implementation (colloquially, the 'just do it' mode), and an 'assessment' mode which focuses on a tendency to engage in exhaustive comparison of available alternatives (the 'do the right thing' mode). Results showed that boredom proneness was consistently negatively associated with locomotion and positively (albeit weakly) associated with the assessment mode of goal pursuit across multiple samples (Mugon et al., 2018b). The ability to get started and to continue on a task (i.e., locomotion) seems to act as a prophylactic against boredom, whereas exhaustively thinking about what will *optimally* satisfy one's needs (i.e., assessment) may lead to boredom. This suggests that the conundrum of wanting but failing to launch into action is also a key part of the state signal. Those who respond rapidly and effectively to that signal only feel it fleetingly. For many though, state boredom is uncomfortable precisely because the feeling persists.

One possible explanation for the conundrum signalled by state boredom is that in-the-moment we may feel like a more satisfying option for engagement is missing and as a consequence are less willing to engage in the currently available options for action. The negative relationship between boredom proneness and locomotion provides some support for the hypothesis that decreased willingness to engage is associated with boredom – yet, there are no studies to date that have investigated this association directly. Here two hypotheses were pursued; 1) that willingness to engage is negatively associated with both state and trait boredom and 2) that willingness to engage is potentially one of the reasons why boredom prone individuals are more likely to experience the state of boredom. Prior work suggests that boredom prone individuals are more likely to appraise their situations as being more boring (Dal Mas & Wittmann, 2017; Farmer & Sundberg, 1986; Harris, 2000). For example, Harris (2000) found that highly boredom prone individuals found their classes and jobs to be more boring compared to their low boredom prone counterparts. Additionally, Dal Mas & Wittmann (2017) found that boredom proneness positively predicted boredom ratings at the end of a task. Observing that willingness to engage mediates the relationship between boredom proneness and state boredom would provide preliminary evidence for such a hypothesis. The next two studies investigated these hypotheses.

2.2 Study 1

The goal of this study was to test the hypothesis that both state and trait boredom are negatively associated with willingness to engage and that willingness to engage mediates the relationship between the two. As mentioned, boredom involves an appraisal of our current state as being disengaged. Previous research has focused on getting participants to think of a situation in which they felt a specific emotion and then to provide a retrospective judgement of the situation on several dimensions (Smith & Ellsworth, 1985; Van Tilburg & Igou, 2012). Arguably, the same can be done for prospective judgements of emotions. Participants were asked to judge how willing they would be to engage in a variety of traditional cognitive experimental tasks. They were also asked to rate how boring they thought those tasks would be. Such evaluations can be taken as an indication of how bored participants anticipated that they *would be* if they were to actually do the task. Indeed, previous research suggests that appraisal of a situation is a reliable indicator of the emotion that can be felt from that situation (Lazarus & Smith, 1988; Smith & Ellsworth, 1985). This suggests that participants do not need to be induced in a state of boredom in order to test whether they is a relationship between boredom and willingness to engage in tasks. Instead, participant's evaluation of different situations can be taken as an indication of prospective judgements of boredom.

2.3 Methods

Participants

A total of four hundred and ten North American participants were recruited from Amazon Mechanical Turk in August 2017. Nineteen of them were removed because they either failed the attention check or reported that they had randomly selected their answers. This led to a total number of three hundred and ninety-one participants (mean age: 37.87 years; SD: 10.58). Participants received monetary compensation in exchange for participation. This study received ethics clearance from University of Waterloo office of Research Ethics and participants gave informed consent prior to participating.

Procedure

Using a within subjects design, participants read descriptions of five attentional tasks commonly used in psychology studies (Posner's Covert Orienting of Visuospatial Attention Task (COVAT), the Sustained Attention to Response Task (SART), the Stroop, an N-back and the Starry Night task; see below for task descriptions). These tasks were chosen for a number of reasons; first, they are commonly used lab-based tasks that focus on the ability to deploy attention – an ability shown consistently to be impaired in highly boredom prone individuals (Cheyne et al., 2006; Goldberg, Eastwood, Laguardia, & Danckert, 2011; Malkovsky, Merrifield, Goldberg, & Danckert, 2012). Second, many of these tasks have a known association with state boredom. That is, poor performance on at least one of these tasks has been shown to be predictive of state boredom (Hunter & Eastwood, 2018). Finally, these tasks themselves could be thought of as excellent boredom inducers as they typically involve sparse visual environs/stimuli, monotonous task requirements and substantial time to complete, all factors one might expect would lead to increased boredom (Danckert & Merrifield, 2016; Gerritsen, Toplak, Sciaraffa, & Eastwood, 2014; Helton & Russell, 2011; Malkovsky et al., 2012; Pattyn, Neyt, Henderickx, & Soetens, 2008; Raffaelli, Mills, & Christoff, 2018). Importantly, participants were not asked to complete the tasks in question. Instead, they were presented with descriptions of the tasks (see below) and were then asked to rate how boring they thought the tasks were and how willing they would be to complete them. Task descriptions were presented in a counter balanced order, with ratings of willingness to engage made on a Likert scale of 1 (not willing at all) to 5 (extremely willing). Task boringness was rated on a similar 5-point Likert scale ranging from 1 (not boring at all) to 5 (extremely boring). Participants also completed the short Boredom Proneness Scale (SBPS; Struk et al., 2017) at the end of the study.

Task Descriptions

COVAT Task – On the computer screen, you will see a fixation cross and two boxes on either side of the fixation cross. During this task, a cue followed by a target object will appear for a brief amount of time. The cue and target object may or may not appear in the same box. Your task is to press a button corresponding to the box on the screen whenever you see a target object appear. You will do this while looking at the center of the screen and respond as fast and accurately as possible.

Stroop Task – For this task, you will be focusing on the fixation cross. Words in different colours will appear individually for approximately 350 milliseconds on the middle of the screen. Each word will be followed by a fixation cross for 500 milliseconds. Your task is to press a button corresponding to the colour of the word whenever you see a word on the screen. You will do this while looking at the center of the screen and respond as fast and accurately as possible.

SART Task – For this task, single digits (0-9) in varying sizes and fonts will be presented individually in the middle of the screen. Each digit will stay on the screen for 300 milliseconds. Each digit will be followed by a fixation cross for a brief amount of time. Your task is to press the <SPACEBAR> when you see any digit other than 3. Do not press any key when you see the digit 3. Just wait for the next digit. You will do this while looking at the center of the screen and respond as fast and accurately as possible.

N-Back Task – For this task, you will be presented with a sequence of stimuli. Each stimulus will appear in the middle of the screen for a brief period of time. Your task is to press a button when the current stimulus matches the one from 1 step earlier in the sequence. You will do this while looking at the center of the screen and respond as fast and accurately as possible.

Starry Night Task – For this task, you will be presented a series of white dots (representing ‘stars’) on a black screen. Your task is to press a button whenever you detect an appearance or a disappearance of a star. You will do this while looking at the center of the screen and respond as fast and accurately as possible.

Data analysis

To investigate the relationship between task boringness (i.e., prospective state boredom), willingness to engage, and trait boredom, Spearman correlations were calculated. A mediation analysis was conducted using the mediation package in R (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014).

2.4 Study 2.1 Results

All tasks were rated as very boring with a median boringness rating of 4 out of 5 and a median absolute deviation of 1.48 for all tasks. Participants were also generally willing to engage in the task with a median willingness to engage rating of 4 out of 5 and a median absolute deviation of 1.48 for all tasks (see Appendix B for comparisons between tasks for task boringness and willingness to engage ratings). Task boringness scores and willingness to engage scores were averaged across all tasks with the resulting internal consistency of 0.82 for task boringness and 0.79 for willingness to engage (Appendix B). These scores were then subjected to correlational analyses.

Spearman correlations revealed a strong negative association between willingness to engage and task boringness ($r = -0.45$, $p < 0.001$) such that the less willing participants were to engage in the task, the more boring they rated the tasks to be. Additionally, boredom proneness showed a small negative relation to willingness to engage ($r = -0.13$, $p = 0.02$) and a small positive relation to task boringness ($r = 0.12$, $p = 0.02$; Table 2.1).

Table 2.1 Correlations between study variables

	2	3
1. Boredom proneness	-0.13*	0.12*
2. Willingness to engage		-0.45***
3. Task Boringness		

p* = 0.02; * *p* < 0.001

Mediation analysis

The relationship between boredom proneness and perceived task boringness was partially mediated by willingness to engage in the tasks (Figure 2.1). The relationship between boredom proneness and task boringness prior to the inclusion of willingness to engage was significant (B = 0.15, p = 0.003), such that highly boredom prone participants were more likely to perceive tasks to be boring. Following the inclusion of willingness to engage, the relationship between boredom proneness and task boringness remained significant (B = 0.09, p = 0.04) and the relationship between willingness to engage and task boringness was also significant (B = -0.47, p < 0.001), such that the less willing participants were to engage in the tasks, the more boring they rated the tasks to be. To test the magnitude of the mediation, direct and indirect effects were estimated using bootstrapping (with bias-corrected and accelerated (bca) interval estimation). Ten thousand Monte Carlo simulations were used to estimate parameters. Results from the mediation analysis suggest a significant unstandardized indirect effect (B = 0.06, p = 0.02) and a significant unstandardized direct effect (B = 0.09, p = 0.04). Willingness to engage mediated 39% of the relationship between boredom proneness and task boringness (Figure 2.1).

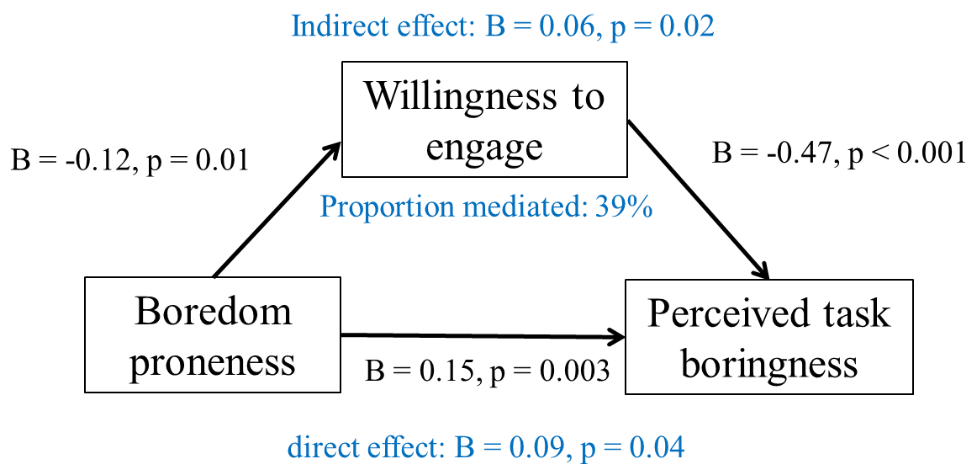

Figure 2.1 Willingness to engage mediates the relationship between boredom proneness and perceived task boringness. All estimates are unstandardized

2.5 Study 2.1 Discussion

Current results support the notion that willingness to engage was negatively associated with boredom. That is, decreased willingness to engage was both higher among the highly boredom prone and was associated with increased prospective judgements of state boredom. Replicating previous research (Dal Mas & Wittmann, 2017; Farmer & Sundberg, 1986), boredom proneness was positively associated with prospective judgements of state boredom. Importantly, willingness to engage served as a significant mediator of this relationship. Although the current design prohibits the firm establishment of a causal relationship among these variables, this pattern of results is consistent with the study hypothesis. Moreover, this study supports the notion that when bored we experience a failure to launch into action, with one potential reason for the failure being a decreased willingness to engage in activities. The current results may of course, be driven by the fact that the tasks described for engagement were intentionally boring and were indeed rated to be highly boring. The next study explored whether the relations observed here would hold when the tasks described were rated as more engaging.

2.6 Study 2.2: Introduction

Study 2.2 parallels that of study 2.1 with the only difference being that the tasks included were chosen to represent appealing – or at least not boring – options for engagement. Based on the results of the previous study, it was hypothesized that willingness to engage would be negatively associated with both prospective measures of state boredom (as operationalized by measures of perceived task boringness) and trait boredom. It was further hypothesized that willingness to engage would mediate the relationship between boredom proneness and task boringness.

2.7 Study 2.2 Methods

Participants

A total of two hundred and sixteen North American participants were recruited from Amazon Mechanical Turk in June 2018. Twenty-eight participants either failed the attentional check, answered randomly or were deemed as bots and were removed. This led to a total number of one hundred and eighty-eight participants (mean age: 36.63 years; SD: 10). Participants received monetary compensation in exchange for their participation. This study received ethics clearance from University of Waterloo office of Research Ethics and participants gave informed consent prior to participating.

Procedure

Participants in this study read descriptions of five tasks (see below). These tasks were; the foraging task, the boggle task, the apple catcher task, and the dot task. The tasks were chosen from experimental paradigms developed in the lab for other purposes[1]. A fifth task was included as a potentially more engaging task selected from traditional neuropsychological test batteries – the Wisconsin Card Sorting Task (WCST; Meier, 1974). Task descriptions were presented in a counter balanced order. After reading each description, participants rated their willingness to engage in the task on a Likert scale of 1 (not willing at all) to 5 (extremely willing). They also rated how boring (i.e., task boringness) and how engaging (i.e., task engagement) they thought the task was using a similar 5-point Likert scale. The task engagement variable was added as a manipulation check to determine whether or not the tasks were indeed perceived to be engaging. Participants also completed the short Boredom Proneness Scale (SBPS; Struk et al., 2017) at the end of the study.

Task descriptions

Foraging task: In this game, your task is to explore a grassy environment and pick as many berries as you can to fill a juice bar within a set time. The juice bar is at the top of the screen. You explore the environment by tapping and dragging your finger along the touch

[1] The reason for choosing some of these tasks was that in an unrelated study and as part of my Masters work, 297 undergraduates had engaged in the foraging task, boggle task, dot task and an N-back working memory task in a within subjects' design. At the end of each task participants were asked to rate how boring they found each task on a scale of 1 (not at all boring) to 7 (extremely boring). All tasks except the working memory task had a median boring rating of 3 out of 7, whereas the working memory task had a median boredom rating of 6 out of 7.

screen. To pick berries, just tap on them. Larger berries are worth more juice than smaller ones. Your goal is to fill the juice bar by picking as many berries as possible.

Dot task: In this game, you will be presented with a random display of black dots and one green dot on your screen. Your task is to connect the dots and create as many variations as possible within a set time. To connect the dots, drag your finger across from one dot to another. You always have to start with the green dot and move from there. The only rule is that lines connecting dots cannot cross each other. The game sets how many variations can be created using all dots without crossing any lines. Your goal is to find all possible ways of connecting the dots by creating as many variations as possible. Points are awarded for each unique completed variation.

Boggle task: In this game, your will be presented with a series of 3x3 grids of letters. The central letter will be highlighted in grey. Your task is to create as many words as you can within a set time. However, each word has to contain the central letter highlighted in grey. Each grid has a minimum of one 9-letter word. Longer words are worth more points than shorter words. Your goal is to get the maximum possible score by creating as many words as possible.

Apple catcher task: In this game, your task is to catch as many falling apples as you can within a set time. Points are awarded for caught apples only. The apples are falling at different rates and speeds. To catch apples, you drag a basket across the bottom of the screen. A counter on the top, middle of the screen shows you how many apples you have collected and the highest score (to be achieved) is on the top left side of the screen. Your goal is to achieve the highest score by catching as many apples as possible.

Wisconsin Card Sorting Task: In this game, you will be presented with multiple cards – each containing different symbols. You will also be presented with a target card. Your task is to match the target card with the presented cards within a set time. However, you will not be told how to match them. After you have made a match, you will be told whether that particular match is right or wrong. Points are awarded for correct matches only. Your goal is to figure out the matching rule and achieve the highest score set by the game.

2.8 Study 2.2 Results

Table 2.2 shows the median ratings for willingness to engage, task boringness and task engagingness for each task (see Appendix B for comparisons between tasks for all three ratings). The median absolute deviation for all ratings was 1.48. As a manipulation check, most tasks were rated to be fairly engaging (rating of 3 out of 5), with the exception of the Boggle task which was more highly rated (rating of 4 out of 5). Scores for willingness to engage, task boringness and task engagement were averaged across all tasks with the resulting internal consistency of 0.72 for willingness to engage, 0.61 for task boringness and 0.72 for task engagement (Appendix B).

Table 2.2 Median ratings for each engaging task

	Willingness to engage	Task boringness	Task engagement
Foraging task	3	3	3
Dot task	3	2	3
Boggle task	4	2	4
Apple-catcher task	3	2	3
Wisconsin card sorting task	3	2	3

Spearman correlations (Table 2.3) replicated associations observed in Study 2.1 and revealed a strong negative association between willingness to engage and task boringness ($r = -0.54$, $p < 0.0001$) such that the more boring participants rated the tasks to be, the less willing they were to engage in them. There was also a strong positive association between willingness to engage and ratings of task engagement ($r = 0.68$, $p < 0.0001$) such that participants who rated the tasks as *being* (prospectively) more engaging were also more willing to engage in them. Furthermore, there was a strong negative association between task engagement and task boringness ($r = -0.59$, $p < 0.0001$) such that the more engaging a task was rated to be, the less boring it was rated. Boredom proneness was yet again negatively related to willingness to engage ($r = -0.25$, $p < 0.001$), and positively related to task boringness ($r = 0.19$, $p < 0.01$). With regards to task engagement, boredom prone individuals tended to rate tasks as less engaging ($r = -0.24$, $p < 0.001$).

Table 2.3 Correlations between study variables

	2	3	4
1. Boredom proneness	-0.25**	-0.24**	0.19*
2. Willingness to engage		0.68***	-0.54***
3. Task engagement			-0.59***
4. Task Boringness			

* p < 0.01, ** p < 0.001, *** p < 0.0001

Willingness to engage as mediator

A mediation analysis was conducted to test whether willingness to engage mediates the relationship between boredom proneness and task boringness, this time with tasks generally rated to be engaging. Results suggested that willingness to engage fully mediated the relationship between boredom proneness and perceived task boringness (Figure 2.2). The relationship between boredom proneness and task boringness prior to the inclusion of willingness to engage was significant ($B = 0.14$, $p = 0.04$), such that highly boredom prone participants were more likely to perceive tasks as being boring. Following the inclusion of willingness to engage, the relationship between boredom proneness and task boringness became insignificant ($B = 0.01$, $p = 0.83$), while the relationship between willingness to engage and task boringness remained significant ($B = -0.6$, $p < 0.001$), such that the less willing participants were to engage in the tasks, the more boring they rated the tasks to be. To test the magnitude of the mediation, direct and indirect effects were estimated using bootstrapping (with bias-corrected and accelerated (bca) interval estimation). Ten thousand Monte Carlo simulations were used to estimate parameters. Results from the mediation analysis suggest a significant unstandardized indirect effect (B = 0.13, p = 0.01) and an insignificant unstandardized direct effect (B = 0.01, p = 0.82). Willingness to engage mediated 91% of the relationship between boredom proneness and task boringness when participants were presented with engaging task descriptions (Figure 2.2).

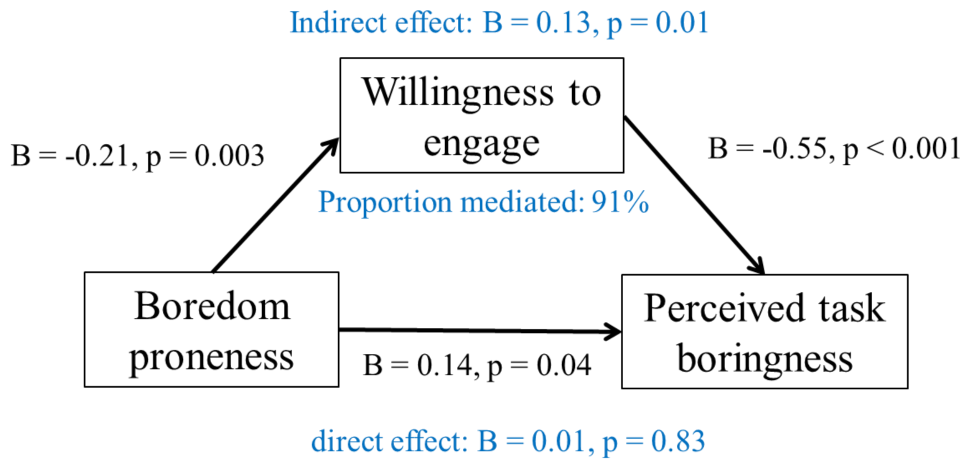

Figure 2.2 Willingness to engage mediates the relationship between boredom proneness and perceived task boringness when participants were presented with engage task descriptions. All estimates are unstandardized

2.9 Study 2.1 Discussion

In a replication of study 2.1, the current study employed tasks descriptions that were assumed to be engaging. Task ratings indicated that they were rated to be reasonably engaging and lower in prospective judgements of boredom than the tasks used in Study 2.1 (Appendix B). As was the case for boring tasks, results showed that those who rated the tasks to be more boring were also less willing to engage in them. This suggests that regardless of the type of task, increased anticipation of experiencing state boredom is associated with decreased willingness to engage. Furthermore, willingness to engage once again mediated the relationship between boredom proneness and task boringness – further highlighting that willingness to engage may be one of the many reasons that boredom prone individuals perceive tasks to be more boring. Given the correlational nature of the current study, it is not possible to infer a definitive causal relationship.

2.10 Discussion

The goal of the current chapter was to test whether decreased willingness to engage was associated with differing levels of both state and trait boredom. Ratings of task boringness were used as a *prospective* measure of state boredom. That is, high task boringness scores indicated that should participants *have* to do this task, they expected it to be boring. In both studies, the more boring participants rated the tasks to be, the less willing they were to engage in tasks (even when the tasks were themselves considered to be engaging). Indeed, Eastwood and colleagues (2012) define the state of boredom as wanting but failing to engage with the environment or task at hand. The authors further suggest that this failure can stem from having to do something you would rather not do. The results of these two studies are the first to provide objective evidence for this claim. Nonetheless, experimental research is still needed to confirm the causal nature of this relationship.

As mentioned in the Introduction, previous work in the lab has shown that boredom proneness is associated with an increased frequency and intensity of experiencing the state of boredom. This in turn provides support for the theoretical characterisation of the so-called 'boredom conundrum' – the fact that the signal indicates the desire to engage in some satisfying activity, coupled with an inability (unwillingness?) to engage in the currently viable options to satisfy that desire, leading to a 'failure to launch' into action (Mugon et al., 2018b). The state boredom signal is felt as uncomfortable precisely because the individual *wants* to engage but not with the options currently available. As such, the current studies show that decreased willingness to engage in the currently available options may be a potential cause for boredom. What remains unclear is what factors lead people to be less willing to engage in tasks? It may be the case that the boredom signal arises when available options for engagement seem too effortful. The next chapter investigates the role of effort regulation on boredom.

Chapter 3: Exploring the relationship between boredom and effort regulation

3.1 Introduction

The theoretical accounts and findings thus far suggest that one's willingness to engage in a task is negatively related to boredom at both the state and trait level. The decreased willingness to engage stills begs the questions of why this is so. One possibility is that when bored, options for engagement may seem like they require too much effort. Inzlicht and colleagues (2018) define effort as an increase of either mental or physical activity. In an investigation of this, Thackray and colleagues (1977) found state boredom to be positively related to subjective perceptions of effort. In their study, participants who reported exerting greater effort to perform a vigilance task over a prolonged period of time also reported greater levels of state boredom compared to those who reported exerting less effort. Various theoretical accounts also posit that a relationship exists between state boredom and effort, although with a more nuanced set of claims (Inzlicht, Shenhav, & Olivola, 2018; Kurzban, Duckworth, Kable, & Myers, 2013; Leary, Rogers, Canfield, & Coe, 1986; O'Hanlon, 1981). For example, O'Hanlon (1981) suggests that state boredom arises during periods of low arousal or under-stimulation. In order to maintain a homeostatic level of arousal (i.e., to alleviate boredom), a person can quit the task, make the task more interesting or if constrained to remain in place, exert effort to maintain arousal at optimal levels. Furthermore, O'Hanlon (1981) claims that effort has a negative affective component that can lead to aversive feelings towards the task or environment that requires it (see also Inzlicht et al., 2018). Therefore, exerting effort to maintain arousal can be particularly hard because effort in itself can push us to avoid the task. In other words, the more effort a task requires, the more aversive the task is felt to be and the more bored one gets. Similarly, Leary and colleagues (1986) have argued that the state of boredom arises as a result of people needing to exert effort to sustain attention to stimuli that are not intrinsically captivating (for example vigilance tasks). More recently, the opportunity cost model suggests that feelings of state boredom, like subjective feelings of effort, indicate that the value of alternative options for engagement is high (Kurzban et al., 2013). As such, as the amount of subjective effort required to continue engaging in the current task increases, so too does state boredom. These theories point to the cyclical relationship between boredom and effort. Failure to exert effort can lead to feelings of boredom which in turn further decreases one's willingness to exert effort.

With regards to trait boredom, previous research has found a positive association between boredom proneness and perceived effort (Farmer & Sundberg, 1986; Leong & Schneller, 1993). Farmer & Sundberg (1986) found that high boredom prone individuals rated everyday tasks such as performing well in school and entertaining oneself when alone, to be more effortful. Moreover, Leong and Schneller (1993) found that high boredom prone individuals reported being less likely to persist with everyday tasks compared to their low boredom prone counterparts. These findings suggest that boredom prone individuals perceive tasks as subjectively more effortful which may in turn impact their willingness to engage thereby further increasing their propensity to be bored. Taken together, these findings suggest that subjective effort is positively related to boredom at both the state and trait level.

3.2 Study 3.1

The current study explored the relationship between boredom (state and trait) and effort regulation using an effort discounting paradigm previously shown to elicit varying levels of effort (Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009). In this study, participants were required to make a choice between a hard or an easy task on a trial-by-trial basis (Treadway et al., 2009). If state boredom, in part, reflects a sense that engagement (in whatever task) is 'too effortful', then higher ratings of state boredom would be expected to lead to a greater proportion of easy task choices. This study also explored the relationship between boredom proneness and effort discounting with the hypothesis that boredom prone individuals would also discount hard options in favor of easier ones.

3.3 Study 3.1 Methods

Participants

One hundred and forty-two undergraduates (112 females, mean age = 19.92 (1.72) years) participated in this study in exchange for course credit. Data was collected throughout the Winter 2019 term. It was decided a priori that data collection would continue until the end of the term. This study received ethics clearance from the University of Waterloo Office of Research Ethics and participants gave informed consent prior to participating.

Measures and Procedure

As with previous studies all participants completed the boredom proneness scale as part of online testing at the beginning of term.

EEfRT – Effort Expenditure for Rewards Task. The EEfRT (Treadway et al., 2009) was designed to assess decision-making behaviors based on monetary rewards. On each trial, participants have five seconds to choose between either a “hard” or an “easy” task. For the hard task, participants used their little finger of their non-dominant hand to make 100 button presses in 21 seconds. For the easy task, participants made 30 button-presses in 7 seconds using their index finger of their dominant hand (Figure 3.1). If participants did not make a choice, a random trial was generated for them. Participants made their decision based on two factors – the reward value associated with each task and the probability of winning that reward. For the easy tasks, participants had the chance to win $1 on each trial if they successfully completed it. For the hard tasks, participants could win between $1.24 - $4.30. Their chances of winning money after each successful trial were divided into three probability categories: 12%, 50% and 88% chances. These probability categories were clearly indicated on each trial for both the easy and hard tasks. On each trial, an initial fixation cross was presented for 1 second followed by a 5-second choice period during which participants were explicitly provided the respective reward amount and the probability of winning for both the easy and hard tasks (Figure 3.1). Next, participants were shown a “ready” screen for 1 second and then a ‘button press’ screen indicating they should being that trial. Each button press raised the level of a virtual ‘battery’ which participants could see on the screen. Following task completion, participants were shown a 2-second feedback screen which informed them whether they successfully completed the task. If participants were successful, another feedback screen appeared for 2 seconds which detailed the amount of money won for that trial (Figure 3.1). Participants were also informed that at the end of the study, they would receive the monetary reward from two randomly selected completed trials.

Participants were informed that the task would last 20 minutes regardless of whether they chose more of the easy or hard tasks. Treadway and colleagues (2009) state that the multiple components of this task (different rewards levels, probability of winning, loss of time for future trials) does not allow for a formal calculation of an optimal strategy for engagement. Furthermore, participants only had a small amount of time to make a decision on each trial, which according to Treadway and colleagues (2009) reflected individual differences in the willingness to expend effort for a given level of expected reward as opposed to an optimal strategy for engagement. These task characteristics were advantageous for this study as they helped differentiate whether differing levels of either state or trait boredom would lead to different rates of discounting the hard task in favor of the easy task. Indeed, the effort discounting threshold is the point at which a participant deemed the reward to be too low to be worth their effort (i.e., effort discounting).

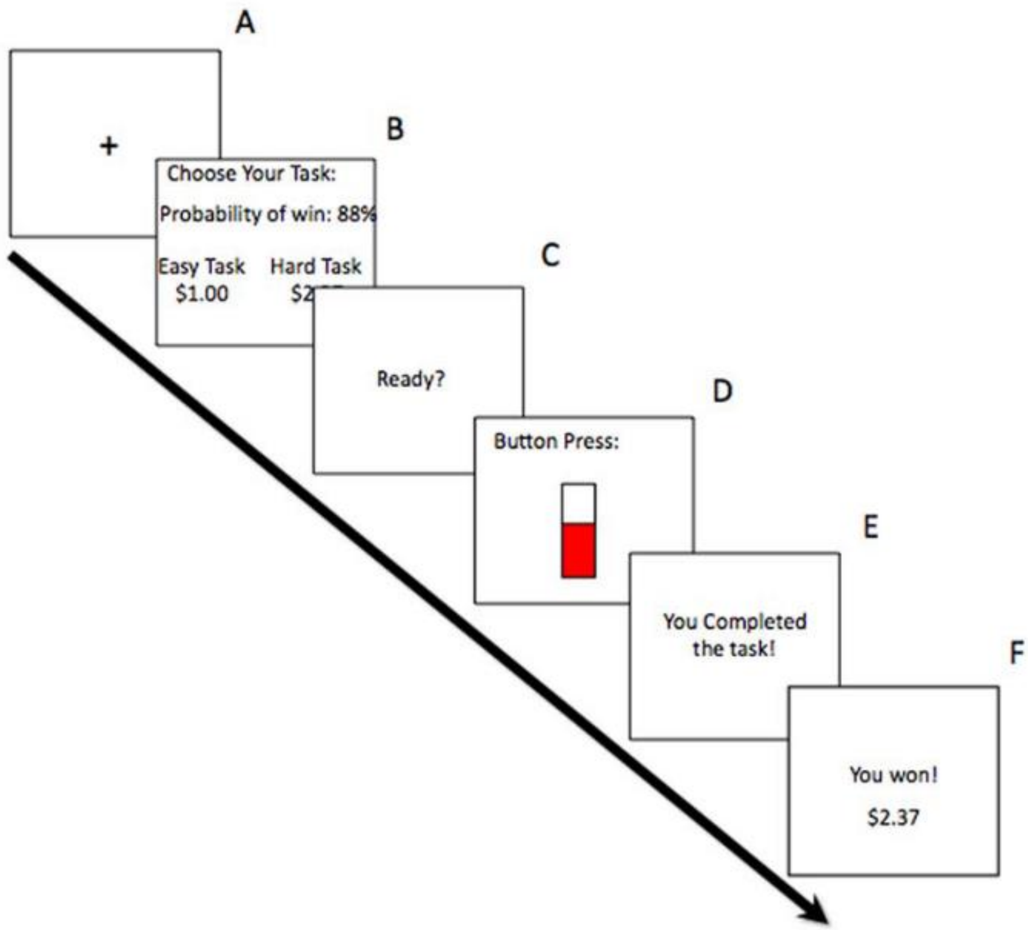

Figure 3.1 Schematic example from Tredway et al., (2009) of one trial of the EEfRT. In this trial, a participant chose the hard task with an 88% probability of wining and received a monetary reward of $2.37 after successfully completing the task.

Pre and post EEfRT subjective measures. Prior to starting the task, participants rated their current state boredom and how difficult they thought the task would be. After completing the task, participants once again rated their state boredom and how difficult they thought the task was. Both measures were taken using a Likert scale of 1 “not at all” to 7 “extremely.” Note that other measures were added for exploratory purposes (for a complete list of questions see Appendix C).

Data Analyses

A few metrics were calculated from the EEfRT. First, the effort discounting threshold was quantified by the proportion of hard tasks chosen (i.e., the proportion of hard tasks chosen given the total number of tasks completed). Second, an average Expected Value (EV) for the hard task was calculated for each participant. The EV represented the average amount of reward by probability of success for hard choices (i.e., if the reward is high but probability low, expected value will be low). Third, mean proportions of hard-task choices were calculated for all participants across each level of probability (12%, 50%, and 88%). Finally, difference scores between the pre and post self-report measures (post minus pre) were calculated to determine whether these metrics changed over time. Higher difference scores indicate that participants believed the task was more difficult than they had expected it to be before playing. Positive scores for state boredom would indicate that participants experienced an increase in state boredom as the task progressed.

Given that the easy tasks took 7-seconds to complete and the hard tasks took 21 seconds to complete, the number of trials that participants completed within the 20-minute interval varied (mean trials completed = 70, SD = 10, range = 47 – 101 trials). Repeated measures ANOVA was used to test whether there were any differences in the proportion of hard task choices for each probability level. Correlational analyses were performed to determine the relation amongst variables. Regression analyses were used to test whether the proportion of hard-task options predicted state boredom by the end of the task.

3.4 Study 3.1 Results

Table 3.1 shows the median and median absolute deviation for all study variables.

Table 3.1 Median and Median absolute deviation for study variables

Study Variable	Median (median absolute deviation)	Study Variable	Median (median absolute deviation)
Boredom proneness	23 (8.9)	Pre state boredom	3 (1.48)
Prop Hard	0.37 (0.14)	Post state boredom	4 (2.22)
EV for hard tasks	2.13 (0.39)	State boredom diff	0 (1.48)
P-low	0.10 (0.15)	Pre difficulty	5 (1.48)
P-mid	0.30 (0.19)	Post difficulty	4 (1.48)
P-high	0.61 (0.24)	Difficulty diff	0 (1.48)

P-low = mean proportion of hard-task choices for 12% probability trials; P-mid = mean proportion of hard-task choices for 50% probability trials; P-high = mean proportion of hard-task choices for 88% probability trials; diff = difference score (post – pre)

Overall, participants chose easy-tasks 61.73% of the time. Non parametric repeated measures ANOVA using the JMV package (The Jamovi project, 2020) demonstrated a significant main effect of probability level on the proportion of hard task choices (X^2 (2) = 186, p < 0.001). Pairwise comparison using the non-parametric Durbin-Conover method indicated that for hard task choices, participants were more likely to choose the high probability options compared to the low (Statistic = 23.1, $p < 0.001$) and mid (Statistic = 12.6, $p < 0.001$) probability options. Participants were also more likely to choose the mid probability options compared to the low probability options (Statistic = 10.5, $p < 0.001$). For conciseness, only correlations between task metrics, post task measures of boredom and difficulty, and boredom proneness are shown in Table 3.2 (see Appendix C for a correlation table with all task variables). Difference scores were not included as there was no change in boredom, or task difficulty over the course of the task.. It was hypothesized that boredom (both state and trait) would be negatively associated with proportion of hard task options. As such, Bonferroni corrections were only applied to correlations that involved boredom – which resulted in 13 corrections (*Italicized* in Table 3.2)

Table 3.2 Spearman correlation between study variables

	1	2	3	4	5	6	7
1. Prop. Hard							
2. EV	-0.50****						
3. P-low	0.70****	-0.74****					
4. P-mid	0.90****	-0.52****	0.57****				
5. P-high	0.73****	0.06	0.14	0.53****			
6. Post bored	*-0.24*^{sig*}	*0.03*	*-0.13*	*-0.19*	*-0.24*		
7. Post difficult	0.03	-0.08	0.11	-0.03	0.01	*-0.33****	
8. SBPS	*0.02*	*-0.02*	*0.00*	*-0.02*	*0.06*	*0.07*	*-0.07*

SBPS = Short boredom proneness scale; Without Bonferroni: * p < 0.05; ** p < 0.01; *** p < 0.001; **** p < 0.0001. *With Bonferroni (italicized only)* * p < 0.004; ** p < 0.001; *** p < 0.0001; **** p < 0.00001; sig* - without Bonferroni correction although relationship was hypothesized.

Post task boredom was negatively correlated with proportion of hard task choices (r = -0.24, p = 0.01) such that bored participants were more likely to choose easy-task options. Post task boredom was also negatively correlated with post task difficulty (r = -0.33, p <

0.001) such that the more bored participants felt by the end of the task, the less difficult they rated the task to be. Trait boredom proneness was not correlated with any behavioural metric or task measure.

Regression analyses were used to test whether the proportion of hard task choices was predictive of post-task state boredom while accounting for boredom at the beginning of the task. Results suggest a significant relationship for both variables ($F(2,139) = 12.76$, $p < 0.001$) such that the proportion of hard-task choices was a negative predictor of post task state boredom ($B = -1.7$, $p = 0.035$), while pre-task boredom was a positive predictor of post task boredom ($B = 0.4$, $p < 0.001$). In other words, when accounting for baseline boredom, choosing the easy task led to higher levels of state boredom at the end of the task.

3.5 Study 3.1 Discussion

Overall, participants chose easy tasks more than hard tasks. Pre-task boredom was correlated with post task boredom ($r = 0.36$, $p < 0.001$, Table C.3 in Appendix C) suggesting that those who were bored prior to starting the task tended to remain bored by the end. Pre-task boredom was also associated with the proportion of hard-task choices ($r = -0.2$, $p = 0.02$, Table C.3 in Appendix C) suggesting that boredom may have led participants to choose fewer hard task options. These results support an opportunity cost model of effort regulation (Kurzban et al., 2013) which suggests that not only perceived effort, but also boredom arises because the current task is unengaging and thus characterized by high opportunity costs. This in turn motivates us to reduce the amount of effort we dedicate to the current task (i.e., selecting more of the easy options). However, a third variable affecting boredom and choice cannot be fully ruled out with the current design. When accounting for pre-task boredom, the proportion of hard-task options was negatively associated with post task boredom, such that choosing fewer hard task options was associated with elevated post-task boredom. This finding suggests that the propensity to choose less effortful tasks may both be *driven* by higher perceived effort and boredom while simultaneously *contributing* to elevated perceptions of effort and boredom. With the current design it is not possible to determine whether the behavior preceded boredom.

Previous research has also shown that people are generally aversive to effort expenditure (Dunn, Koehler, & Risko, 2017; Inzlicht et al., 2018; Kurniawan et al., 2010; Potts, Pastel, & Rosenbaum, 2018). That is, people do not like tasks that require effort – instead preferring tasks that are less effortful. Indeed, participants chose the easy task on the majority of trials (61.73%). Yet, this aversion to effort can exacerbate state boredom. This is consistent with O'Hanlon's (1980) theory of boredom which states that when constrained to remain in place, exerting effort should keep boredom at bay. Participants engaged in the EEfRT for 20 minutes and may have felt compelled to keep doing the task. Given that effort expenditure is aversive, they may have been more likely to choose the easy-task options. This is further supported by the opportunity cost model (Kurzban et al., 2013), which states that boredom signals the possibility that other, more rewarding options for engagement exist relative to our current task. In unconstrained circumstances rising opportunity costs should prompt individuals to explore other options for engagement. In the constrained setting of laboratory experiments, where this is not feasible, participants instead chose the easy way out.

The current study found no association between boredom proneness and effort discounting. This suggests that while boredom prone individuals rate everyday tasks to be more subjectively effortful (Farmer & Sundberg, 1986), these perceptions may not translate to objective behaviour. That is, when faced with options that differ in the amount of effort required, highly boredom prone individuals were equally likely to choose the hard-task option as were low boredom prone individuals. There are a few other potential explanations for the failure to find any such associations here: 1) as mentioned, prior research focused on subjective reports of the effort related to *everyday* tasks; 2) the nature of the current tasks may not have been sensitive enough to differentiate performance of high vs. low boredom prone participants; and 3) the participant pool was fairly low in boredom proneness (median boredom proneness scores were below the midpoint of the scale). Future research should aim to recruit participants who score both high and low on the boredom proneness scale to further assess whether trait differences in boredom proneness influences effort regulation.

Results from the current study suggest that a decreased willingness to exert effort can lead to state boredom. In this study, participants had some level of control over their environment (i.e., they were able to choose between one of two tasks). The next chapter investigates another potential contingency related to state boredom – that of control over one’s environment.

Chapter 4: Exploring the relationship between boredom and autonomy

4.1 Introduction

Participants in the previous study had some level of control over how they proceeded through the experiment. The freedom to choose our actions or the ability of an agent to enact certain specific actions within their environment (i.e., one's sense of autonomy, control, or agency; Skinner, 1996) may also play a role in the experience of boredom. The use of the term 'control' here is meant to invoke one's sense of autonomy (or choice) in any given circumstance, as well as one's sense of agency – that we are the authors of our own actions (Bandura, 2006; Skinner, 1996). The first study presented in this chapter examined the role of control in state boredom, whereas the second investigated the role played by choice in the experience of boredom.

Previous research has found that the state of boredom is associated with a perceived sense that one lacks control (Caldwell, Darling, Payne, & Dowdy, 1999; Dember, Galinsky, & Warm, 1992; Martin, Sadlo, & Stew, 2006; Shaw, Caldwell, & Kleiber, 1996; Steinberger, Moeller, & Schroeter, 2016; van Hooft & van Hooff, 2018). For example, Caldwell and colleagues (1999) investigated the experience of boredom during adolescent's free time and found that a perceived lack of control was predictive of boredom such that the less control adolescents had over their free time, the more bored they felt. Similarly, Shaw and colleagues (1996) found that lack of choice was positively associated with boredom experiences in adolescents. Within the driving context, Steinberger and colleagues (2016) found that drivers who experienced boredom also reported feeling stuck or trapped. Similarly, Martin and colleagues (2006) found that perceived lack of control and work obligations functioned as antecedents to boredom at work.

Experimentally, van Hooft and van Hooff (2018) presented participants with four task options and manipulated control such that in the high-control condition, participants were told they could choose the order in which they completed the tasks, whereas in the low control condition participants were specifically told the order in which tasks were to be completed. Those in the low-control condition found the tasks to be more boring, more frustrating and felt as though they has less control than those in the high control condition. Finally, Dember and colleagues (1992) examined the influence of an illusory choice on performance of a vigilance task. Participants were told in one condition (i.e., high choice) that they could choose between an easy or a hard task, whereas no such choice was given in the low choice condition. In reality, all participants performed the same hard task. Despite performing the same task, results showed that those in the high choice condition were more accurate at detecting changes compared to those in the so-called no choice condition. While state boredom was not measured in this study, there is some indication from previous research that boredom is positively associated with attentional failures in everyday tasks and on laboratory tests of vigilance (Carriere et al., 2008; Damrad-Frye & Laird, 1989; Hunter & Eastwood, 2018; Malkovsky et al., 2012). Therefore, those who experienced more attentional failures (i.e., in the no choice condition) may well have been more bored than those who experienced fewer attentional failures (i.e., the choice condition).

While these findings suggest a positive relationship between perceived lack of control and boredom, other theoretical accounts and research findings suggest that both low and high control situations could lead to boredom. For example, Elpidorou (2018) suggests that boredom does not only arise when we feel constrained but also when we "…are free to act as we see fit" (p. 467) – suggesting that too much control can also lead to boredom. Similarly, within academic contexts, Pekrun's (2006) control-value theory suggests that boredom will be experienced if an activity lacks value and individuals have too much *or* too little control over the activity (see also Pekrun et al., 2002). Pekrun and colleagues (2010a) asked students to evaluate their recent class or study session and found that students felt bored in situations where they perceived themselves as having either low- or high-control. Furthermore, they found that trait academic boredom (i.e., the propensity to be bored in academic settings) was negatively correlated with achievement-related perceptions of control (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010a). Other findings suggest that the more students felt that their instructors gave them control over their learning (by encouraging students to ask questions, giving students options and choices over tasks), the less bored they felt in class (Tze, Klassen, & Daniels, 2014). Additionally, giving students choices on tasks has led to students reporting greater positive rather than negative attitudes towards the tasks (Flowerday & Schraw, 2003; Flowerday & Shell, 2015).

Taken together, findings from achievement settings suggest that there may be an optimal 'Goldilocks' level of control that is ideal for engagement and that will likely keep boredom at bay (Danckert et al., 2018; Pekrun, 2006; Pekrun et al., 2010). By extension, these findings also suggest that the relationship between boredom and different levels of control is expected to be U-Shaped – with those who experience low and high levels of control being more bored than those who experience moderate levels. This is in contrast with other experimental findings that suggests a negative linear relationship between boredom and control (van Hooft & van Hooff, 2018). In a direct investigation of this U-shaped relationship between control and boredom, Struk and colleagues (2015) had participants play 'Rock-Paper-Scissors' against a computer in which participants either arbitrarily won (high control) or lost (low control) all matches. Participants were periodically probed for their subjective sense of control, challenge, state boredom and frustration. Despite objectively dichotomous conditions, participants reported experiencing varying levels of control. Furthermore, those who reported very high or very low levels of control also experienced higher levels of state boredom compared to those reporting intermediate levels of control – thereby supporting the U-Shaped relationship between boredom and control. However, this study confounded varying levels of challenge. That is, participants in the low control condition perceived the task to be more challenging than those in the high control condition (Struk, Scholer, & Danckert, 2015), probably because participants in this condition never won regardless of their play choices, whereas those in the high control condition may not have perceived the task as challenging because they won all the time. As such, study 4.1 attempted to directly investigate the influence of control on boredom while keeping variables such as challenge and meaning constant, whereas study 4.2 investigated whether different levels of choice (i.e., how much control participants have) predicted state boredom.

4.2 Study 4.1

The current study attempted to disentangle control from challenge and to more directly examine the influence of control on state boredom. Participants viewed a slideshow with objectively neutral images which they were asked to rate in terms of how much they liked them. This task was selected because there is no explicit competitive or challenging aspect to it and as such it was expected that all participants would perceive the task to be low in challenge. Those in the high control condition had the ability to scroll through the images at a pace of their choosing, whereas those in the low control condition did not have such control. Instead, their viewing times were yoked to the timing of those in the high control condition. It was hypothesized that those in the high control condition would feel more in control compared to those in the low control condition. With regards to boredom, one of two possibilities were plausible: either the high control condition will induce lower levels of state boredom than the low control condition – a hypothesis in conjunction with van Hooft & van Hooff (2018) findings. Alternatively, state boredom could be highest for those rating the task to be either very low or very high in control, replicating the U-shaped relationship between boredom and control seen in the Struk and colleagues (2015) study (see also Pekrun 2006; Pekrun et al., 2010).

Furthermore, it was hypothesized that those who experienced high control and low boredom would rate the neutral pictures as more pleasant than those who experienced low control and high boredom. At the end of the experiment, participants were given a surprise memory test to examine the potential influence of state boredom on memory performance.

While the influence of control on memory is exploratory, it was hypothesized that bored participants would perform more poorly compared to non-bored participants on this test. Finally, the relationship between boredom proneness, state boredom and control was also explored.

4.3 Study 4.1 Methods

Participants

One hundred and twenty undergraduates (92 females, mean age = 19.84 (2.12) years) participated in this study in exchange for course credit. Data was collected throughout the Winter, and Fall terms of 2019. It was decided a priori that data collection would continue until at least n = 60 was attained for each condition. This study received ethics clearance from the University Of Waterloo Office Of Research Ethics and participants gave informed consent prior to participating.

Measures and procedure

Participants completed the boredom proneness scale (Struk, Carriere, Cheyne, & Danckert, 2017) as part of a larger battery of questionnaire at the beginning of the term. For the in-lab portion, seventy-five neutral images were selected from the International Affective Picture System (IAPS) database (Lang et al., 1997). All selected images were empirically rated as not arousing with a mean arousal rating of 2.72 out of 7 (SD = 0.31) using a Likert scale of 1 – not arousing at all to 7 – extremely arousing. That is, these images were selected so as to elicit a neutral affective response from participants. The images were also rated to be somewhat likeable with a mean rating of 4.98 out of 7 (SD = 0.35) using a Likert scale of 1 – extreme dislike to 7 – extremely like. Images were presented to participants using a 21" monitor and participants were seated approximately 75 centimeters away from the monitor.

This study employed a between subjects designs. Participants in the high control condition were able to flip through the images at their own pace by pressing the space bar on the keyboard. That is, they could view each image for as long (or as short) as they wished. Images were presented in a randomized order and following each image, participants were asked to rate how much they liked the displayed image on a Likert scale from 1 – "extremely dislike" to 7 – "extremely like." This was done to draw attention away from the true purpose of this study. For every participant who experienced the high control condition, one participant was yoked to their viewing times and order of image presentation in the low control condition. This meant that participants in the low control condition did not have any control over the speed at which the images were presented. Participants in this condition also rated how much they liked each displayed image.

At the end of this task, participants were asked to fill out a state measure questionnaire containing seven statements using a Likert scale of 1 – "*not at all"* to 7 – *"extremely"*. Items in the questionnaire included: 1) I controlled how this task progressed, 2) I felt like I was in complete control of what happened in this task, 3) I found this task to be boring, 4) I was bored while doing this task, 5) I felt this task was challenging, 6) This task was frustrating, 7) I found this task to be meaningful. Questions were presented in a randomized order. Boredom and control were each measured using two questions in order to ensure that participants' experiences were accurately captured. The challenge and meaning questions were included as manipulation checks as this task was designed to have little to no challenge or meaning. The frustration question was intended to explore whether participants would report greater boredom and frustration due to lack of control. Findings from Struk and colleagues (2015) suggest that participants who experienced low control reported both increased boredom and frustration compared to those who reported high control.

Following these state ratings, participants performed a surprise two-alternative force choice memory test for the images they had just seen. The goal of this surprise memory test was two-fold; first it acted as an attentional check and provided information on whether participants truly paid attention to the task and second it allowed the exploration of whether different levels of boredom and control influenced memory performance. Indeed, past research has demonstrated that boredom is associated with lapses in attention and memory (Carriere et al., 2008; Goldberg et al., 2011; Malkovsky et al., 2012). For the memory test, 75 additional neutral images were selected from the IAPS and these were intermixed with 25 randomly selected images from the previous task. Participants were presented with one image at a time and they had to indicate whether they had previously seen the image. Participants were told to press the 'd' key on their keyboard if they recognized the image as an 'old' image (i.e., they had seen it previously) or the 'j' key if it was a 'new' image (i.e., they had not seen it before).

Data analyses

Behavioural metrics included the average time participants spent per slide for those in the high control condition, the average 'liking' ratings per condition and the proportion of correct answers for the memory test. The responses to the two control and boredom questions were averaged separately to create a single measure of perceived control and state boredom (see Appendix E for individual ratings). Independent samples t-tests were used to determine any differences in state measures between groups and correlational analyses were used to explore the influence of boredom on task measures and states. To investigate the potential for a U-shaped relation between boredom and control, regression analyses were fitted with a quadratic function. All data analyses were conducted in R (R Core Team, 2015).

4.4 Study 4.1 Results

Table 4.1 shows the median and median absolute deviation for all study variables.

Table 4.1 Descriptive statistics for study variables

	Conditions			
	High control condition (n = 60)		Low control condition (n = 60)	
1.	Control	5.5 (1.48)	Control	3.75 (1.85)
2.	Boredom	3.25 (1.85)	Boredom	3.5 (1.48)
3.	challenging	1 (0)	challenging	1 (0)
4.	frustrating	1 (0)	frustrating	1.5 (0.74)
5.	meaningful	3 (1.48)	meaningful	3 (1.48)
6.	Total Correct	97 (2.97)	Total Correct	96 (2.97)
7.	Av. rating	3.97 (0.36)	Av. rating	4 (0.369)
8.	Av. Time	1.54 (0.51)	Average Time	1.54 (0.51)
9.	SBPS	25 (8.9)	SBPS	23 (8.9)

Total correct = total number of correct answers on memory test (out of 100); Av. Rating = average rating of pictures based on a Likert scale of 1 – "*not at all"* to 7 – *"extremely."* Av. time = average time in seconds spent on each slide. SBPS = Boredom proneness scale

Wilcoxon Signed rank test showed that the manipulation of control worked such that those in high control condition reported higher levels of perceived control (median = 5.5; mean = 5.26) than those in the low control, yoked condition (median = 3.75, mean = 3.71, $W = 2832.5$, $p < 0.001$). However, there was no significant difference between conditions in how bored participants felt ($W = 1790.5$, $p = 0.96$). That is, participants reported similar levels of state boredom regardless of whether they had low or high control. The challenge and meaning variables were included to account for potential confounding variables with results suggesting that there were no significant differences between conditions for meaning (W = 1873.5, p = 0.7) but there was a significant difference for challenge (W = 1485, p = 0.04), such that participants in the low control condition found the task to be more challenging (median = 1, mean = 1.62) compared to the high control condition (median = 1; mean = 1.32). Although significantly different, both groups reported experiencing very low levels of challenge from the task. Furthermore, results suggested no significant differences in how frustrated participants in the different conditions felt (W = 1537, p = 0.13). Participants in both conditions rated the pictures as equally neutral (W = 1846.5, p = 0.81) and performed equally well on the following memory test (W = 1984, p = 0.33).

Next, Spearman correlations between all study variables in each condition were examined, separately. Table 4.2 shows the correlation for participants in the high control condition. The goal of this study was to investigate the relationship between perceived control and state boredom. As such, Bonferroni corrections were only applied to correlations involving state boredom – which resulted in 8 corrections in each of the two conditions (*Italicized* in table). Results suggest no association between state boredom and control. There was a negative association between boredom and meaning (r = -0.39, $p < 0.01$) such that the more bored participants were, the less meaningful they rated the task to be. With regards to trait boredom, boredom proneness was not significantly associated with any study variables (although prior to Bonferroni correction, boredom proneness was positively associated with state boredom r = 0.33, $p < 0.05$). No other significant correlations were found.

Table 4.2 Correlations between study variables for high control condition

	1	2	*3*	4	5	6	7	8
1. SBPS								
2. Control	0.23							
3. Boredom	*0.33*	*0.09*						
4. challenging	0	-0.17	*0.07*					
5. frustrating	0.24	-0.14	*0.32*	0.26*				
6. meaningful	0.11	-0.18	*-0.39**	0.17	-0.24			
7. Total Correct	-0.25	0.2	*-0.19*	-0.13	-0.14	-0.12		
8. Av. Time	-0.19	0.13	*-0.03*	0.1	0.05	0.12	0.27	
9. Av. Rating	-0.1	-0.19	*0.04*	0	-0.04	-0.05	-0.1	0.05

SBPS = boredom proneness scale; Total correct = total number of correct answers on memory test (out of 100); Av. Time = Average time per slide in seconds. Av. Rating = Average rating of pictures; With Bonferroni correction (italicised): * $p < 0.006$; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$

Table 4.3 shows the correlations for participants in the low control condition. There was a significant positive association between state boredom and frustration ($r = 0.43$, $p < 0.001$), such that bored participants were more likely to perceive the task as frustrating. Similar to the full control condition, there was a negative association between state boredom and meaning for those in the low control condition ($r = -0.51$, $p < 0.001$), such that the more bored participants were, the less likely they were to perceive the task as meaningful. There was also a significant negative relationship between how bored participants felt by the end of the slideshow task and how well they performed on the subsequent memory test ($r = -0.43$, p

< 0.001), such that those who were more bored by the end of the slideshow task performed more poorly in the subsequent memory test. With regards to trait boredom where no Bonferroni corrections were applied, boredom prone participants were more likely to perceive the slideshow task as more challenging (*r* = 0.27, p < 0.05).

Table 4.3 Correlations between study variables for low control condition

	1	2	*3*	4	5	6	7	8
1. SBPS								
2. Control	0.03							
3. Boredom	*0.05*	*-0.2*						
4. challenging	0.27*	-0.11	*-0.07*					
5. frustrating	0.11	-0.32*	*0.43***	0.38**				
6. meaningful	0.14	0.17	*-0.51****	0.22	-0.26			
7. Total Correct	-0.06	0.14	*-0.43***	0.12	-0.22	0.23		
8. Av. Time	-0.18	0.18	*-0.06*	-0.08	0.05	-0.02	0.15	
9. Av. Rating	0.17	0.23	*-0.28*	0.1	-0.1	0.22	0.24	0.05

SBPS = boredom proneness scale; Total correct = total number of correct answers on memory test (out of 100); Av. Time = Average time per slide in seconds. Av. Rating = Average rating of pictures; With Bonferroni correction (italicised): * p < 0.01; ** p < 0.001; *** p < 0.0001; without Bonferroni correction: * p < 0.05, ** p < 0.01

In order to test for a quadratic relationship between boredom and control, conditions were collapsed so that a full range of control scores could be obtained. Scores on the control measure ranged from 1 to 7 with a median of 5.4 and a mean of 4.49.The overall model fit was non-significant ($F(2,117) = 0.07$, $p = 0.94$) – neither a linear (β=0.00, p=0.971), nor a quadratic (β= -0.03, $p = 0.719$) relationship was significant.

4.5 Study 4.1 Discussion

The manipulation of control was successful with those in the high control condition experiencing greater perceptions of control than those in the low control condition, although it is worth pointing out that both conditions reported experiencing moderate to high levels of control. The two groups did not differ in terms of how frustrating or meaningful they found the task to be. Of note, participants in both conditions found the task to be not at all frustrating (median rating between 1 and 1.5), moderately meaningful (median rating of 3) and rated the neutral pictures as equally likeable (median rating between 3.97 and 4). With regards to boredom, participants were equally bored in both conditions (median rating of 3 in both conditions). Current results are contrary to those found by van Hooft & van Hooff (2018) in which participants in a high control condition experienced less state boredom than the low control condition. These results also suggest a negative relationship between perceived task meaningfulness and boredom, such that the less meaningful participants found the task to be, the more bored they were. This is consistent with prior work on the relation between situational meaning and boredom (Chan et al., 2018; van Tilburg & Igou, 2012; van Tilburg & Igou, 2011).

While efforts were made to keep challenge constant throughout the task, the low control group found the task to be more challenging than the high control group, suggesting that perception of challenge was a confound here. However, it should be noted that while there was a difference between groups on challenge, the mean for both groups on the measure was very low, suggesting that the task itself was generally not felt to be challenging.

This also suggests that control and challenge are intrinsically related to one another such that low perceived control can promote perceptions of challenge during a task. It may be the case that any manipulation of control cannot be successfully isolated from manipulations of challenge. In studies that have attempted to do so (e.g., in Pekrun, 2010), those who reported higher state boredom together with high perceived control may have been bored because the task was in fact, not challenging enough. Conversely, those who reported higher state boredom due to low perceived control may have been bored because the task was *too* challenging. Support for the first part of this hypothesis comes from Csikszentmihalyi's (1975) conception of boredom where the state arises when there is a mismatch between skill level and challenge. That is, boredom arises when challenge is low and the individual's ability to do the task is high (signifying high perceived control). Support for the second part of this hypothesis comes from Pekrun and colleagues (2010a) who propose that boredom within achievement settings is likely to arise because learning tasks are inclined to be challenging and student's ability to do the task are more likely to be moderate to low (signifying moderate to low perceived control). Given that perceptions of control were moderate to high in the current study (high control median = 5.5; low control median = 3.75), it suggests that the manipulation may not have sufficiently dampened perceived levels of control in the low control group to lead to rising feelings of boredom. Alternatively, the low ratings of challenge in both groups may reflect the fact that both conditions led to equivalent feelings of boredom due to poor skill-challenge fit (i.e., high control, low challenge).

4.6 Study 4.2

Given the ambiguous manipulation of control and challenge in the previous study, the current study took a different approach to further investigate the relation between perceived sense of autonomy/control and the experience of boredom. Based on the experimental procedure of previous studies, control was operationalized by the amount of choice participants were given (Dember et al., 1992; van Hooft & van Hooff, 2018). Specifically, the current study had two research questions: 1) Would having *continual options* for choice over what to do lead to less boredom than having no choice? It was hypothesized that continual choice would lead to less boredom. 2) Would participants who had an *initial* choice be less bored than those who were randomly assigned to a task? It was hypothesized that those who at least had an initial choice of what to engage in would be less bored compared to those who did not have such a choice. Exploratory analyses also examined whether trait boredom proneness influenced any of the relationships hypothesized in the first two questions. It was hypothesized that high boredom prone participants may switch more between tasks when given the choice – indicative of difficulty sustaining attention on a single task.

4.7 Study 4.2 Methods

Participants

Two hundred and fifty-two undergraduates (188 females, mean age = 20.27 (2.27) years) participated in this study in exchange for course credit. It was decided a priori that data collection would start at the beginning of Winter 2018 and finish at the end of the term. As such, there were a total of 71 participants in the continual choice condition, 53 participants in the yoked condition, 63 participants in the initial choice condition and 66 participants in the no-choice condition. This study received ethics clearance from the University of Waterloo Office of Research Ethics and participants gave informed consent prior to participating.

Measures and Task description

Choice task. Autonomy was operationalized by giving participants choice over the tasks they could engage in and by manipulating the nature of those choices. At the beginning of the study participants were presented with condition specific instructions (below), three task descriptions and, a button corresponding to each task option (Figure 4.1). The tasks that were chosen for this study were the SART, the COVAT, and the Stroop task. The reasoning behind choosing such tasks was that if participants were presented with interesting tasks, they might develop a personal preference for a specific task. Any such preference would act as a confound to the stated goal of examining the influence of choice on state boredom. As such participants were presented with equally boring tasks (based on study 2.1, the median task boringness rating for each of the above tasks was 4 out of 5, corresponding to a rating of "very boring") with the reasoning being that participants would not express any particular affinity towards any single task. All tasks were programmed using Psychopy 3.0 and presented on a 27" monitor with a screen resolution of 2560 x 1440 pixels and a refresh rate of 60 hertz. Participants used a mouse and a keyboard to make responses throughout the study.

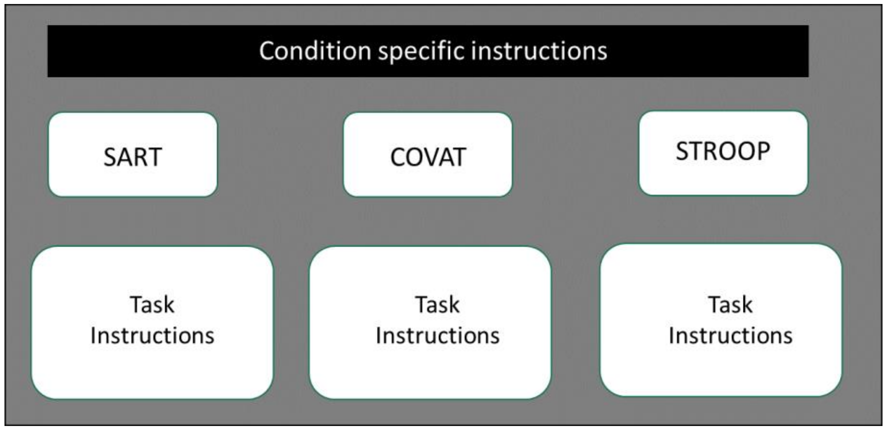

Figure 4.1 A screen shot of the choice study. All participants saw this screen prior to making a choice or being assigned to a task.

The task instructions for each of the task are as follows:

SART: During this task, single digits (0-9) will be presented individually in the middle of the screen for brief periods of time. Each digit will be followed by a fixation cross for a brief amount of time. Your task is to press the <SPACEBAR> when you see any digit other than 3. Do not press any key when you see the digit 3. Just wait for the next digit.

COVAT: During this task, a cue followed by a target object will appear for a brief amount of time. The cue and target object may or may not appear in the same box. Your task is to press the <SPACEBAR> as soon as you see a target object appear.

STROOP: During this task, words in different colours (Red, blue, yellow, green) will appear individually in the middle of the screen. Your task is to press a button corresponding to the colour of the word.

State Probe measures. Participants were probed at three time points during the experiment – after reading task instructions, prior to performing the first task of the experiment (i.e. after practice) and at the end of the experiment. State boredom, perceived levels of autonomy/control, levels of frustration, the perceived level of challenge of the task, and finally their motivation levels for performing the task, were all measured on a Likert scale ranging from 1 "low" to 7 "very high". Challenge was included to test whether one condition was perceived as more challenging than another. Frustration and motivation were included as covariates given that lack of choice may also lead to greater frustration and reduced motivation.

Procedure

Participants completed the boredom proneness scale (Struk, Carriere, Cheyne, & Danckert, 2017) as part of a larger battery of questionnaire at the beginning of the term. In lab, at the beginning of the experiment, participants saw a screen with a button corresponding to each psychological task (Figure 4.1). They were randomly assigned to one of four conditions and were given instructions relevant to their specific conditions:

Continual choice condition: In this condition, participants could choose which task to begin with and could change between tasks at will during the study. The condition specific instructions were as follows: *"Your task is to read each description below and choose a task to engage in. If at any point, you want to switch to another task, you can press the "switch" button at the bottom of the task screen. You can switch as many times as you want until the end of the study (10 minutes). If you want to stay on the current task, you can do so."*

Yoked condition: Participants in this condition were yoked to the choices made by participants in the Full control condition. That is, they were unable to choose which task to begin with or when the tasks changed. The condition specific instructions were as follows: "*Your task is to read each description below and press continue once done. The computer will then choose a task for you to engage in. Once the task has begun, the computer may or may not randomly switch between tasks. Each time the computer decides to switch between tasks, you will be presented with task specific instructions for the upcoming task. You will not have a choice of when to stop or what task is selected next – the computer will do that for you. This portion of the study will take 10 minutes.*"

Initial choice condition: In this condition participants were asked to make one choice at the beginning of the experiment. The condition specific instructions were as follows: "*Your task is to read each description. Once you have done this, you will choose a task that you want to engage in for 10 minutes. Once started, you will not be allowed to switch between tasks."*

No choice condition: Participants in this condition were unable to make choices at any point throughout the task. Instead, they were told that the computer would randomly select a task for them to do. The condition specific instructions were as follows: "*Your task is* *to read each description and press continue once done. The computer will then choose which task you will engage in. Once chosen, you will engage in the task for 10 minutes. You will not be able to choose which task to engage in or switch between tasks.”*

Following the condition specific instructions, participants were probed about their current states of boredom, control, motivation, frustration and how challenging they think the experiment will be (probe 1 = before practice). This was followed by a practice phase where participants practiced 10 trials of each task. This ensured that all participants were familiar with each task. They were then probed again and answered questions about their current state (probe 2 = before experiment). Participants then engaged in the experimental phase which lasted 10 minutes. At the beginning of the experimental phase, they were reminded of whether or not they had choice via the condition specific instructions. At the end of the experimental phase, participants again answered the same state probes (probe 3 = after experiment).

Data Analyses

In terms of behavioural metrics, the number of switches between tasks was calculated for those in the full control condition. Performance on the tasks themselves were not analyzed given that not all groups performed all tasks and tasks were performed for varying amounts of time. In order to test whether there were any differences between groups across time points, mixed design analyses of variance (ANOVA) were calculated separately for each variable of interest with time as the within subjects variable and conditions as the between subjects variable. To test whether groups differed at each probed time point, Wilcoxon t-tests were used. Correlation and regression analyses were employed for exploratory analyses investigating the role of trait boredom proneness. All data analyses were conducted in R (R Core Team, 2015).

4.8 Study 4.2 Results

Table 4.4 shows the median and median absolute deviation for all study variables.

Table 4.4 Descriptive statistics for study variables

	Continual choice Condition (n = 71)			**Yoked condition (n = 53)**		
	Before Practice	Before experiment	After experiment	Before Practice	Before experiment	After experiment
Boredom	3 (1.48)	3 (1.48)	5 (2.97)	4 (1.48)	3 (1.48)	5 (1.48)
Control	5 (1.48)	5 (1.48)	6 (1.48)	6 (1.48)	5 (1.48)	5 (1.48)
Frustration	1 (0)	2 (1.48)	2 (1.48)	2 (1.48)	3 (1.48)	3 (1.48)
Challenge	3 (1.48)	3 (1.48)	2 (1.48)	3 (1.48)	3 (1.48)	3 (1.48)
Motivation	6 (1.48)	6 (1.48)	5 (1.48)	6 (1.48)	6 (1.48)	5 (1.48)
SBPS	24 (10.38)			24 (8.9)		

	Initial choice condition (n = 66)			**No choice condition (n = 62)**		
	Before Practice	Before experiment	After experiment	Before Practice	Before experiment	After experiment
Boredom	4 (1.48)	4 (1.48)	4 (1.48)	3 (1.48)	3 (1.48)	4 (1.48)
Control	5 (1.48)	5 (1.48)	5 (1.48)	5 (1.48)	5 (1.48)	4 (1.48)
Frustration	1 (0)	2 (1.48)	2 (1.48)	1 (0)	2 (1.48)	3 (2.97)
Challenge	2 (1.48)	3 (1.48)	2 (1.48)	2 (1.48)	2.5 (2.22)	3 (2.97)
Motivation	6 (1.48)	6 (1.48)	5.5 (2.22)	6 (1.48)	6 (1.48)	5 (1.48)
SBPS	24 (8.9)			26.5 (9.64)		

Manipulation check

A mixed design ANOVA, with probes as the within subjects variable and condition as the between subjects variable was used to test whether there was a main effect of probe and condition on perceived control. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated (Mauchly's W = 0.95, $p = 0.004$), and therefore, a Greenhouse-Geisser correction was used to correct the degrees of freedom. Results showed that there was a main effect of probe ($F(1.91,450.94) = 11.34$, $p < 0.001$), condition ($F(3,236) = 3.55$, $p = 0.02$) and a significant probe by condition interaction ($F(5.73,450.94) = 9.84$, $p < 0.001$; Figure 4.2). Visual inspection of the interaction (Figure 4.2) suggests that participants in conditions with no choice (i.e., the yoked and no-choice conditions) experienced a decrease in control, whereas those who had some choice (i.e., continual choice and initial choice condition) control was unchanged throughout the course of the experiment. To further investigate the probe by condition interaction, non-parametric between subjects analysis of variance (ANOVA) and pairwise comparisons were calculated for each probe – before practice, before the experiment, and after the experiment using the JMV package in R ("The Jamovi project," 2020). The Kruskal-Wallis ANOVA suggested that there was no significant difference between all four conditions in perception of control before practice ($X^2(3) = 1.31$, $p = 0.73$; Figure 4.2). Before the experiment, perception of control was significantly different across the four conditions ($X^2(3) = 12.4$, $p = 0.006$; Figure 4.2). Non-parametric pairwise comparisons with a Bonferroni correction revealed that those in the yoked condition felt less in control (median = 5, mean = 4.49) compared to those in the continual choice (median = 5, mean = 5.2; W = -3.69, $p = 0.04$) and initial choice conditions (median = 5, mean = 5.3; W = 4.11, $p = 0.02$). No other comparisons were significant.

After the experiment, perception of control again differed significantly between conditions ($X^2(3) = 31.7$, $p < 0.001$; Figure 4.2), such that those in the continual choice condition felt more in control (median = 6, mean = 5.25) compared to the yoked (median = 5, mean = 4.42; W = -4.59, p = 0.006) and no choice conditions (median = 4, mean = 4; W = -6.05, p < 0.001). Those in the initial choice condition felt more in control (median = 5, mean = 5.36) than those in the yoked (median = 5, mean = 4.42; W = 4.89, p = 0.003) and no choice conditions (median = 4, mean = 4; W = -6.37, p < 0.001). There was no significant difference in perceived control between the continual choice (median = 6, mean = 5.25) and initial choice conditions (median = 5, mean = 5.36; W = 0.42, p = 0.99). There were also no significant differences in control between the yoked (median = 5, mean = 4.42) and no choice conditions (median = 4, mean = 4; W = -1.9, p = 0.53).

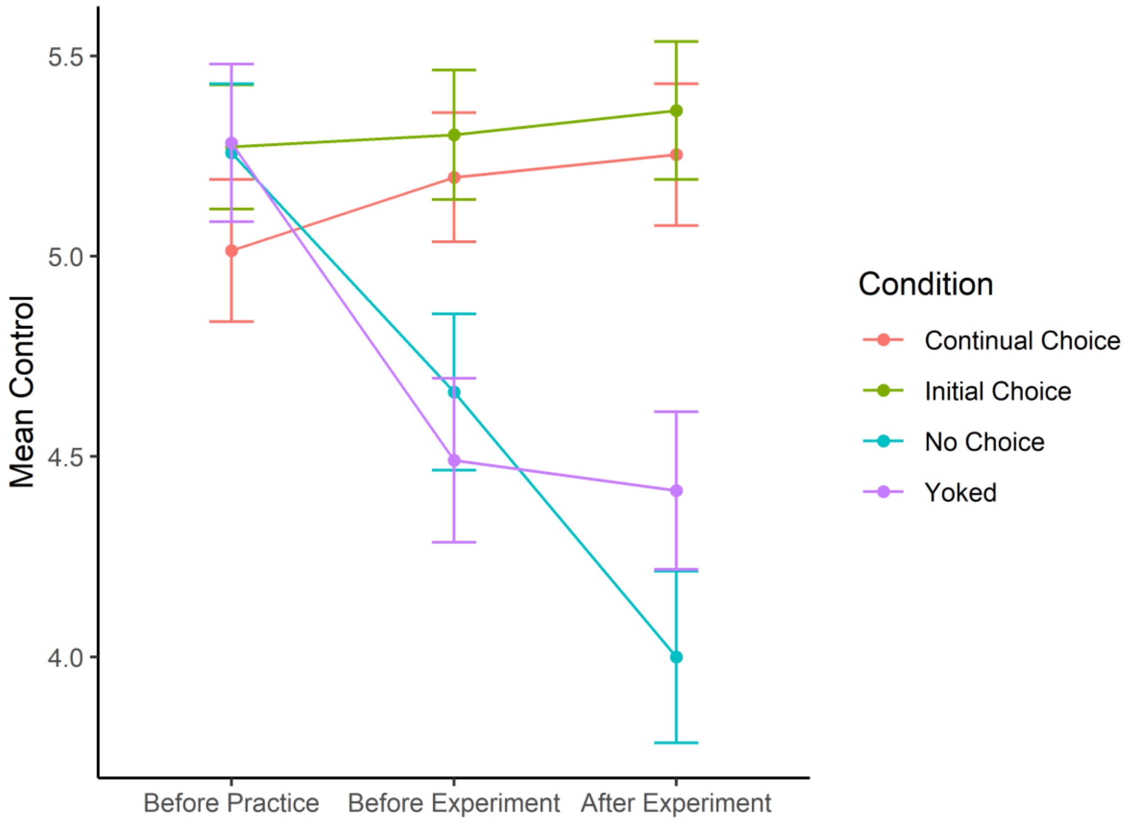

Figure 4.2 Participants mean control levels before practice, before experiment and after experiment.Error bars represent standard error.

State Boredom. A mixed design ANOVA, with probes as the within subjects variable and condition as the between subjects variable was again used to test whether there was a main effect of time and condition on state boredom. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated (Mauchly's W = 0.87, $p < .0001$), and therefore, a Greenhouse-Geisser correction was used to correct the degrees of freedom. Results suggest that there was a main effect of probe ($F(1.77,417.73) = 7.15$, $p < 0.001$; Figure 4.3) but no main effect of condition ($F(3,236) = 0.74$, $p = 0.53$). No other significant differences were found. To further investigate the main effect of probe, a Wilcoxon rank test was used to compare boredom at probe 1 and probe 2 with results suggesting no significant difference (probe 1 mean boredom = 3.32; probe 2 mean boredom = 3.27; $W = 7020$, $p > 0.05$). However, state boredom significantly increased from probe 2 to probe 3 (probe 2 mean boredom = 3.27; probe 3 mean boredom = 4.33; $W = 2047.5$, $p < 0.001$) regardless of condition (Figure 4.3).

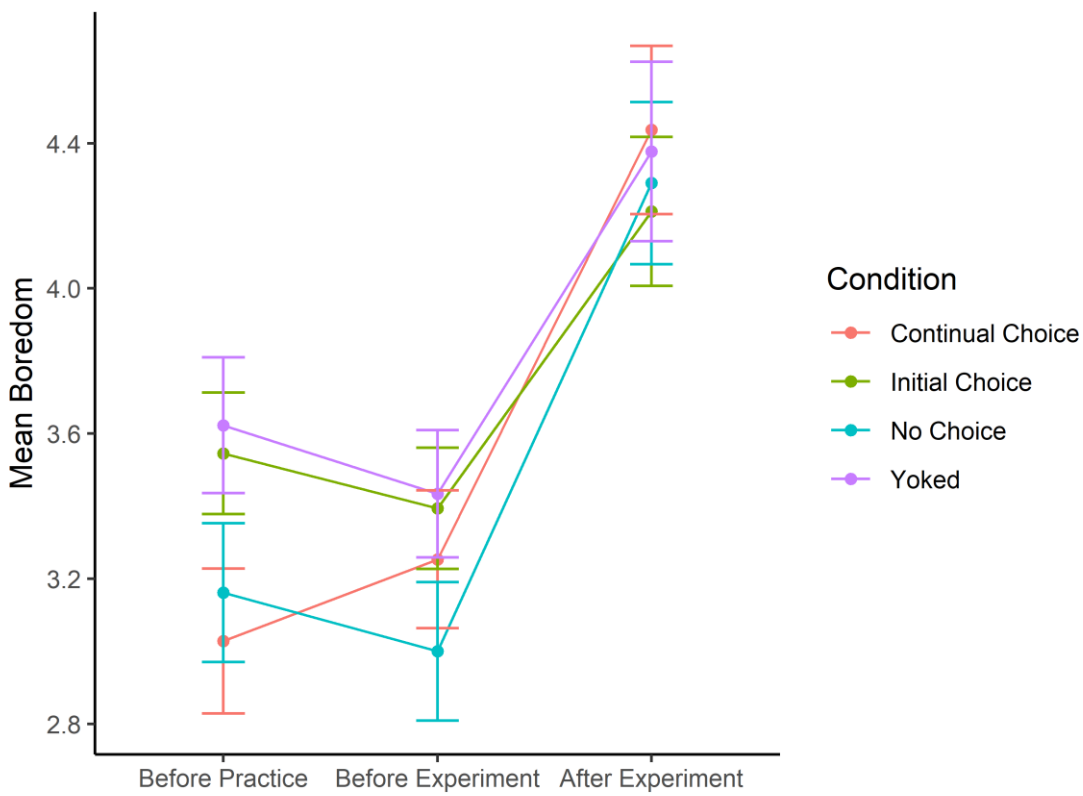

Figure 4.3 Participants mean state boredom levels before practice, before experiment and after experiment. Error bars represent standard error.

Challenge, Frustration and Motivation. With regards to challenge, a mixed design ANOVA was again used to test whether there was a main effect of time and condition on challenge. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated (Mauchly's W = 0.95, p = 0.003), and therefore, a Greenhouse-Geisser correction was used to adjust the degrees of freedom. Results from a mixed effect ANOVA suggests a main effect of probe ($F(1.91,449.85) = 8.3$, $p < 0.001$), no main effect of condition ($F(3, 236) = 1.93$, $p = 0.13$) and a probe by condition interaction ($F(5.72,449.85) = 2.75$, $p = 0.01$; Figure 4.4). Visual inspection of the interaction (Figure 4.4) suggested that that there were multiple cross-overs across the three different probes points. Most notably, those in the initial choice condition experienced an increase in perceived task challenge before the beginning of the experimental phase (i.e., prior to making their choice as to which task they would do) and a decrease in perceived task challenge after the experiment. To further investigate the probe by condition interaction, non-parametric between subjects analysis of variance (ANOVA) and pairwise comparisons were calculated for each probe – before practice, before experiment and, after experiment. The Kruskal-Wallis ANOVA suggested that there was no significant difference between all four conditions in perception of challenge before practice ($X^2(3) = 6.59$, $p = 0.09$; Figure 4.4). Before the experiment, reports of challenge were significantly different across the four conditions ($X^2(3) = 10.1$, $p = 0.018$; Figure 4.4). However, follow-up non-parametric pairwise comparisons with a Bonferroni correction revealed that none of the groups were significantly different from one another[2]. After the

[2] Without the Bonferroni correction, those in the yoked condition reported marginally greater challenge (median = 3, mean = 3.38) than those in the continual choice condition (median = 3, mean = 2.76; W = 3.40, p = 0.08)

experiment, ratings of challenge did not differ between conditions ($X^2(3) = 6.22$, $p = 0.101$; Figure 4.4).

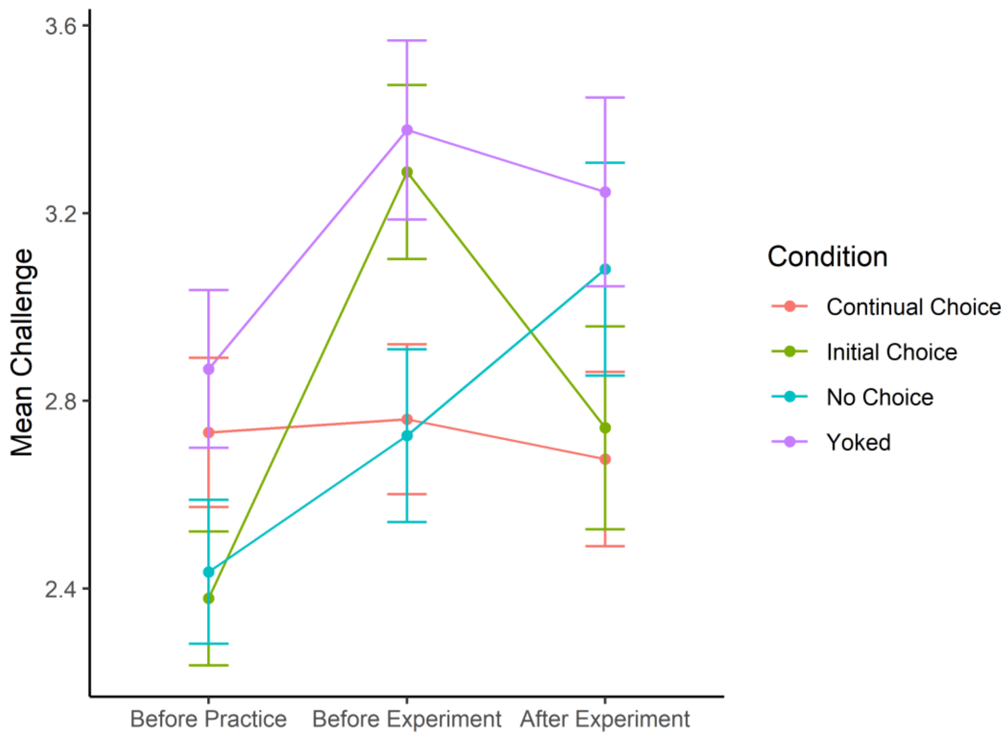

Figure 4.4 Participants mean challenge rating before practice, before experiment and after experiment. Error bars represent standard error.

With regards to frustration, results from a mixed effect ANOVA suggests a main effect of probe ($F(2,472) = 52.68$, $p < 0.001$) but no effect of condition ($F(3, 236) = 2.28$, $p = 0.08$). Follow up comparisons using a Wilcox test show a significant difference in frustration

---

and those in the no choice condition (median = 2.5, mean = 2.73; W = -3.43, p = 0.07).

between probe #1 and probe #2 (W = 2114, $p < 0.001$), such that participants were more frustrated before commencing the experiment (probe #2 mean = 2.24, median = 2; probe #1 mean = 1.89, median = 1). Participants were also more frustrated by the end of the task (i.e., probe #3; mean = 2.80, median = 2) compared to before experiment (i.e. probe #2; mean = 2.24, median = 2; W = 2640, $p < 0.001$). Similarly, with regards to motivation, results from a mixed effect ANOVA suggests a main effect of probe ($F(2,472) = 80.22$, $p < 0.001$) but no effect of condition ($F(3, 236) = 0.76$, $p = 0.52$). Follow up comparisons using a Wilcox test suggest that there was no significant difference in motivation between probes #1 and #2 (W = 3768.5, $p > 0.05$). However, there was a significant difference between probe #2 and #3 (W = 9486, $p < 0.001$), such that participants were less motivated by the end of the task (probe #3 mean = 4.77, median = 5; probe #2 mean = 5.62, median = 6)

Exploratory analyses

State measures and number of switches. Number of switches refers to the amount of times participants switched from one task to another. The number of switches, only relevant in the continual choice condition and their yoked counterparts, ranged from 0 to 5 switches within the 10 minutes experimental phase. Of the participants in the continual choice condition, 36% chose to not switch between tasks, 21% made one switch, 13% switched twice, another 13% switched three times, 7% switched four times and 10% switched five times. Regression models were used to test whether boredom levels at the end of the task changed as a function of the number of switches made. Results suggest that the number of switches made was marginally associated with boredom at the end of task for the continual choice condition ($F(1,69) = 3.482$, $p = 0.07$, $R^2 = 3.4\%$), such that more switches were marginally predictive of increased levels of state boredom. To examine whether making at least one switch increased levels of boredom, participants who made no switches were removed from the regression model. Results suggest that as the number of switches increased, so did boredom at the end of task ($F(1,43) = 4.267$, $p = 0.04$, $R^2 = 6.9\%$). Number of switches did not predicted boredom at the end of task for the yoked condition ($F(1,51) = 1.485$, $p = 0.2$).

Regression models also tested whether perceived control at the end of the task changed as a function of the number of switches with results suggesting that for those in the continual choice condition, the number of switches did not predict variation in levels of perceived control measured at the end of the task ($F(1,69) = 2.17$, $p = 0.15$). That is, the act of switching between tasks did not make participants feel more or less autonomy. For those who experienced switches without choosing them (i.e., the yoked condition), the number of switches significantly negatively predicted participants perceived control ($F(1,51) = 4.41$, $p = 0.04$). That is, the experience of switches emphasized participants' decreased sense of autonomy. The number of switches did not predict how challenging, frustrating, or motivated participants felt by the end of task.

Trait boredom proneness. Boredom proneness did not significantly differ across conditions ($X^2(3) = 1.01$, $p > 0.05$) suggesting that participants in all conditions were equally boredom prone. Spearman correlations between all study variables were examined for each condition independently (Appendix E). For this study, it was hypothesized that high boredom prone participants would switch between tasks more frequently. As such, this analysis was restricted to the continual control condition and Bonferroni corrections were only applied to correlations involving boredom proneness – which resulted in 16 corrections for the continual choice (*Italicized* in table E.1 in Appendix E). Results suggest no significant association between boredom proneness and any study variable.

4.9 Study 4.2 Discussion

The manipulation of choice in the current study was somewhat successful in that at the beginning of the experiment, participants did not differ in their level of perceived control. However, by the end of the experiment those in conditions with minimal control (i.e., the yoked and no choice conditions) felt less in control relative to their baseline scores while perceived control for those in the conditions that had some level of choice (i.e., the continual and initial choice conditions; Figure 4.2) remained fairly stable. Therefore, the manipulation led to feelings of *loss of control* for those in the yoked and no choice conditions. Nevertheless, participants in all conditions reported moderate to high levels of perceived control. That is, even in the conditions with minimal control the median perceived control after experiment ranged between 4 and 5 out of 7 – suggesting that participants felt moderate to somewhat high levels of control regardless of the condition. This may be due in part to the design of the experiment. When asked about their sense of control, participants may have inferred their response based on their performance on the attentional tasks (i.e., how they were doing on the task and whether they felt in control of their responses in the moment), as opposed to focusing on their initial choices and capacity to switch (or lack thereof). Given that perceived control for all conditions ranged between 4 and 6 by the end of the experiment, the current design was not able to infer the relationship between low control and boredom.

Moreover, there were no differences in state boredom as a function of the choice manipulation suggesting that the act of choosing in itself had little to no consequence for state boredom when available options were equally boring. Instead, what likely matters are the actual choices one makes when the available options have different consequences for boredom. That is, choice may matter more when options differ in their levels of challenge, meaning or intrinsic value. While there were no differences in state boredom among the conditions, there was a main effect of probe, such that all participants experienced an increase in state boredom by the end of the task. This suggests that the tasks themselves – even with only 10 minutes of performing them – induced boredom to equally high levels (Figure 4.3)

While state boredom did not differ across conditions, the number of switches was found to be marginally positively associated with reports of state boredom at the end of the experiment. Indeed, various theoretical accounts of boredom have suggested that people tend to switch between tasks in order to deal with boredom (Bench & Lench, 2013; Troutwine & O'Neal, 1981; van Tilburg & Igou, 2012; Westgate & Wilson, 2018). The initial reasoning for choosing boring tasks was so that participants do not develop a personal preference for any given task. In this study, 36% of participants who had control over which task to engage with chose to engage in only one task for the duration of the study. This might reflect a personal preference to maintain engagement in a single task. When these participants were removed from the analysis, the number of switches was positively associated with state boredom at the end of task. It may be the case that when people switch often they fail to fully engage with any given task and thus have rising feelings of boredom.

4.10 General Discussion

This chapter investigated the relationship between autonomy and boredom. While some prior work suggest that increases in control leads to decreases in boredom (van Hooft & van Hooff, 2018; Shaw, Caldwell, & Kleiber, 1996; Tze et al., 2014), other theoretical accounts and findings suggest that both high and low control should lead to increased boredom given that both pose a challenge to successful engagement (Struk et al., 2015, Pekrun et al., 2010). To further disambiguate the relationship between boredom and control, Study 4.1 attempted to more directly manipulate control while holding potential confounds such as, meaning, frustration and personal preference constant. Study 4.2 investigated whether autonomy as operationalized by different levels of choice would predict boredom.

The manipulation of control was moderately successful in both studies in that the conditions in which some level of control was granted to participants perceived control was indeed reported to be higher (Table 4.1 and Figure 4.2). Even though such differences were present, participants in both studies reported moderate to high levels of perceived control suggesting that the experimental designs failed to elicit either low or very high levels of control. Furthermore, while efforts were made to ensure that the tasks were not challenging, participants in both experiments reported the tasks to be low to moderate in challenge levels – highlighting that perhaps challenge and control are intrinsically, and in these two experiments, inversely related, such that the less participants felt they were in control, the more challenging they rated the task to be. It should also be noted that both experiments used tasks that were not very challenging. It is possible that challenge and control are positively related when task challenge is high and participants experience a sense of perceived control over the task.

The manipulations of control did not differentiate the different groups in terms of state boredom in both studies. Furthermore, given that no participant group experienced low levels of control, it is unsurprising that there was no evidence for a quadratic relationship between boredom and control in study 4.1. Previous theoretical accounts and research findings supporting this quadratic relationship have combined control with other variables (such as value or challenge) to explain its influence on boredom (Pekrun, 2006; Pekrun et al. 2010a; Struk et al., 2015). For example, Pekrun's (2006) control-value theory suggests that boredom will be experienced if the activity lacks any value *and* the individual has too much *or* too little control over the activity. This suggests that both control and lack of intrinsic value have an influence on boredom. Furthermore, in Struk and colleagues (2015) study, those who experienced low control (i.e., lost all rock-paper-scissors matches) were also likely to have experienced the task as more challenging, again highlighting the possibility that control and challenge interact to amplify boredom. Current results are also in contrast with previous findings showing that higher levels of autonomy lead to a diminished experience of boredom (van Hooft & van Hooff, 2018; Shaw, Caldwell, & Kleiber, 1996; Tze et al., 2014). This might be because the tasks used in both experiments were not overly engaging. Of note, in Experiment 4.2, measures of state boredom rose with time on task such that by the end of the task, participants were more bored compared to before and after the practice phase – regardless of condition. This suggests that the tasks themselves acted as robust boredom inducers and overshadowed any potential effects that control may have had over state boredom. The next chapter employs a task that has previously been rated as fairly engaging and explores whether control over challenge levels influences boredom.

Chapter 5: Exploring the relationship between boredom control over challenge

5.1 Introduction

The study presented in Chapter 3 focused on the role of effort in boredom. Another construct related to effort is challenge. While effort and challenge are often interchangeably used, Inzlicht and colleagues (2018) differentiate between the two constructs by suggesting that effort is the subjective increase of mental and/or physical activity needed to achieve a goal, whereas challenge is a property of the task itself that determines how much mental or physical labor will be required. In other words, challenge is a feature of the task, whereas effort is based on an individual's capacity to engage. Of course, changes in effort and challenge are often modulated in concert – as something becomes more challenging it also feels more effortful. But this is not ubiquitously the case. For examples, athletes who report feeling the sensation of flow while doing challenging tasks, report the sensation as effortless. Study 3.1 suggested that the more bored participants felt by the end of task, the less challenging they rated the task to be –suggesting that perhaps the task was of low challenge to some participants. Furthermore, Chapter 4 concluded that control or autonomy alone does not strongly influence boredom. Control may have had little influence in the previous experiments because the tasks themselves were not too challenging. This possibility is examined here in a study that explored the relationship between control, challenge and boredom.

Boredom has been posited to arise from situations that lack challenge (Bench & Lench, 2013; Elpidorou, 2014, 2018a, 2018b; Farmer & Sundberg, 1986; Harris, 2000; Moneta &

Csikszentmihalyi, 1996; Csikszentmihalyi 2000; Van Tilburg & Igou, 2012, 2017; Vodanovich & Kass, 1990). For example, van Tilburg and Igou (2012) had participants recall an experience in which they felt bored and rate the experiential content of that recollection. They found that when bored, participants reported feeling unchallenged, restless and unsure of the purpose of the activity they were engaged in (see also Van Tilburg & Igou, 2017). Csikszentmihalyi (2000) conceptualises boredom as a state of low perceived challenge and suggests that situations in which perceived skills are greater than perceived challenge will result in individuals seeking more challenging activities (see also Moneta & Csikszentmihalyi, 1996). Functional accounts of boredom have theorised that boredom acts as a self-regulatory signal that pushes us out of an unchallenging situation and motivates us to seek alternatives for engagement (Bench & Lench, 2013; Danckert, 2019; Elpidorou, 2014a, 2018a). Therefore, seeking optimally challenging acitivities has the potential to alleviate boredom. That said, in order for individuals to seek alternative, more challenging (or at least optimally challenging) options for engagement when bored, they need to have some sort of control over their environment. In a recent survey of over 3,000 Italian adults asking about their experience of social isolation during the recent covid-19 pandemic, lack of freedom (which encompasses loss of control/ choice) and boredom were cited as the first and second most commonly negative side effects of social distancing (Barari et al., 2020). The loss of freedom may mean that individuals were not able to engage in activities that differ along multiple dimensions including challenge, meaning and intrinsic value, which in turn may have exacerbated feelings of boredom.

Research within academic contexts suggests that boredom arises not only in situations where one perceives their skills to be greater than the current challenge but also in situations where the challenges *exceed* one's skills (Acee et al., 2010; Daschmann et al., 2011; Pekrun et al., 2010b; Robinson, 1975). For example, Daschmann and colleagues (2011) found that the reasons students were bored in Mathematics class were twofold: for some students it was because they found the subject to be over-challenging, whereas for others the topic felt under-challenging. Acee and colleauges (2010) found that in over-challenging situations, students report feeling bored, as well as other negative emotions such as anger, hopelessness and shame. These research findings suggest that people are in search of a 'Goldilocks' zone' for engagement and boredom may signal that the current task is either under- or over-challenging (Danckert, 2019). One aspect that stands out in these findings is that over- or under-challenged students may not have the *option* to seek an optimal level of challenge for engagement. Instead, they are often trapped in an environment where they do not have control over the task difficulty (or the option to choose a different task altogether). Taken together, these findings suggest that lack of control over situations that are both over- and under-challenging can lead to boredom.

5.2 Study 5.1

The current study sought to explore the relationship between control, challenge and boredom. That is, does having control over how challenging a task is reduce boredom? Using a between subjects design, participants played a gamified version of the apple-catcher task (see study 2.2 in Chapter 2) in which they were able to control the challenge level (or not, see below). Participants were told to catch as many apples as they could. Challenge levels (i.e., task difficulty) were manipulated by altering the speed and rate with which apples fell from the tree. Control was manipulated by allowing (or preventing) participants to set the challenge level. Participants were split into four groups: those in the full control condition were able to control the task difficulty throughout the experiment (i.e., they could increase or decrease task difficulty at any point during the task). To find out whether challenge without control influenced state boredom, those in the yoked condition were yoked to the changes in task difficulty made by participants in the full control condition (i.e., they did not have control, but they did experience changes in task difficulty). Those in the one-choice condition were able to choose their desired task difficulty after practice but before starting the experimental phase. For these participants there was some control over task difficulty, but no opportunity to adjust challenge levels during the task. Finally, those in the no-choice condition were yoked to the choices of those in the one-choice condition. It was hypothesized that state boredom would differ based on how much control participants had over task difficulty such that participants who had control over the difficulty of the game (full control and one-choice conditions) would be less bored compared to those who did not have control over task difficulty (yoked and no-choice conditions). It was further hypothesized that the extent of control over task difficulty would influence boredom such that those in the full control condition would be the least bored among all four conditions. It is expected that task difficulty level would be positively related to perceptions of challenge. Within each condition, it was hypothesised that higher levels of task difficulty and subjective challenge would be associated with decreased state boredom.

This study also explored whether boredom proneness influenced participants' behaviours or state. Previous research has found that boredom prone individuals often perceive their environments to be lacking in challenge (Farmer & Sundberg, 1986; Harris, 2000; Vodanovich & Kass, 1990). While the relations between boredom proneness and task/ states measures were exploratory, it was hypothesised that boredom prone individuals might select higher challenge levels – indicative of a higher need for stimulation (Dahlen, Martin, Ragan, & Kuhlman, 2004; Vodanovich, Verner, & Gilbride, 1991)

5.3 Study 5.1 Methods

Participants

Four hundred and twenty-nine undergraduates (346 females, mean age = 20.06 (1.91) years) participated in this study in exchange for course credit. It was decided a priori that data collection would start at the beginning of Fall 2018 and finish at the end of the term. As such, there were a total of 109 participants in the full control condition, 106 participants in the yoked condition, 111 participants in the single choice condition and 103 participants in the no-choice yoked condition. This study received ethics clearance from the University of Waterloo Office of Research Ethics and participants gave informed consent prior to participating.

Measures and procedure

Participants completed the boredom proneness scale (Struk et al., 2017) as part of a larger battery of questionnaire at the beginning of the term. During the in-lab portion of this study, participants engaged in a gamified version of the apple-catcher task where their goal was to catch as many of the falling apples as possible using their mouse (Figure 5.1). Participants were also given a high score to beat in the experimental phase. This high score was unattainable but participants were not aware of this fact. This was done so that participants would be motivated to maintain engagement throughout the game. The game was displayed on a 25-inch screen with a 1920 x 1080 resolution. All participants practiced the apple-catcher game for one minute prior to the experimental phase. During the practice phase, all participants were allowed to change the game's challenge level. There were 7 challenge levels in total. As challenge level increased from 1 to 7, the speed at which apples dropped (i.e., falling from the top of the screen to the bottom – henceforth referred to as drop speed) decreased by 0.15 seconds and the interval between apple drops (i.e., rate of apple drops) decreased by 0.1 seconds. At level 1, drop speed was 1.4 seconds with an interval of 0.7 seconds, while at level 7, drop speed was 0.5 seconds with an interval of 0.1 seconds. All participants started practice at level 4 which had a drop speed of 0.95 seconds and an interval of 0.4 seconds, which was visually depicted as the middle of the challenge level slider (Figure 5.1). During the practice phase, participants were told to practice increasing or decreasing the challenge level and catching the falling apples. Following the practice phase, participants were given further information regarding how much control they had for the experimental phase.

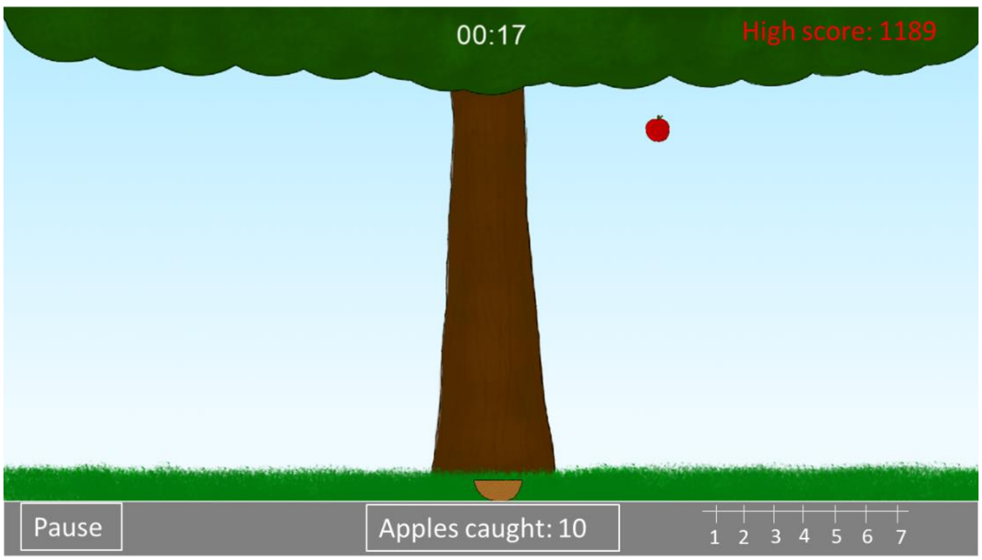

Figure 5.1 Overview of apple-catcher game. The pause button was only visible in the full control condition. The single-choice and no-choice conditions did not have the challenge slider scale during the experimental phase.

The experimental phase lasted 10 minutes. Those in the full control condition could pause the game play at any point by pressing the pause button at the bottom of their screen and change or adjust their challenge levels using a slider (also at the bottom of their screen) before resuming game play (Figure 5.1). Participants were informed that once they paused the game, the timer for the game would also pause to ensure they did not lose game play time or miss any apples that were currently falling. For every participant who experienced the full control condition, one participant was yoked to their choices of challenge levels (i.e., hereafter referred to as the yoked condition). Those in the yoked condition were told that they did not have any control over the challenge levels and that the computer may or may not decide to increase or decrease the challenge level during play. In the single-choice condition, participants were able to choose their desired challenge level after practice but before starting the experimental phase. These participants were told that they would not be able to change challenge levels throughout the game. For every participant who experienced the single-choice condition, one participant was yoked to their initial choice in the no-choice condition. Those in the no-choice yoked condition participants were told that the computer would randomly select a challenge level for them.

All participants were asked about their state boredom at two time points – before experimental phase (i.e., after practice and after receiving instructions for the experimental phase) and at the end of the experiment. Additionally, at the end of the experiment, participants were also asked to rate how much control they felt during the game, how challenging they found the game and, how frustrated and motivated they were during the game using a Likert scale of 1 “Not at all” to 7 “Extremely.” Control and challenge were assessed to ensure that the manipulation worked while frustration and motivation were used as covariates.

Data Analyses

A few behavioural metrics were calculated from the apple-catcher game including the proportion of apples caught and, mean task difficulty level. For those in the full control condition, the number of switches between difficulty levels and time spent in each level were also calculated. In order to test whether groups differed on state measures and behavioural metrics, analyses of variance and follow up post-hoc pairwise comparisons were used. Exploratory analyses looked at correlations between state and trait boredom and study variables separately for each condition. All data analyses were conducted in R (R Core Team, 2015).

5.4 Study 5.1 Results:

Table 5.1 shows the median, median absolute deviation and mean (*M)* for all study variables. Of note, while the practice phase started with a task difficulty of level 4, the median task difficulty level across all conditions for the experimental phase was 5 – suggesting that participants did not deviate too much from their starting point.

Table 5.1 Descriptive statistics for study variables

	Full control condition	Yoked condition	one choice	No choice (yoked)
Baseline boredom	4 (1.48) *M = 3.49*	4 (0) *M =3.67*	4 (1.48) *M =3.57*	4 (1.48) *M =3.47*
Boredom	4 (1.48) *M =3.79*	3 (1.48) *M =3.71*	4 (1.48) *M =3.93*	4 (1.48) *M =3.85*
Challenge	4 (1.48) *M =3.58*	5 (1.48) *M =4.52*	4 (1.48) *M =3.82*	4 (2.97) *M =3.39*
Control	5 (1.48) *M =4.81*	4 (1.48) *M =3.81*	4 (1.48) *M =4.4*	5 (1.48) *M =4.59*
Frustration	3 (1.48) *M =2.87*	4 (1.48) *M =3.64*	3 (1.48) *M =3.08*	3 (1.48) *M =3.04*
Motivation	5 (1.48) *M =4.56*	5 (1.48) *M =4.67*	5 (1.48) *M =4.56*	5 (1.48) *M =4.4*
# of switches	4 (1.48) *M =4.66*	4 (1.48) *M =4.7*	-	-
Task difficulty level	5 (0.42) *M =5.11*	5.1 (0.46) *M =5.11*	5 (0) *M =4.71*	5 (0) *M =4.69*
Time per level (s)	150 (74.13) *M =160.53*	150 (74.13) *M =156.45*	-	-
Mean hits	0.88 (0.08) *M =0.86*	0.76 (1.72) *M =0.73*	0.91 (0.09) *M =0.88*	0.92 (0.1) *M =0.89*
Boredom proneness	26 (8.9) *M =26.44*	27 (8.9) *M =26.35*	25 (8.9) *M =27*	25 (8.9) *M =26.4*

Task difficulty level = median difficulty level throughout game play. Time per level = median amount of time (in seconds) spent in each task difficulty level. Mean hits = proportion of apple catches throughout game play.

Next, to test whether conditions differed in terms of subjective perceptions of challenge, control, boredom (state and trait), frustration and motivation, as well as objective measures of performance (proportion of apples caught, mean task difficulty levels), non-parametric between subject's analysis of variance (ANOVA) and pairwise comparisons were calculated for each variable using the JMV package in R ("The Jamovi project," 2020).

Challenge: Results from a Kruskal-Wallis ANOVA suggests that there was a significant difference between all four conditions in how challenging participants perceived the task to be upon completion ($X^2(3) = 31.5$, $p < 0.001$; Figure 5.2A). Follow up comparisons using the Dwass-Steel-Critchlow-Fligner pairwise comparison method (Critchlow & Fligner, 1991) suggested that those in the yoked condition found the task to be significantly more challenging than those in the full control ($W = 6.5$, $p < 0.001$), single-choice ($W = 4.59$, $p < 0.001$), and no choice conditions ($W = -7.23$, $p < 0.001$). No other significant pairwise differences were found.

Control: A similar pattern of results were found with regards to perceived control. Results from the Kruskal-Wallis ANOVA suggests that there was a significant difference between all four conditions in perceptions of control upon completion ($X^2(3) = 29.4$, $p < 0.001$; Figure 5.2B). Follow up comparisons indicated that those in the yoked condition reported significantly lower levels of perceived control than those in the full control ($W = -7.62$, $p < 0.001$), single-choice ($W = 4.44$, $p < 0.01$), and no choice conditions ($W = 5.23$, $p < 0.001$). No other significant pairwise differences were found. Taken together, the above results suggest that it is only those in the yoked condition who perceived the task as being more challenging and concomitantly reported lower levels of perceived control compared to the other three groups.

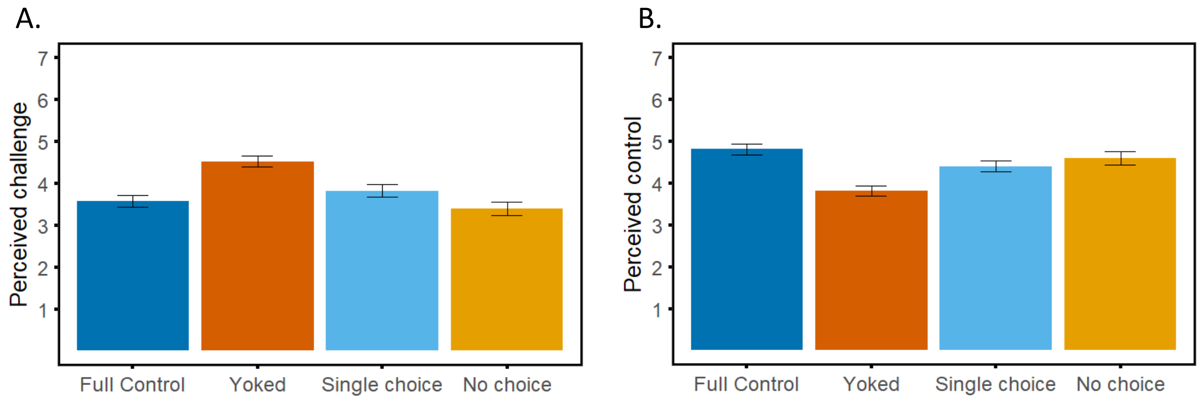

Figure 5.2 A – Mean perceived challenge levels by the end of game play. B – Mean perceived control by the end of game play. Error bars represent confidence intervals

Boredom: A mixed design ANOVA, with boredom probes as the within subjects variable and condition as the between subjects variable, was used to test whether there was a main effect of probe and condition on state boredom. Results showed that there was a main effect of probe ($F(1.421) = 10.84$, $p < 0.01$). A paired Wilcox rank test compared baseline boredom and end of task boredom, with results indicating that there was an increase in overall boredom relative to baseline (baseline mean boredom = 3.55, median = 4, mean boredom at the end = 3.82, median = 4; V = 36944, $p < 0.01$). The fact that there was no main effect of condition suggests that the manipulation of control and challenge failed to influence in-the-moment feelings of boredom.

Frustration: Results from a Kruskal-Wallis test suggests that there was a significant difference between all four conditions in how frustrated participants were by the end of the task ($X^2(3) = 12.9$, $p = 0.005$), such that those in the yoked condition were significantly more frustrated compared to those in the full control condition ($W = 4.82$, $p = 0.004$). Those in the yoked condition were also marginally more frustrated than those in the single-choice ($W = -3.52$, $p = 0.06$) and no-choice conditions ($W = -3.62$, $p = 0.05$). No other significant differences were found.

Motivation: With regards motivation, participants were all equally motivated by the end of the task ($X^2(3) = 1.36$, $p > 0.05$).

Mean hits: Objective performance in the form of the proportion of apples caught was also measured. Results from a Kruskal-Wallis test suggests that there was a significant difference between all four conditions in how many apples were caught ($X^2(3) = 76.7$, $p < 0.001$). Those in the yoked condition caught significantly fewer apples compared to the full control ($W = -9.25$, $p < 0.001$), single-choice ($W = 10.56$, $p < 0.001$) and no-choice conditions ($W = 9.55$, $p < 0.001$). No other significant differences were found.

Task difficulty level: Given that participants in the yoked condition were tethered to the choices made by those in the full control condition and that participants in the no-choice condition were yoked to those in the single-choice condition, a Wilcoxon rank sum test was used to determine whether there was a significant difference in task difficulty between the two conditions that had some semblance of control over task difficulty. Results demonstrated a significant difference such that the full control condition chose higher task difficulty levels compared to the one-choice condition ($W = 7628$, $p < 0.0005$, mean task difficulty is 5.11 for full control and 4.71 for single-choice condition).

Next, Spearman correlations were calculated for each condition independently (Table 5.2; – See also Table G.1 to G.4 in appendix G for separate correlation tables for each condition). Given the goal of the study was to examine the influence of control and challenge on state boredom, Bonferroni corrections were applied only to the correlations involving state boredom which resulted in ten corrections in each of the first two conditions (full control and yoked conditions). The variables `# of switches' and 'time per level' were not available for the one-choice and no-choice conditions. As such, there were a total of eight correlations with a Bonferroni correction for these conditions. Table 5.2 shows the correlations between state boredom at the end of game play and all study variables separately for each condition.

Of note, there was a positive correlation between baseline state boredom and state boredom at the end of game play for participants in the full control condition ($r = 0.29$, $p < 0.001$) and those in the single-choice condition ($r = 0.34$, $p < 0.001$) – suggesting that for participants who had some sort of control over challenge options, those who had higher levels of boredom prior to the task were also more bored by the end of the task. Across all four conditions, motivation was negatively correlated with state boredom at the end of game play (r ranges from -0.52 to -0.6, $p < 0.00001$) such that those who were less motivated were more likely to experience state boredom.

Table 5.2 Spearman correlations between state boredom at the end of game play and all study variables for all conditions

	State boredom at the end of game play			
	Full control (n = 109)	Yoked (n = 106)	One – choice (n = 111)	No – Choice (n = 103)
1.Baseline boredom	0.29**	0.09	0.34**	0.09
2.Challenge	-0.38***	0.03	-0.14	-0.2
3. Control	0.19	-0.11	-0.17	-0.1
4. Frustration	-0.09	0.08	0.12	-0.08
5. Motivation	-0.60****	-0.55****	-0.52****	-0.55****
6.# of switches	-0.13	0.08		
7.Task diff. level	-0.32**	-0.08	-0.02	-0.16
8.Time per level	0.12	-0.08		
9. Mean hits	0.32**	0.05	-0.04	0.11
10. SBPS	0.1	-0.09	0.07	-0.12

Task diff. level = median difficulty level throughout game play. Time per level = median amount of time (in seconds) spent in each task difficulty level. Mean hits = proportion of apple catches throughout game play. SBPS = Boredom proneness scale. Bonferroni correction for full control and yoked conditions: * $p < 0.005$; ** $p < 0.001$; *** $p < 0.0001$; **** $p < 0.00001$. Bonferroni correction for single-choice and no-choice conditions: * $p < 0.006$; ** $p < 0.001$; *** $p < 0.0001$; **** $p < 0.00001$

With regards to the full control condition, there was also a negative correlation between perceptions of challenge and boredom at the end of game play, such that those who perceived the task to be more challenging were likely to experience less boredom ($r = -0.38$, $p < 0.0001$). Furthermore, those who were more likely to choose higher task difficulty levels throughout game play were also less likely to be bored by the end of game play ($r = -0.32$, p

< 0.001). This can be contrasted to the lack of significant correlations between state boredom and perceived challenge and between state boredom and task difficulty for those in the other conditions, suggesting that full control over challenge levels plays a role in warding off state boredom. Interestingly, those who caught more apples in the full control condition were also more likely to report higher levels of boredom (r = 0.32, p < 0.001), whereas no such correlations were significant for any of the other conditions (Figure 5.3). This is counterintuitive because participants in the full control condition had the ability to change the task difficulty in such a way that ought to have minimised boredom. Closer inspection of the relationship between state boredom at the end of game play and proportion of apples caught (Figure 5.3) revealed that participants in the full control condition were catching upwards of 60% of the falling apples with the majority of participants catching more than 80%.

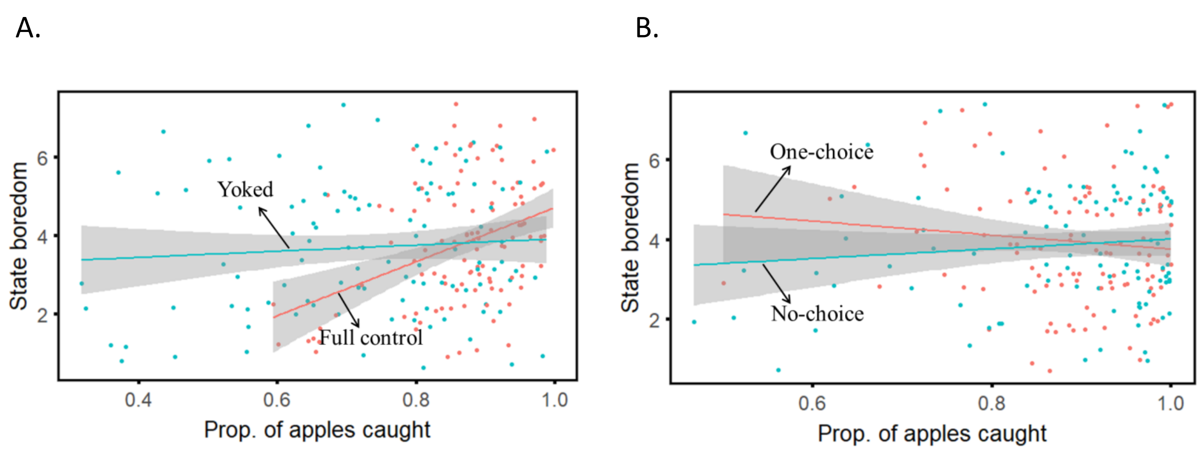

Figure 5.3 relationship between proportions of apples caught and state boredom at the end of game play. A - full control and yoked condition; B – One choice and no choice condition

With regards to trait boredom, there was a small positive correlation between boredom proneness and baseline boredom ($r = 0.21$, $p < 0.05$) for those in the full control condition. While the correlation was not significant for the other conditions, they were in the same (i.e., positive) direction suggesting that boredom prone participants were more likely to report higher levels of state boredom prior to engaging in the task.

5.5 Study 5.1 Discussion

Results of the current study suggested that those who did not have control but experienced changes in task difficulty throughout game play (i.e., yoked condition) experienced the task to be more challenging and felt less in control compared to those in all other conditions (Figure 5.2A). This suggests that the manipulation only succeeded in influencing a single condition – the yoked condition. This may relate to the very nature of the task. Regardless of how changes in challenge were presented to the participant, the actions they were tasked with performing involved them controlling the computer mouse to catch apples – something they were explicitly controlling. If participants were responding to control probes by reference to this behaviour and not the control over challenge levels, then it would be unlikely that perceived control would be modulated across conditions. What differentiated the yoked condition from all others was that changes in difficulty level were unpredictable (for the initial choice and the no control condition no such ‘in game’ changes occurred). Regardless, the various differences in how participants could or could not choose challenge levels failed to move the needle for feelings of state boredom. In all four conditions there was a negative relation between boredom and motivation. That is, as would be expected, participants high in motivation reported lower levels of boredom. In addition, motivation levels across all groups were in the moderate to high range (Table 5.1). It may be the case then, that motivation levels were sufficiently high, regardless of condition, to preclude the detection of minor changes in state boredom. Put another way, the sensitivity to detect changes in state boredom was likely very low given that motivation levels were uniformly high.

The relations between challenge, task difficulty and boredom followed expected directions for the full control group only. First, perception of challenge and task difficulty level were positively associated, such that higher task difficulty levels were related to higher perception of challenge (Table F.1 in Appendix F). Second, state boredom at the end of game play was negatively correlated with perceptions of challenge and task difficulty, such that the easier participants felt the task to be (i.e., low challenge, low task difficulty) the more bored they reported being. These relationships mirror those seen in study 3.1 where state boredom was also negatively associated with perceived task difficulty by the end of the task. No such relationships were present in the other three groups. For those in the yoked condition, control over challenge levels was out of their hands. Perhaps that lack of autonomy meant that the relation between boredom and challenge was absent. For the remaining two groups, challenge levels did not change over the course of the task. Without some variability in challenge the relation with state boredom dissolved. Clearly, these hypotheses are highly speculative and would require further research.

Chapter 6: General Discussion

Boredom has been defined as a self-regulatory signal that informs us that what we are currently doing is failing to satisfy our needs or meet our goals in some important ways, pushing us to explore alternative options for engagement (Bench & Lench, 2013; Danckert, 2019; Eastwood et al., 2012; Elpidorou, 2014, 2018). Trait boredom proneness has been associated with a slew of negative affective, behavioural and cognitive outcomes ranging from depression to problem gambling to failures of attention (Eastwood et al., 2012, Vodanovich, 2003; Westgate & Wilson., 2018). In order to minimise the experience and consequences of boredom, it is important to better understand the causes and correlates of the feeling state. Prior work has extensively investigated how boredom can arise from monotonous and repetitive situations (Johansson et al., 1978; Thackray et al., 1977), situations that lack meaning (Fahlman et al., 2009; van Tilburg & Igou, 2012) and situations that evoke lapses of attention (Damrad- Frye & Laird, 1989; Hunter & Eastwood, 2018). The work presented in this thesis examined some of the lesser investigated correlates and causes of boredom.

Chapter 2 explored the boredom conundrum – that boredom signals a desire to be engaged in some satisfying activity coupled with an unwillingness to engage in anything currently available. The studies presented in Chapter 2 showed that willingness to engage was indeed negatively associated with prospective judgements of boredom, such that bored participants were less willing to engage in the available tasks. Although correlational in nature, these results are the first to support the theoretical claim that in-the-moment feelings of boredom are characterised by wanting to engage in something but not with what is currently available, even when those options are subjectively rated to be interesting (Danckert et al., 2018; Eastwood et al., 2012). The relationship between willingness to engage and boredom is also in line with prior work that found a consistent negative association between boredom proneness and the locomotion mode of goal pursuit (i.e., a tendency for action implementation; Kruglanski 2000; Mugon et al., 2018b). That is, the ability to get started and continue on a task (i.e., locomotion) seems to act as a prophylactic against boredom. This resembles current relations in that those who were more willing to engage were also less likely to be bored. This is not to say that locomotion and willingness to engage are the same constructs. However, the fact that both are negatively related to boredom suggests that doing something or *being willing* to do a task, has the potential to keep boredom at bay. It could also be that boredom and willingness to engage influence each other in a cyclical manner.

Chapter 3 investigated the relationship between boredom and effort regulation using an effort discounting task to determine whether people are less willing to engage when bored because they perceive things to require too much effort. Previous research found that people are aversive to tasks that require a lot of effort (Dunn et al., 2017; Inzlicht et al., 2018; Kurniawan et al., 2010; Potts et al., 2018). Results suggested that overall, participants were indeed aversive to effort. That is, participants chose the easy task in over two thirds of the trials – indicative of a bias towards easy-task options. Furthermore, both pre- and post-task boredom were negatively associated with the proportion of hard-task options chosen. Given the current design, it is impossible to determine whether the act of choosing preceded feelings of boredom. Nonetheless, when accounting for the pre-task boredom, the proportion of hard-task options was negatively associated with post task boredom. Therefore, it is possible that participant's aversion to effort expenditure exacerbates boredom.

Chapter 4 explored whether a lack of autonomy influenced boredom. In study 4.1, participants either had or did not have the ability to view a slideshow at their own pace. Results suggested that the different levels of control did not influence state boredom. These findings are in contrast with previous research findings that either demonstrated that high control groups were less bored (van Hooft & van Hooff, 2018) or demonstrated a quadratic relationship between boredom and control (Struk et al., 2015, see also Pekrun 2006). While frustration and meaning were successfully held constant, the low control group felt that the task was more challenging than did the high control group (albeit both groups rating the task to be relatively low in challenge). This suggests that control and challenge may be intrinsically related such that participants may find situations that lack control as challenging, both of which can lead to increased boredom. Indeed, Pekrun and colleagues (2010) propose that within achievement settings, boredom can arise because learning tasks can be challenging and student's perceived control is low. Additionally, within study 4.1, task meaningfulness was strongly negatively related to boredom suggesting that the less meaningful participants perceived the task to be, the more bored they were. Indeed, participants in both conditions rated the task to be low to moderate in meaning. Previous research has characterised the experience of boredom as lacking meaning (Fahlman et al., 2009; van Tilburg and Igou 2012; Westgate & Wilson, 2018). Perhaps, if the tasks were high in meaning, the control manipulation would have differentiated individual differences in state boredom.

Study 4.2 manipulated the level of choice over which attentional task participants could engage in and found that the various choice manipulations had no consequence on state boredom. Of note, while conditions with little to no choice reported feeling lower levels of perceived control, ratings of control were in general moderate to high across all groups. This suggests that participants may have inferred their level of control in part based on their performance on the attentional tasks themselves and in part on how much control they had over determining which task they could engage in. Indeed, previous research suggests that we are sensitive to the degree of control we have over our environment (Eitam, Kennedy, & Higgins, 2013). Within this study, it is possible that participant's need to respond to each trial may have led to feelings of moderate to high control. Furthermore, Eitam and colleagues (2013) suggest that feeling in control is intrinsically motivating. Within study 4.2, participants consistently reported moderate to high motivation levels across the different probes and control was positively related to motivation.[3] Therefore, not only is the nature of the attentional tasks partly responsible for participants feeling in control, it may also have helped to maintain motivation. This suggests an intriguing relationship between control and motivation and further supports the notion that boredom is unlikely to be determined by a single factor. It is also worth noting that state boredom increased across all conditions,

[3] While some of the correlations between motivation and control were not significant, they were still trending in a positive direction.

suggesting that time on task is an important variable to consider when investigating the causes of boredom, especially when the tasks in question are repetitive or monotonous (Dember et al., 1992; Pattyn et al., 2008).

Chapter 5 explored whether control by itself may influence boredom when available options for engagement differed in challenge level. As such, in study 5.1 participants were given different levels of control over challenge inherent to the task. While the manipulations of control led yoked participants to report lower levels of control (and concomitantly higher levels of challenge), it did not differentiate the different conditions in terms of state boredom. Here too, participants may have attributed their ability to catch falling apples as a sense of control over the task. This coupled with the motivation to beat the high score may have prevented the manipulation of control from differentially influencing state boredom. Of note, participants were all equally motivated to perform this task and there was a strong negative correlation between motivation and state boredom in all four conditions suggesting that higher levels of motivation were associated with lower levels of boredom.

Throughout this thesis, the relationship between trait boredom and various study variables was also analysed. Of note, Chapter 2 found that high boredom prone individuals were more likely to report greater prospective state boredom and were less willing to engage in tasks. However, boredom proneness did not have any substantive influence either as a consequence of the specific manipulations or on any of the behavioural metrics tested. This suggests that high boredom prone individuals behave the same as low boredom prone individuals when faced with similar constraints. It is possible that high boredom prone individuals are either predisposed or tend to choose situations that are not optimal for engagement thereby increasing their likelihood of being bored, a situation not exploited in the current thesis (i.e., highly boredom prone participants were not differentially able to choose what to engage in relative to low boredom prone participants).

6.1 The challenge of isolating state boredom contingencies

This thesis attempted to isolate individual factors (effort, control, challenge) to investigate the unique contributions of each to the experience of state boredom. The attempted manipulations often only achieved partial success. It is plausible that feelings of state boredom do not arise as a consequence of changes in any single factor. Indeed, there are some theories that suggest that boredom arises as a result of several factors (Pekrun, 2006b; Westgate & Wilson, 2018). For example, in Pekrun's Control-Value theory of boredom within academic settings (Pekrun, 2006b), it is only when a learning activity is considered to be *both* of low value and learners have either high or low control that boredom ensues. Pekrun and colleagues (2010a) further argue that lack of control within achievement settings can arise due to the current tasks being too challenging – suggesting that it is not only control and value that can influence boredom, but that challenge also plays a role in influencing control and thereby boredom.

Another theoretical account that suggests that boredom arises from multiple factors comes from the Meaning and Attention Components (MAC) model of boredom which states that boredom is likely to arise in situations where we are not cognitively engaged (i.e., our attentional capacity is either under or over-stimulated) and the current task is deemed to be lacking in meaningful (Westgate & Wilson, 2018). In this sense, trying to manipulate the contingencies that lead to boredom is a little like building a ship in a bottle – every which way you move comes up against constraints. If you try to manipulate challenge levels to be low, meaning will also likely be low. If you give participants control over a task that is low in meaning (e.g., the slideshow task in Study 4.1), their sense of control will not be uniquely manipulated. This also raises the spectre of potential differences in the magnitude of various factor to induce boredom. Here, challenge, effort and control have been investigated, but there is no guarantee that each factor contributes equally to the experience of boredom. Unexamined were factors such as meaning, monotony and value, each of which may be expected to be significant drivers of the experience of boredom (O'Hanlon, 1981; Pekrun, Hall, Goetz, & Perry, 2014; Thackray, 1981; Van Tilburg & Igou, 2012). Indeed, in the current studies there were strong relations between boredom and motivation (study 3.1, 4.2 and 5.1) and boredom and meaning (study 4.1) depite the fact that these variables were not the explicit focus of the studies. It may be the case then that any attempt to investigate the antecedents to state boredom would need to manipulate "natural pairs". For example, monotony and challenge may naturally modulate in concert – as something becomes more monotonous it is presumably also less challenging. This suggestion of course, poses challenges for experimental design in which it is always preferrable to manipulate only one variable at a time. However, complex feeling states such as boredom may simply not lend themselves to such an approach. Of course, it may simply be that the manipulations attempted here were not sensitive or sophisticated enough to achieve the stated aims. Several potential future directions are outlined below that follow both possibilities – on the one hand an approach that manipulates pairs of factors and on the other, an approach that attempts to devise stronger manipulations of individual factors.

6.2 Future directions

Manipulating individual factors

Effort: Past research has suggested that exerting effort in a monotonous or boring circumstance could potentially decrease boredom (O'Hanlon, 1980). The task used in Study 3.1 not only involved effort regulation (i.e., perform either an easy or a hard task), but also choice. As such, most participants opted for the easy task on most trials. A follow-up experiment could have hard and easy trials randomly assigned to participants with different groups experiencing differing proportions of effort. If those who experienced more "hard" trials were less bored by the end of the task, this would confirm the hypothesis that exerting effort keeps boredom at bay. This would be in line with O'Hanlon's (1980) theory of boredom which states that when constrained to remain in place, exerting effort should decrease boredom. Of course, this removes the participant's capacity to choose what they engage in. As discussed earlier, experimental attempts to isolate factors that cause boredom face the challenge of inadvertently changing other factors that also contribute to the experience of boredom.

Challenge: Previous theoretical accounts have suggested that boredom may arise due to lack of skill-challenge fit (Danckert, 2019; Moneta & Csikszentmihalyi, 1996). Within achievement settings, boredom has been shown to arise in situations that are both over- and under-challenging (Acee et al., 2010). To further investigate whether subtle changes in challenges lead to different levels of boredom, a potential future experiment could use a Tetris like game in which different groups of participant experience different challenge levels (Mathiak, Klasen, Zvyagintsev, Weber & Mathiak, 2013; Ulrich, Keller & Gron, 2016). Challenge can be differentiated by manipulating the speed at which the Tetris pieces fall. Those in the low challenge condition would experience the pieces falling at a rate where pieces were easily manipulated. In an "optimal" condition the rate at which pieces fell could be titrated to particular success rate predicted to maintain motivation. In an 'overload' condition, pieces would fall at a rate beyond the capacity of the individual participant to successfully manipulate them. Here, it is predicted that if boredom arises in situations that are over- and under-challenging then, the low and high challenge groups would be more bored compared to those experiencing a skill-challenge fit.

Willingness to engage: Chapter 2 showed that decreased willingness to engage can lead to experiences of boredom. One strategy to increase willingness to engage has been demonstrated by Sansone and colleagues (1992) who ostensibly told participants that the boring copying task they were doing had some associated health benefits. Their results suggest that participants re-defined the activity as an opportunity to learn and subsequently were more likely to request additional tasks compared to those who were not told about the health benefits (Sansone, Weir, Harpster, & Morgan, 1992). While the researchers did not measure state boredom, the findings do suggest that the way in which an activity is portrayed can influence willingness to engage. As such, future studies could use a similar framework to manipulate participant's willingness to engage (essentially motivation manipulations) to determine what influence framing of this kind would have on state boredom. With respect to trait boredom proneness it may be the case that this manipulation is ineffectual as those high in trait boredom may struggle to reframe tasks successfully.

Manipulating multiple factors

Control and effort: The experimental design used in study 3.1 confounded control with effort. That is, participants had a choice to make on every trial and they chose a greater proportion of easy trials. It may be the case that with little to no control, the relation between effort and boredom is eliminated. Future studies could employ a between subjects design with participants in the high control group being able to choose between easy and hard task options on a trial by trial basis (similar to those in study 3.1). Presumably, participants who have control would choose a greater proportion of easy-task options. In contrast, those in a 'no control, high effort' condition, would be forced to engage with the hard task options for 75% of the trials, while participants in a 'no control, low effort' condition, would engage with the easy task option for 75% of the trials. It is predicted that those in the no control high effort condition will be the less bored compared to the no control low effort condition and the high control condition. It is also predicted that the latter two conditions will be equally bored.

This result would suggest that having control leads people to choose options that are less effortful and more boring.

Effort and motivation: Results from study 3.1 found that participants chose the easy task option approximately two-thirds of the time. It may be possible to change a participant's preference towards easy options in favor of the hard options by manipulating their motivation to engage in hard options. Such change in behaviour may in turn lead to decreased experiences of boredom. Indeed, boredom and motivation were found to be strongly negatively associated in study 3.1, 4.1 and 5.1. Using the same task design as study 3.1, different groups of participants could be provided with differential monetary rewards for successful completion of hard tasks. One potential control would be to reward randomly selected trials. Those in the high motivation group ought to select a greater proportion of hard task options and consequently be less bored than those in the randomly rewarded condition.

6.3 Conclusions

The goal of this thesis was to investigate the unique contributions of lesser studied contingencies to state boredom. The attempted manipulations often achieved only partial success and as such, did not dramatically differentiate groups in terms of state boredom. It is possible that with stronger manipulations, the individual factors studied here would lead to different levels of state boredom. It is also possible that the complex emotion of boredom arises from the interaction of multiple variables. Given the pervasiveness of boredom and its negative consequences, it is imperative that future studies continue to investigate the contingencies to this universal experience.

References

Acee, T. W., Kim, H., Kim, H. J., Kim, J. I., Chu, H. N. R., Kim, M., … Wicker, F. W. (2010). Academic boredom in under- and over-challenging situations. *Contemporary Educational Psychology*, *35*(1), 17–27. https://doi.org/10.1016/j.cedpsych.2009.08.002

Bandura, A. (2006). Toward a Psychology of Human Agency. *Perspectives on Psychological Science*, *1*(2), 164–180.

Barari, S., Caria, S., Davola, A., Falco, P., Fetzer, T., Fiorin, S., … Raimondi Slepoi, F. (2020). Evaluating COVID-19 Public Health Messaging in Italy: Self-Reported Compliance and Growing Mental Health Concerns. *MedRxiv*. https://doi.org/10.1101/2020.03.27.20042820

Bench, S., & Lench, H. (2013). On the Function of Boredom. *Behavioral Sciences*, *3*, 459–472. https://doi.org/10.3390/bs3030459

Caldwell, L. L., Darling, N., Payne, L. L., & Dowdy, B. (1999). "Why are You Bored?": An Examination of Psychological and Social Control Causes of Boredom Among Adolescents. *Journal of Leisure Rsearch*, *31*(2), 103–121. https://doi.org/10.1080/00222216.1999.11949853

Carriere, J. S. A., Cheyne, J. A., & Smilek, D. (2008). Everyday attention lapses and memory failures: The affective consequences of mindlessness. *Consciousness and Cognition*, *17*(3), 835–847. https://doi.org/10.1016/j.concog.2007.04.008

Chan, C. S., van Tilburg, W. A. P., Igou, E. R., Poon, C. Y. S., Tam, K. Y. Y., Wong, V. U. T., & Cheung, S. K. (2018). Situational meaninglessness and state boredom: Cross-sectional and experience-sampling findings. *Motivation and Emotion*, *42*(4), 555–565. https://doi.org/10.1007/s11031-018-9693-3

Cheyne, J. A., Carriere, J. S. A., & Smilek, D. (2006). Absent-mindedness: Lapses of conscious awareness and everyday cognitive failures. *Consciousness and Cognition*, *15*(3), 578–592. https://doi.org/10.1016/j.concog.2005.11.009

Chin, A., Markey, A., Bhargava, S., Kassam, K. S., & Loewenstein, G. (2016). Bored in the USA: Experience Sampling and Boredom in Everyday Life. *Emotion*, *17*(2), 359–368. Retrieved from https://www.cmu.edu/dietrich/sds/docs/loewenstein/BoredUSA.pdf

Critchlow, D. E., & Fligner, M. A. (1991). On distribution-free multiple comparisons in the one-way analysis of variance. *Communications in Statistics - Theory and Methods, 20*(1), 127–139. https://doi.org/10.1080/03610929108830487

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. San Fransisco, CA: Jossey-Bass. Retrieved from http://permalink.obvsg.at/AC05756119

Cumings, M., Gao, F., & Thornburg KM. (2015). Boredom in the Workplace: A New Look at an Old Problem. *Human Factors*, *58*(2), 279–300. https://doi.org/10.1177/0018720815609503

Curtin, F., & Schulz, P. (1998). Multiple correlations and Bonferroni's correction. *Biological*

Psychiatry, *44*(8), 775–777. https://doi.org/10.1016/S0006-3223(98)00043-2

Dahlen, E. R., Martin, R. C., Ragan, K., & Kuhlman, M. M. (2004). Boredom proneness in anger and aggression: Effects of impulsiveness and sensation seeking. *Personality and Individual Differences*, *37*(8), 1615–1627. https://doi.org/10.1016/j.paid.2004.02.016

Dal Mas, D. E., & Wittmann, B. C. (2017). Avoiding boredom: Caudate and insula activity reflects boredom-elicited purchase bias. *Cortex*, *92*, 57–69. https://doi.org/10.1016/j.cortex.2017.03.008

Damrad-Frye, R., & Laird, J. D. (1989). The Experience of Boredom: The Role of the Self-Perception of Attention. *Journal of Personality and Social Psychology*, *57*(2), 315–320. https://doi.org/10.1037/0022-3514.57.2.315

Danckert, J. (2019). Boredom: Managing the Delicate Balance Between Exploration and Exploitation. In R. V. J. (Ed.), *Boredom Is in Your Mind* (pp. 37–53). Cham: Springer. https://doi.org/10.1007/978-3-030-26395-9_3

Danckert, J., & Merrifield, C. (2016). Boredom, sustained attention and the default mode network. *Exp Brain Res*. https://doi.org/10.1007/s00221-016-4617-5

Danckert, J., Mugon, J., Struk, A., & Eastwood, J. (2018). Boredom: What is it good for? In *The Function of Emotions: When and Why Emotions Help Us* (pp. 93–119). Springer International Publishing. https://doi.org/10.1007/978-3-319-77619-4_6

Daschmann, E. C., Goetz, T., & Stupnisky, R. H. (2011). Testing the predictors of boredom at school: development and validation of the precursors to boredom scales. *The British Journal of Educational Psychology*, *81*(Pt 3), 421–440. https://doi.org/10.1348/000709910X526038

Dember, W. N., Galinsky, T. L., & Warm, J. S. (1992). The role of choice in vigilance performance. *Bulletin of the Psychonomic Society*, *30*(3), 201–204. Retrieved from https://link.springer.com/content/pdf/10.3758%2FBF03330441.pdf

Dunn, T. L., Koehler, D. J., & Risko, E. F. (2017). Evaluating Effort: Influences of Evaluation Mode on Judgments of Task-specific Efforts. *Journal of Behavioral Decision Making*, *30*(4), 869–888. https://doi.org/10.1002/bdm.2018

Eastwood, J. D., Frischen, A., Fenske, M. J., & Smilek, D. (2012). The Unengaged Mind: Defining Boredom in Terms of Attention. *Perspectives on Psychological Science : A Journal of the Association for Psychological Science*, *7*(5), 482–495. https://doi.org/10.1177/1745691612456044

Eitam, B., Kennedy, P. M., & Higgins, E. T. (2013). Motivation from control. *Experimental Brain Research*, *229*(3), 475–484. https://doi.org/10.1007/s00221-012-3370-7

Elpidorou, A. (2014a). The bright side of boredom. *Frontiers in Psychology*, *5*, 1245. https://doi.org/10.3389/fpsyg.2014.01245

Elpidorou, A. (2014b). The bright side of boredom. *Frontiers in Psychology*, *5*(NOV), 1245.

https://doi.org/10.3389/fpsyg.2014.01245

Elpidorou, A. (2018a). The bored mind is a guiding mind: toward a regulatory theory of boredom. *Phenomenology and the Cognitive Sciences*, *17*(3), 455–484. https://doi.org/10.1007/s11097-017-9515-1

Elpidorou, A. (2018b). The good of boredom. *Philosophical Psychology*, *31*(3), 323–351. https://doi.org/10.1080/09515089.2017.1346240

Fahlman, S., Mercer, K., Gaskovski, P., Eastwood, A., & Eastwood, J. D. (2009). Does a lack of life meaning cause boredom? Results from psychometric, longitudinal, and experimental analyses. *Journal of Social and Clinical Psychology*, *28*(3), 307–340.

Farmer, R., & Sundberg, N. D. (1986). Boredom Proneness--The Development and Correlates of a New Scale. *Journal of Personality Assessment*, *50*(1), 4–17. https://doi.org/10.1207/s15327752jpa5001_2

Fenichel, O. (1953). On the Psychology of Boredom. The Collected Papers of O tto Fenichel. In O. Fenichel (Ed.), *The collected papers of Otto Fenichel* (Vol. 1, pp. 292–302). New York, NY: W.W. Norton.

Flowerday, T., & Schraw, G. (2003). Effect of Choice on Cognitive and Affective Engagement. *The Journal of Educational Research*, *96*(4), 207–215. Retrieved from http://www.jstor.org/stable/27542434

Flowerday, T., & Shell, D. F. (2015). Disentangling the effects of interest and choice on learning, engagement, and attitude. *Learning and Individual Differences*, *40*, 134–140. https://doi.org/10.1016/j.lindif.2015.05.003

Geiwitz, P. J. (1966). Structure of boredom. *Journal of Personality and Social Psychology*, *3*(5), 592–600. https://doi.org/10.1037/h0023202

Gerritsen, C. J., Toplak, M. E., Sciaraffa, J., & Eastwood, J. (2014). I can't get no satisfaction: Potential causes of boredom. *Consciousness and Cognition*, *27*(1), 27–41. https://doi.org/10.1016/j.concog.2013.10.001

Goetz, T., Frenzel, A. C., Hall, N. C., Nett, U. E., Pekrun, R., & Lipnevich, A. A. (2014). Types of boredom: An experience sampling approach. *Motivation and Emotion*, *38*(3), 401–419. https://doi.org/10.1007/s11031-013-9385-y

Goldberg, Y., Eastwood, J., Laguardia, J., & Danckert, J. (2011). Boredom: An Emotional Experience Distinct From Apathy, Anhedonia, or Depression. *Journal of Social and Clinical Psychology*, *30*(6), 647–666. Retrieved from https://www.researchgate.net/profile/James_Danckert/publication/269599951_Boredom_An_Emotional_Experience_Distinct_from_Apathy_Anhedonia_or_Depression/links/551d426a0cf2000f8f93898a.pdf

Harris, M. B. (2000). Correlates and characteristics of boredom proneness and boredom. *Journal of Applied Social Psychology*, *30*(3), 576–598. https://doi.org/10.1111/j.1559-

1816.2000.tb02497.x

Helton, W. S., & Russell, P. N. (2011). Working memory load and the vigilance decrement. *Experimental Brain Research*, *212*(3), 429–437. https://doi.org/10.1007/s00221-011-2749-1

Hunter, A., & Eastwood, J. D. (2018). Does state boredom cause failures of attention? Examining the relations between trait boredom, state boredom, and sustained attention. *Experimental Brain Research*, *236*(9), 2483–2492. https://doi.org/10.1007/s00221-016-4749-7

Inzlicht, M., Shenhav, A., & Olivola, C. Y. (2018). The Effort Paradox: Effort Is Both Costly and Valued. *Trends in Cognitive Sciences*, *22*(4), 337–349. https://doi.org/10.1016/j.tics.2018.01.007

Jarvis, S., & Seifert, T. (2002). Work avoidance as a manifestation of hostility, helplessness, and boredom. *Alberta Journal of Educational Research*, *48*(2), 174–187.

Johansson, G., Aronsson, G., & Lindstrom, B. O. (1978). Social Psychological and Neuroendocrine Stress Reactions in Highly Mechanised Work. *Ergonomics*, *21*(8), 583–599. https://doi.org/10.1080/00140137808931761

Kruglanski, A. W., Higgins, E. T., Pierro, A., Thompson, E. P., Atash, M. N., Shah, J. Y., & Spiegel, S. (2000). To “do the right thing” or to “just do it”: Locomotion and assessment as distinct self-regulatory imperatives. *Journal of Personality and Social Psychology*, *79*(5), 793–815. https://doi.org/10.1037/0022-3514.79.5.793

Kurniawan, I. T., Seymour, B., Talmi, D., Yoshida, W., Chater, N., & Dolan, R. J. (2010). Choosing to make an effort: The role of striatum in signaling physical effort of a chosen action. *Journal of Neurophysiology*, *104*(1), 313–321. https://doi.org/10.1152/jn.00027.2010

Kurzban, R., Duckworth, A., Kable, J. W., & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *Behavioural and Brain Sciences*, *36*(6), 661–679. https://doi.org/10.1017/S0140525X12003196

Lang, P. J., Bradley, M. M., Cuthbert, &, Greenwald, M., Dhman, A., Vaid, D., … Hayden, S. (1997). *International Affective Picture System (IAPS): Technical Manual and Affective Ratings*. *International Affective Picture System (IAPS*.

Lazarus, R. S., & Smith, C. A. (1988). Knowledge and Appraisal in the Cognition-Emotion Relationship. *Cognition & Emotion*, *2*(4), 281–300. https://doi.org/10.1080/02699938808412701

Leary, M. R., Rogers, P. A., Canfield, R. W., & Coe, C. (1986). Boredom in Interpersonal Encounters. Antecedents and Social Implications. *Journal of Personality and Social Psychology*, *51*(5), 968–975. https://doi.org/10.1037/0022-3514.51.5.968

Leong, F. T. L., & Schneller, G. R. (1993). Boredom proneness: Temperamental and cognitive components. *Personality and Individual Differences*, *14*(1), 233–239.

https://doi.org/10.1016/0191-8869(93)90193-7

MacDonald, D. A., & Holland, D. (2002). Spirituality and boredom proneness. *Personality and Individual Differences*, *32*(6), 1113–1119. https://doi.org/10.1016/S0191-8869(01)00114-3

Malkovsky, E., Merrifield, C., Goldberg, Y., & Danckert, J. (2012). Exploring the relationship between boredom and sustained attention. *Experimental Brain Research*, *221*(1), 59–67. https://doi.org/10.1007/s00221-012-3147-z

Martin, M., Sadlo, G., & Stew, G. (2006). Qualitative Research in Psychology The phenomenon of boredom. *Qualitative Research in Psychology*, *3*(3), 193–211. https://doi.org/10.1191/1478088706qrp066oa

Mathiak, K. A., Klasen, M., Zvyagintsev, M., Weber, R., & Mathiak, K. (2013). Neural networks underlying affective states in a multimodal virtual environment: contributions to boredom. Frontiers in human neuroscience, 7, 820.

Meier, M. J. (1974). Some challenges for clinical neuropsy-chology. In R. M. Reitan & L. A. Davison (Eds.), *Clinical neuropsychology: Current status and applications.* . Washington, D.C: V. H. Winston.

Melton, A. M. A., & Schulenberg, S. E. (2007). On the relationship between meaning in life and boredom proneness: Examining a logotherapy postulate. *Psychological Reports*, *101*, 1016–1022.

Moneta, G. B., & Csikszentmihalyi, M. (1996). The Effect of Perceived Challenges and Skills on the Quality of Subjective Experience. *Journal of Personality*, *64*(2). https://doi.org/10.1111/j.1467-6494.1996.tb00512.x

Mugon, J, Danckert, J., & Eastwood, J. (2018a). The costs and benefits of boredom in the classroom. In K. A. Renninger & S. E. Hidi (Eds.), *Cambridge Handbook on Motivation and Learning* (pp. 490–513). Cambridge, UK: Cambridge University Press.

Mugon, Jhotisha, Struk, A., & Danckert, J. (2018b). A failure to launch: Regulatory modes and boredom proneness. *Frontiers in Psychology*, *9*(JUL), 1–7. https://doi.org/10.3389/fpsyg.2018.01126

Munsterberg, H. (1913). *Psychology and Industrial Efficiency*. Boston: Mifflin.

O'Hanlon, J. F. (1981). Boredom: Practical consequences and a theory. *Acta Psychologica*, *49*(1), 53–82. https://doi.org/10.1016/0001-6918(81)90033-0

Pattyn, N., Neyt, X., Henderickx, D., & Soetens, E. (2008). Psychophysiological investigation of vigilance decrement: Boredom or cognitive fatigue? *Physiology & Behavior*, *93*(1), 369–378. https://doi.org/10.1016/j.physbeh.2007.09.016

Pekrun, R. (2006a). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*(4), 315–341. https://doi.org/10.1007/s10648-006-9029-9

Pekrun, R. (2006b). The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice. https://doi.org/10.1007/s10648-006-9029-9

Pekrun, R., Goetz, T., Daniels, L. M., Stupnisky, R. H., & Perry, R. P. (2010a). Boredom in Achievement Settings: Exploring Control-Value Antecedents and Performance Outcomes of a Neglected Emotion. *Journal of Educational Psychology*, *102*(3), 531–549. https://doi.org/10.1037/a0019243

Pekrun, R., Goetz, T., Daniels, L. M., Stupnisky, R. H., & Perry, R. P. (2010b). Boredom in achievement settings: Exploring control–value antecedents and performance outcomes of a neglected emotion. *Journal of Educational Psychology*, *102*(3), 531–549. https://doi.org/10.1037/a0019243

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemporary Educational Psychology*, *36*(1), 36–48. https://doi.org/10.1016/j.cedpsych.2010.10.002

Pekrun, R., Goetz, T., Titz, W., & Raymond, P. (2002). Academic Emotions in Students' Self-Regulated Learning and Achievement: A Program of Qualitative and Quantitative Research. *Educational Psychologist*, *37*(2), 91–105. https://doi.org/10.1207/S15326985EP3702_4

Pekrun, R., Hall, N. C., Goetz, T., & Perry, R. P. (2014). Boredom and Academic Achievement: Testing a Model of Reciprocal Causation. *Journal of Educational Psychology*, *106*(3), 696–710. https://doi.org/10.1037/a0036006

Perkind, R. E., & Hill, A. B. (1985). Cognitive and affective aspects of boredom. *British Journal of Psychology*, *76*(2), 221–234. https://doi.org/10.1111/j.2044-8295.1985.tb01946.x

Potts, C. A., Pastel, S., & Rosenbaum, D. A. (2018). How are cognitive and physical difficulty compared? *Attention, Perception, and Psychophysics*, *80*(2), 500–511. https://doi.org/10.3758/s13414-017-1434-2

Raffaelli, Q., Mills, C., & Christoff, K. (2018). The knowns and unknowns of boredom: a review of the literature. *Experimental Brain Research*, *236*(9), 2451–2462. https://doi.org/10.1007/s00221-017-4922-7

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). “Oops!”: Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neur*, *34*(6), 747–758.

Robinson, W. P. (1975). Boredom at school. *The British Journal of Educational Psychology*, *45*(2), 141–152. https://doi.org/10.1111/j.2044-8279.1975.tb03239.x

Sansone, C., Weir, C., Harpster, L., & Morgan, C. (1992). Once a boring task always a boring task? Interest as a self-regulatory mechanism. *Journal of Personality and Social*

Psychology, *63*(3), 379–390. https://doi.org/10.1037/0022-3514.63.3.379

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples)!, *52*(3/4), 591–611. Retrieved from https://academic.oup.com/biomet/article-abstract/52/3-4/591/336553

Shaw, S. M., Caldwell, L. L., & Kleiber, D. A. (1996). *Boredom, Stress and Social Control in the Daily Activities of Adolescents*. *Journal of Leisure Research Copyright* (Vol. 28). Retrieved from https://www.nrpa.org/globalassets/journals/jlr/1996/volume-28/jlr-volume-28-number-4-pp-274-292.pdf

Skinner, E. (1996). A Guide to Constructs of Control. *Article in Journal of Personality and Social Psychology*. https://doi.org/10.1037/0022-3514.71.3.549

Smith, C. A., & Ellsworth, P. C. (1985). Patterns of Cognitive Appraisal in Emotion. *Journal of Personality and Social Psychology*, *48*(4), 813–838. https://doi.org/10.1037/0022-3514.48.4.813

Smith, R. P. (1981). Boredom: A Review. *Human Factors*, *23*(3), 329–340.

Snibbe, A. C., & Markus, H. R. (2005). You can’t always get what you want: Educational attainment, agency, and choice. *Journal of Personality and Social Psychology*, *88*(4), 703–720. https://doi.org/10.1037/0022-3514.88.4.703

Steinberger, F., Moeller, A., & Schroeter, R. (2016). The antecedents, experience, and coping strategies of driver boredom in young adult males. *Journal of Safety Research*, *59*, 69–82. https://doi.org/10.1016/j.jsr.2016.10.007

Streiner, D. L. (2010). Coefficient Alpha and Internal Consistency. *Journal of Personality Assessment, 80*(1), 99–103. https://doi.org/10.1207/S15327752JPA8001_18

Struk, A. A., Carriere, J. S. A., Cheyne, J. A., & Danckert, J. (2017). A Short Boredom Proneness Scale. *Assessment*, *24*(3), 346–359. https://doi.org/10.1177/1073191115609996

Struk, A., Scholer, A., & Danckert, J. (2015). Low Perceived Control Predicts Engagement and Diminished Boredom. In *Poster presented at the Canadian Society for Brain, Behaviour and Cognitive Science*. Ottawa.

Team, R. C. (2015). A language and environment for statistical computing [Computer software manual]. Retrieved February 6, 2020, from https://www.r-project.org/

Thackray, R. I. (1981). The Stress of Boredom and Monotony: A Consideration of the Evidence. *Psychosomatic Medicine*, *43*(2), 165–176.

Thackray, R. I., Bailey, P., & Mark Touchstone, M. R. (1977). Physiological, subjective, and performance correlates of reported boredom and monotony while performing a simulated radar control task. In *Vigilance* (pp. 203–215). Boston, MA: Springer.

The Jamovi project. (2020). Retrieved February 6, 2020, from https://rdrr.io/cran/jmv/man/

The National Center on Addiction and Substance Use. (2003). Report on Teen Cigarette Smoking and Marijuana Use. Retrieved January 28, 2020, from https://www.centeronaddiction.org/addiction-research/reports/report-teen-cigarette-smoking-and-marijuana-use

Tingley, D., Yamamoto, T., Hirose, K., Keele, L., & Imai, K. (2014). Journal of Statistical Software mediation: R Package for Causal Mediation Analysis. *Journal of Statistical Software*, *59*, 1–38. Retrieved from http://www.jstatsoft.org/

Treadway, M. T., Buckholtz, J. W., Schwartzman, A. N., Lambert, W. E., & Zald, D. H. (2009). Worth the "EEfRT"? The Effort Expenditure for Rewards Task as an Objective Measure of Motivation and Anhedonia. *PLoS ONE*, *4*(8). https://doi.org/10.1371/journal.pone.0006598

Troutwine, R., & O 'neal, E. C. (1981). VOLITION, PERFORMANCE OF A BORING TASK AND TIME ESTIMATION. @ *Perceptual and Motor Skills*, *52*, 865–866. Retrieved from http://journals.sagepub.com/doi/pdf/10.2466/pms.1981.52.3.865

Tze, V. M. C., Daniels, L. M., & Klassen, R. M. (2016). Evaluating the Relationship Between Boredom and Academic Outcomes: A Meta-Analysis. *Educational Psychology Review*, *28*(1), 119–144. https://doi.org/10.1007/s10648-015-9301-y

Tze, V. M. C., Klassen, R. M., & Daniels, L. M. (2014). Patterns of boredom and its relationship with perceived autonomy support and engagement. *Contemporary*

Educational Psychology, *39*(3), 175–187. https://doi.org/10.1016/j.cedpsych.2014.05.001

Ulrich, M., Keller, J., & Grön, G. (2016). Neural signatures of experimentally induced flow experiences identified in a typical fMRI block design with BOLD imaging. Social cognitive and affective neuroscience, 11(3), 496-507.

van Hooft, E. A. J., & van Hooff, M. L. M. (2018). The state of boredom: Frustrating or depressing? *Motivation and Emotion*, *42*(6), 931–946. https://doi.org/10.1007/s11031-018-9710-6

Van Tilburg, W. A. P., & Igou, E. R. (2017). Boredom Begs to Differ: Differentiation From Other Negative Emotions. *Emotion*, *17*(2), 309–322. https://doi.org/10.1037/emo0000233

van Tilburg, W., & Igou, E. R. (2011). On Boredom and Social Identity: A Pragmatic Meaning-Regulation Approach. *Personality & Social Psychology Bulletin*, *37*(12), 1679–1691. https://doi.org/10.1177/0146167211418530

van Tilburg, W., & Igou, E. R. (2012). On boredom: Lack of challenge and meaning as distinct boredom experiences. *Motivation and Emotion*, *36*(2), 181–194. https://doi.org/10.1007/s11031-011-9234-9

Vodanovich, S. J. (2003). Psychometric Measures of Boredom: A Review of the Literature. *The Journal of Psychology*, *137*(6), 569–595.

https://doi.org/10.1080/00223980309600636

Vodanovich, S. J., & Kass, S. J. (1990). A Factor Analytic Study of the Boredom Proneness Scale. *Journal of Personality Assessment*, *55*(1–2), 115–123. https://doi.org/10.1080/00223891.1990.9674051

Vodanovich, S. J., Verner, K. M., & Gilbride, T. V. (1991). Boredom pronenessL its relationship to positive and negative affect. *Psychological Reports*, *69*, 1139–1146.

Weinstein, L., Xie, X., & Cleanthous, C. C. (1995). Purpose in life, boredom, and volunteerism in a group of retirees. *Psychological Reports*, *76*(2), 482–482.

Westgate, E. C., & Wilson, T. D. (2018). Boring Thoughts and Bored Minds: The MAC Model of Boredom and Cognitive Engagement. *Psychological Review*, *125*(5), 689–713. https://doi.org/10.1037/rev0000097

Wyatt, S. (1929). Boredom in industry. *Personnel Journal*, *3*, 161–173.

Appendix A: Short Boredom Proneness Scale

Short Boredom Proneness Scale (SBPS; Struk, Carriere, Cheyne, & Danckert, 2017)

Instructions: The following are some statements that may or may not describe you, in general, on a typical day. Please rate each statement using the 7-point scale above by circling the number that corresponds to how much you do or do not feel like the sentence describes you. Remember to rate each statement based on how much it describes you in general.

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

I often find myself at "loose ends", not knowing what to do.	1	2	3	4	5	6	7
I find it hard to entertain myself.	1	2	3	4	5	6	7
Many things I have to do are repetitive and monotonous.	1	2	3	4	5	6	7
It takes more stimulation to get me going than most people.	1	2	3	4	5	6	7
I don't feel motivated by most things that I do.	1	2	3	4	5	6	7
In most situations, it is hard for me to find something to do or see to keep me interested	1	2	3	4	5	6	7
Much of the time I just sit around doing nothing.	1	2	3	4	5	6	7
Unless I am doing something exciting, even dangerous, I feel half-dead and dull	1	2	3	4	5	6	7

The following items were added to the scale but not used in calculating participant's scores.

In any given week, how often would you say you feel bored?

1 = not at all	2 = rarely	3 = Not much	4 = A little	5 = Often	6 = Very often	7 = Extremely often

When you are bored, how intense would you rate the feeling to be?

1 = not at all intense	2	3	4 = moderately intense	5	6	7 = extremely intense

Appendix B: Additional Analyses for study 2.1 and 2.1

Study 2.1 Additional analyses

For comparisons between tasks, the Friedman test (Friedman, 1937) was calculated and for pairwise comparisons, the Durbin-Conover test (Conover, 1999) was used. All comparison analyses were conducted using the jmv package ("The Jamovi project," 2020); p-values are based on two-tailed tests. A Bonferroni correction was applied to all pairwise corrections.

Task boringness

All tasks were rated as very boring with a median boringness rating of 4 out of 5 for all of them. Comparisons between tasks revealed a significant difference in how boring each task was perceived to be ($\chi^2(4) = 18.5$, $p < 0.001$). Follow-up comparisons revealed that the Starry Night task was rated as less boring than the COVAT (Statistic = 4.09, $p < 0.001$) and the N-back tasks (mean = 3.69, Statistic = 3.18, $p = 0.001$). No other significant differences were found. Despite being rated as the least boring task, the Starry Night task was still rated on average to be between "fairly boring" and "boring" and so was included in the full dataset presented in the chapter.

Willingness to engage

Participants reported a median willingness to engage rating of 4 out of 5 for all tasks. Comparisons between tasks revealed a significant difference in how willing participants were to engage in the tasks ($\chi^2(4) = 65.2$, $p < 0.001$). Follow-up comparisons revealed that participants were less willing to engage in the N-back task compared to the COVAT (Statistic = 3.11, $p < 0.01$), Stroop (Statistic = 3.33, $p < 0.01$), SART (Statistic = 6.85, $p < 0.01$) and Starry night tasks (Statistic = 6.92, $p < 0.01$). Participants were also less willing to engage in the COVAT compared to the SART (Statistic = 3.74, $p < 0.01$) and Starry night tasks (Statistic = 3.81, $p < 0.01$). Finally, participants were also less willing to engage in the Stroop task compared to the SART (Statistic = 3.52, $p < 0.01$) and Starry night tasks (Statistic = 3.59, $p < 0.01$). Nonetheless, all tasks were rated between 3 "fairly willing" and 4 "very willing" signifying that participants were willing to engage in all tasks.

Internal consistency of task boringness and willingness to engage

To look at the relationship between task boringness and willingness to engage, a single measure for task boringness and willingness to engage was calculated respectively by taking an average of scores across all tasks. The resulting internal consistency (i.e., the degree to which items relate to each other as a group) of each instrument was adequate (Streiner, 2010). Cronbach's alpha for task boringness was 0.82 and 0.79 for willingness to engage.

Study 2.2 Additional analyses for engaging tasks

For comparisons between tasks, the Friedman test (Friedman, 1937) was calculated and for pairwise comparisons, the Durbin-Conover test (Conover, 1999) was used. A Bonferroni correction was applied for multiple comparisons. All comparison analyses were conducted using the jmv package ("The Jamovi project," 2020); p-values are based on two-tailed tests. A Bonferroni correction was applied to all pairwise corrections.

Task engagement

All tasks were rated as fairly engaging with median engagement ratings of 3 out of 5 for all tasks except the boggle task which received a rating of 4 (engaging) out of 5. Comparisons between tasks revealed a significant difference in how engaging each task was perceived to be ($\chi^2(4) = 56.2$, $p < 0.001$). Follow-up comparisons revealed that the foraging tasks was considered significantly less engaging than the dot task (Statistic = 3.93, $p < 0.01$), the Boggle task (Statistic = 7.59, $p < 0.01$), the apple-catcher task (Statistic = 5.17, $p < 0.01$) and the Wisconsin card sorting task (Statistic = 3.9, $p < 0.01$). Furthermore, the Boggle task was rated as more engaging compared to the dot task (Statistic = 3.66, $p < 0.01$) and the Wisconsin card sorting task (Statistic = 3.68, $p < 0.01$). No other significant differences were found. Despite the differences between the tasks, all tasks were rated to be fairly engaging.

Task boringness

All tasks were rated as slightly boring with median boringness ratings of 2 (‘slightly boring’) out of 5 for all tasks except the foraging task which received a rating of 3 (‘fairly boring’) out of 5. Comparisons between tasks revealed a significant difference in how boring each task was perceived to be ($\chi^2(4) = 30.6$, $p < 0.001$). Follow-up comparisons with a Bonferroni correction revealed that the foraging task was rated to be significantly more boring than the Boggle (Statistic = 5.12, $p < 0.001$) and apple-catcher tasks (Statistic = 4.01, $p < 0.001$). Additionally, the dot task was rated as more boring than the Boggle task (Statistic = 3.26, $p = 0.001$). No other significant differences were found. Despite the differences between the tasks, all tasks were rated to between slightly boring to fairly boring and so were included in the analyses presented in the chapter.

Willingness to engage

Median willingness to engage ratings for the Boggle and apple-catcher tasks were 4 (‘willing’) out of 5. Median willingness to engage ratings for all other tasks were 3 (‘fairly willing’) out of 5. Comparisons between tasks revealed a significant difference in how willing participants were to engage in the tasks ($\chi^2(4) = 24.7$, $p < 0.001$). Follow-up comparisons revealed that compared to the foraging task, participants were more willing to engage in the Boggle (Statistic = 3.57, $p < 0.01$) and the apple-catcher tasks (Statistic = 3.46, $p < 0.01$). Furthermore, compared to the Wisconsin card sorting task, participants were more willing to engage in the Boggle (Statistic = 3.57, $p < 0.01$) and apple-catcher tasks (Statistic

= 3.46, $p < 0.01$). No other significant differences were found. Despite the differences between the tasks, participants' willingness to engage scores ranged from fairly willing to willing.

Internal consistency of task boringness, task engagement and willingness to engage

A single measure for task boringness, willingness to engage and task engagement was calculated respectively by taking an average of scores across all tasks. The resulting internal consistency (i.e., the degree to which items relate to each other as a group) of each instrument was acceptable (Streiner, 2010). Cronbach's alpha for task boringness was 0.61, 0.72 for willingness to engage and 0.72 for task engagement.

Task boringness rating between study 2.1 and 2.2

A Wilcoxon Signed rank test was used to test whether the tasks used in study 2.1 had higher ratings on prospective measures of state boredom compared to study 2.2. Results suggest that tasks used in study 2.1 were indeed rated higher on task boringness (median = 3.8, mean = 3.63) compared to the tasks used in study 2.2 (median = 2.4, mean = 2.37; $W = 62654$, $p < 0.001$)

Appendix C: Additional analyses for study 3.1

Pre and post EEfRT subjective measures

The table below is a complete list of subjective measures that participants responded to in the EEfRT.

Table C.1 Pre and post subjective measures

Measures	Pre-task	Post-task
1. Task boringness	How boring do you think the task will be?	How boring did you think the task was?
2. State boredom	How bored are you right now?	How bored are you right now?
3. Challenge	How challenging do you think the task will be?	How challenging did you think the task was?
4. Interest	How interesting do you think the task will be	How interesting do you think the task was?
5. Motivation	How motivated are you to do your best on this task?	N/A

Data Analyses

A repeated measures ANOVA was used to see if there were any differences in proportion of hard task choices for each probability level. Correlational and regression analyses were performed to determine the relationship amongst variables.

Descriptive statistics

The median and median absolute deviation for all study variables are shown in Table C.2

Table C.2 Median and Median absolute deviation for study variables

Study Variable	Median (median absolute deviation)	Study Variable	Median (median absolute deviation)
Boredom proneness	23 (8.9)	Pre state boredom	3 (1.48)
Prop Hard	0.36 (0.14)	Post state boredom	4 (2.22)
EV for hard tasks	2.13 (0.39)	State boredom diff	0 (1.48)
P-low	0.1 (0.15)	Pre challenge	5 (1.48)
P-mid	0.30 (0.19)	Post challenge	4 (1.48)
P-high	0.61 (0.24)	Challenge diff	0 (1.48)
Pre task boringness	3 (1.48)	Pre Interest	5 (1.48)
Post task boringness	3 (2.97)	Post Interest	4 (1.48)
Task boringness diff.	0 (1.48)	Interest diff	0 (1.48)
		Pre-Motivation	0 (1.48)

diff = difference score (post – pre)

Spearman correlations between behavioural metrics, state boredom and boredom proneness are shown in Table C.3. Only correlations pertaining to boredom are briefly explained below.

Those who expected the task to be boring were less likely to choose hard options, including options that had a mid and a high probability of winning. Likewise, those who by the end of the task rated it to be boring were less likely to choose hard options including options that had low, mid and high probability of winning. Participants who were bored at the beginning of the task were less likely to choose hard task options and those who were bored at the end of the task were less likely to choose hard task options including options with mid and high probability of winning. There were positive associations between perceptions of task boringness and state boredom for this task such that the more boring participants thought the task was going to be, the more bored they were at the beginning and by the end of the task. Pre-task boringness was also positively associated with post task boringness ratings. Furthermore, by the end of the task, those who were more bored were more likely to rate the task as boring. Finally, there were negative relationships between boredom (task and state) and ratings of challenge, interest and motivation at both pre and post task (Table C.3).

Table C.3 Spearman correlation between study variables

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. SBPS							
2. Prop Hard	0.02						
3. EV	-0.02	-0.50****					
4. P-low	0	0.70****	-0.74****				
5. P-mid	-0.02	0.90****	-0.52****	0.57****			
6. P-high	0.06	0.73****	0.06	0.14	0.53****		
7. Pre - boring	0	-0.20*	0.05	-0.14	-0.17*	-0.17*	
8. Post-boring	0.04	-0.26**	0.08	-0.19*	-0.22**	-0.19*	0.40****
9. Pre bored	0.07	-0.22**	0.05	-0.16	-0.22**	-0.12	0.52****
10. Post-Bored	0.07	-0.24**	0.03	-0.13	-0.19*	-0.24**	0.31***
11. Pre-challenge	0.13	0.06	-0.07	0.08	0.04	0.03	-0.25**
12. Post-challenge	-0.07	0.03	-0.08	0.11	-0.03	-0.01	-0.24**
13. Pre-Interest	0.06	0.16	-0.11	0.19*	0.14	0.07	-0.56****
14. Post-interest	0	0.09	-0.04	0.12	0.04	0.06	-0.41****
15. Pre-motivate	-0.05	0.25**	-0.09	0.18*	0.20*	0.21*	-0.25**

SBPS = short boredom proneness; diff = Difference score (post – pre measures). No Bonferroni corrections were applied. * $p < 0.05$; ** $p < 0.01$; *** $P < 0.001$; **** $p < 0.0001$

Table C.3 Continued.

	8	9	10	11	12	13	14
1. SBPS							
2. Prop Hard							
3. EV							
4. P-low							
5. P-mid							
6. P-high							
7. Pre - boring							
8. Post-boring							
9. Pre bored	0.31***						
10. Post-Bored	0.75****	0.36****					
11. Pre-challenge	-0.19*	-0.21*	-0.17*				
12. Post-challenge	-0.33****	-0.05	-0.33****	0.39****			
13. Pre-Interest	-0.38****	-0.49****	-0.29***	0.34****	0.24**		
14. Post-interest	-0.58****	-0.28***	-0.50****	0.19*	0.34****	0.51****	
15. Pre-motivate	-0.25**	-0.32****	-0.23**	0.04	0.14	0.45****	0.25**

SBPS = short boredom proneness; diff = Difference score (post – pre measures). No Bonferroni corrections were applied. * $p < 0.05$; ** $p < 0.01$; *** $P < 0.001$; **** $p < 0.0001$

Appendix D: Additional analyses for study 4.1

Table D.1 shows the median and median absolute deviation for all study variables.

Table D.1 Median and Median absolute deviation for study variables

Conditions			
High control condition (n = 60)		Low control condition (n = 60)	
1. controlled	5 (1.48)	controlled	3 (1.48)
2. In-control	6 (1.48)	In-control	4 (1.48)
3. Control_c	5.5 (1.48)	Control_c	3.75 (1.85)
4. Boring	3 (1.48)	Boring	3 (1.48)
5. Bored	3 (1.48)	Bored	3(2.97)
6. Boredom_c	3.25 (1.85)	Boredom_c	3.5 (1.48)
7. challenging	1 (0)	challenging	1 (0)
8. frustrating	1 (0)	frustrating	1.5 (0.74)
9. meaningful	3 (1.48)	meaningful	3 (1.48)
10. Total Correct	97 (2.97)	Total Correct	96 (2.97)
11. Av. rating	3.97 (0.36)	Av. rating	4 (0.369)
12. Av. Time	1.54 (0.51)	Average Time	1.54 (0.51)
13. SBPS	25 (8.9)	SBPS	23 (8.9)

Controlc = average of the two control measures. Boredomc = average of two boredom measures. Total correct = total number of correct answers on memory test (out of 100); Av. Rating = average rating of pictures based on a Likert scale of 1 – "*not at all*" to 7 – *"extremely."* Av. time = average time in seconds spent on each slide. SBPS = Boredom proneness scale

Wilcoxon Signed rank test was used to determine whether there were any differences between the two conditions for the individual measures of control and state boredom. Results suggest that those in high control condition reported feeling like they controlled the task more (median = 5; mean = 5.15) and that they felt more in control (median = 6; mean = 5.37) than those in the low control condition (controlled: median = 3, mean = 3.15, W = 2892, $p < 0.001$; in-control: median = 4, mean = 4.27, W = 2517.5, $p < 0.001$). There was no significant difference between conditions in how boring they perceived the task to be (W = 1820.5, $p > 0.05$) or how bored participants felt (W = 1793.5, $p > 0.05$).

Spearman correlations between all study variables in each condition were examined, separately. No Bonferroni corrections were applied to the following correlational tables. In both conditions, the combined measure of control was significantly and positively correlated with participants perception of how much control they had and how in-control participants felt (full control condition: r = 0.74 and r = 0.76 respectively; low control condition: r = 0.9 and r = 0.9 respectively). Similarly, the combined measure of boredom was very highly significantly and positively correlated with participant’s perception of task boringness and their state boredom (full control condition: r = 0.93 and r = 0.94 respectively; low control condition: r = 0.85 and r = 0.94 respectively). Furthermore, perceived task boringness and participant’s state boredom were also positively correlated in both conditions (full control condition: r = 0.77; low control condition: r = 0.64).

For those in the high control condition (Table D.2), the more bored participants were, the more frustrating ($r = 0.4$, $p < 0.01$) and the less meaningful ($r = -0.37$, $p < 0.01$) they rated the task to be. Those who felt the task was boring also rated the task as less meaningful (*r* = -0.35, p < 0.01). With regards to trait boredom, boredom prone individuals rated the task to be more boring (*r* = 0.34, p < 0.01) and were more bored (*r* = 0.26, p < 0.05) by the end of the task. There was also a positive association between challenge and frustration (*r* = 0.26, p < 0.05), such that as perception of challenge increased, so did levels of frustration.

Table D.2 Correlations between study variables for high control condition

	1	2	3	4	5	6	7	8	9	10	11	12
1. SBPS												
2. controlled	0.01											
3. In-control	0.25	0.22										
4. Control_C	0.23	0.74^{****}	0.76^{****}									
5. boring	0.34^{**}	0.13	0.04	0.15								
6. bored	0.26^{*}	0.17	-0.16	0.03	0.77^{****}							
7. Boredom_C	0.33^{*}	0.15	-0.07	0.09	0.93^{****}	0.94^{****}						
8. challenging	0	-0.16	-0.15	-0.17	0	0.13	0.07					
9. frustrating	0.24	-0.17	-0.12	-0.14	0.19	0.4^{**}	0.32^{*}	0.26^{*}				
10. meaningful	0.11	-0.16	-0.13	-0.18	-0.35^{**}	-0.37^{**}	-0.39^{**}	0.17	-0.24			
11. Total Correct	-0.25	0.19	0.11	0.2	-0.2	-0.16	-0.19	-0.13	-0.14	-0.12		
12. Av. Time	-0.19	0.33	-0.22	0.13	-0.08	0.05	-0.03	0.1	0.05	0.12	0.27^{*}	
13. Av. Rating	-0.1	-0.14	-0.16	-0.19	0.06	0.05	0.04	0	-0.04	-0.05	-0.1	0.05

Av. Time = Average time per slide in seconds. Av. Rating = Average rating of pictures * p < 0.05, ** p < 0.01, *** p < 0.001, **** p < 0.0001

For those in the low control condition (Table D.3), those who rated the task to be boring were likely to rated the task to be more frustrating ($r = 0.35$, $p < 0.05$), less meaningful ($r = -0.5$, $p < 0.0001$), performed worse on the subsequent memory task ($r = -0.3$, $p < 0.05$) and rated the pictures as less pleasant ($r = -0.27$, $p < 0.05$). Similar ratings were observed for those who reported greater state boredom by the end of the task. Similar to the full control condition, there was also a positive association between challenge and frustration ($r = 0.38$, $p < 0.01$), such that as perceptions of challenge increased, so too did perceived frustration. Frustration was also negatively related to control ($r = -0.32$, $p < 0.05$), such that those who felt less in control felt more frustration.

Table D.3 Correlations between study variables for low control condition

	1	2	3	4	5	6	7	8	9	10	11	12
1. SBPS												
2. controlled	-0.01											
3. In-control	0.05	0.62****										
4. Control_C	0.03	0.90****	0.90****									
5. boring	0.19	-0.15	-0.05	-0.1								
6. bored	-0.04	-0.16	-0.25	-0.24	0.64****							
7. Boredom_C	0.05	-0.17	-0.19	-0.2	0.85****	0.94****						
8. challenging	0.27*	-0.1	-0.12	-0.11	-0.09	-0.06	-0.07					
9. frustrating	0.11	-0.33*	-0.25	-0.32*	0.35**	0.43**	0.43***	0.38**				
10. Meaningful	0.14	0.17	0.12	0.17	-0.50****	-0.45***	-0.51****	0.22	-0.26			
11. Total Correct	-0.06	0.1	0.13	0.14	-0.3*	-0.47***	-0.43**	0.12	-0.22	0.23		
12. Av. Time	-0.18	0.09	0.27	0.18	-0.02	-0.08	-0.06	-0.08	0.05	-0.02	0.15	
13. Av. Rating	0.17	0.15	0.25	0.23	-0.27*	-0.25	-0.28*	0.10	-0.10	0.22	0.24	0.05

Av. Time = Average time per slide in seconds. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Appendix E: Additional analyses for study 4.2

Table E.1 Correlation between study variables for Continual choice condition

	1	2	3	4	5	6	7	8
1. SBPS								
2. SW	*0.02*							
3. B1	*0.29*	-0.05						
4. B2	*0.1*	0.02	0.56****					
5. B3	*0.04*	0.19	0.26*	0.57****				
6. C1	*-0.23*	0	-0.29*	-0.03	0.13			
7. C2	*-0.07*	-0.1	-0.33**	-0.19	-0.02	0.51****		
8. C3	*-0.19*	0.09	-0.18	-0.15	0.04	0.52****	0.59****	
9. F1	*0.2*	-0.12	0.51****	0.46****	0.24*	-0.27*	-0.22	-0.25*
10. F2	*0.14*	-0.1	0.50****	0.36**	0.13	-0.25*	-0.44***	-0.37**
11. F3	*0.29*	0.08	0.40***	0.13	0.09	-0.31**	-0.26*	-0.49****
12. M1	*-0.24*	0.14	-0.43***	-0.26*	-0.05	0.42***	0.47****	0.28*
13. M2	*-0.17*	0.03	-0.39***	-0.35**	-0.12	0.26*	0.42***	0.27*
14. M3	*-0.19*	-0.12	-0.32**	-0.39***	-0.46****	0.13	0.37**	0.36**
15. Ch1	*0.12*	0.30**	0.2	0.17	0.25*	-0.2	-0.12	-0.1
16. Ch2	*0.17*	0.05	0.24*	-0.12	-0.19	-0.1	-0.33**	-0.31**
17. Ch3	*0.25*	0.16	0.09	-0.16	-0.26*	-0.04	-0.09	-0.17

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; With Bonferroni correction (*Italicised*): * $p < 0.01$, ** $p < 0.001$, *** $p < 0.0001$, **** $p < 0.00001$; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Table E.1 Continued…

	9	10	11	12	13	14	15	16
10. F2	0.63^{****}							
11. F3	0.44^{***}	0.64^{****}						
12. M1	-0.50^{****}	-0.44^{***}	-0.28^{*}					
13. M2	-0.42^{***}	-0.39^{***}	-0.21	0.72^{****}				
14. M3	-0.36^{**}	-0.39^{***}	-0.35^{**}	0.43^{***}	0.54^{****}			
15. Ch1	0.23	0.16	0.25^{*}	-0.08	-0.13	-0.18		
16. Ch2	0.16	0.49^{****}	0.49^{****}	-0.23	-0.13	-0.06	0.28^{*}	
17. Ch3	0.11	0.19	0.40^{***}	-0.1	-0.08	-0.02	0.24^{*}	0.60^{****}

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; With Bonferroni correction (*Italicised*): * $p < 0.01$, ** $p < 0.001$, *** $p < 0.0001$, **** $p < 0.00001$; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Table E.2 Correlation between study variables for Yoked condition

	1	2	3	4	5	6	7	8
1. SBPS								
2. SW	0.07							
3. B1	0.09	0.19						
4. B2	-0.05	0.19	0.49***					
5. B3	0.01	0.16	0.48***	0.60****				
6. C1	0.16	-0.30*	-0.17	-0.21	-0.2			
7. C2	-0.14	-0.34*	-0.30*	-0.28*	-0.32*	0.64****		
8. C3	-0.1	-0.29*	-0.09	-0.26	-0.43**	0.61****	0.65****	
9. F1	0.18	-0.08	0.50***	0.18	0.28*	-0.29*	-0.25	-0.03
10. F2	0.11	-0.05	0.30*	0.30*	0.24	-0.47***	-0.30*	-0.09
11. F3	0.01	0.04	0.2	0.33*	0.28*	-0.45***	-0.25	-0.24
12. M1	-0.09	-0.25	-0.42**	-0.15	0.03	0.36**	0.27	-0.05
13. M2	0.07	-0.15	-0.45***	-0.43**	-0.25	0.37**	0.44**	0.2
14. M3	0.05	-0.18	-0.42**	-0.33*	-0.33*	0.29*	0.39**	0.27
15. Ch1	-0.15	0.18	0.23	0.14	0.17	-0.22	-0.23	0.1
16. Ch2	0.13	0.02	0.30*	-0.01	0.08	-0.06	-0.17	0.17
17. Ch3	0.03	0.24	0.21	0.03	-0.01	-0.28*	-0.24	-0.05

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Table E.2 Continued…

	9	10	11	12	13	14	15	16
10. F2	0.66****							
11. F3	0.34*	0.62****						
12. M1	-0.39**	-0.42**	-0.43**					
13. M2	-0.25	-0.29*	-0.33*	0.60****				
14. M3	-0.02	-0.05	-0.28*	0.37**	0.71****			
15. Ch1	0.38**	0.43**	0.33*	-0.40**	-0.33*	-0.24		
16. Ch2	0.44***	0.48***	0.29*	-0.41**	-0.2	-0.15	0.57****	
17. Ch3	0.23	0.37**	0.55****	-0.57****	-0.33*	-0.33*	0.62****	0.63****

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Table E.3 Correlation between study variables for Single choice

	1	2	3	4	5	6	7	8
1. SBPS								
2. B1	0.05							
3. B2	0.15	0.68^{****}						
4. B3	0.13	0.33^{**}	0.45^{***}					
5. C1	-0.07	-0.27^{*}	-0.24	-0.40^{**}				
6. C2	-0.05	-0.15	-0.22	-0.18	0.71^{****}			
7. C3	-0.35^{*}	-0.18	-0.18	-0.25^{*}	0.61^{****}	0.68^{****}		
8. F1	0.22	0.22	0.31^{*}	0.03	-0.25^{*}	-0.19	-0.2	
9. F2	0.2	0.04	0.12	0.25^{*}	-0.32^{**}	-0.37^{**}	-0.56^{****}	0.43^{***}
10. F3	0.42^{**}	0.01	0.21	0.05	-0.19	-0.19	-0.40^{***}	0.62^{****}
11. M1	0.08	-0.27^{*}	-0.29^{*}	-0.33^{**}	0.16	0.09	0.09	-0.38^{**}
12. M2	-0.14	-0.16	-0.41^{***}	-0.45^{***}	0.23	0.16	0.33^{**}	-0.25^{*}
13. M3	-0.1	-0.1	-0.36^{**}	-0.58^{****}	0.19	0.17	0.24	-0.04
14. Ch1	0.08	-0.09	-0.15	0.14	-0.09	-0.1	-0.22	0.21
15. Ch2	-0.06	0.08	-0.05	-0.12	0.04	-0.24	-0.08	0.2
16. Ch3	0.27	0.04	-0.04	-0.30^{*}	0.14	-0.02	-0.23	0.24

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Table E.3 Continued…

	9	10	11	12	13	14	15
10. F3	0.48****						
11. M1	-0.07	-0.16					
12. M2	-0.33**	-0.31*	0.44***				
13. M3	-0.27*	-0.19	0.31*	0.76****			
14. Ch1	0.28*	-0.04	-0.13	-0.17	-0.15		
15. Ch2	0.27*	0.04	-0.07	0.14	0.12	0.19	
16. Ch3	0.14	0.44***	0.1	-0.06	0.04	-0.03	0.19

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Table E.4 Correlation between study variables for No choice condition

		1	2	3	4	5	6	7	8
1.	SBPS								
2.	B1	0.26							
3.	B2	0.08	0.48****						
4.	B3	0.01	0.30*	0.46***					
5.	C1	-0.21	-0.30*	-0.22	0.09				
6.	C2	-0.16	-0.17	-0.15	-0.01	0.56****			
7.	C3	0.07	-0.26*	-0.2	-0.28*	0.25	0.55****		
8.	F1	-0.05	0.16	0.23	0.1	-0.46***	-0.23	-0.17	
9.	F2	0.11	0.14	0.23	0.16	-0.28*	-0.30*	-0.03	0.57****
10.	F3	0.05	0.22	0.37**	0.37**	-0.18	-0.11	-0.35**	0.50****
11.	M1	0.13	-0.17	-0.59****	-0.19	0.30*	0.21	0.1	-0.23
12.	M2	0.22	-0.11	-0.59****	-0.17	0.23	0.24	0.16	-0.15
13.	M3	0.22	-0.2	-0.49****	-0.37**	0.1	0.1	0.41**	-0.32*
14.	Ch1	-0.06	0.04	-0.01	-0.23	-0.24	0.08	0.12	0.31*
15.	Ch2	-0.07	0.01	-0.13	-0.1	-0.1	-0.05	0.06	0.07
16.	Ch3	-0.03	0.2	0.09	-0.09	-0.16	0.04	-0.15	0.24

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Table E.4 Continued…

	9	10	11	12	13	14	15
10. F3	0.57****						
11. M1	-0.21	-0.24					
12. M2	-0.11	-0.15	0.75****				
13. M3	-0.2	-0.64****	0.61****	0.60****			
14. Ch1	0.31*	0.2	-0.2	-0.13	-0.1		
15. Ch2	0.46***	0.21	-0.16	0.06	0	0.56****	
16. Ch3	0.37**	0.48****	-0.1	0.06	-0.26*	0.54****	0.66****

SBPS = boredom proneness scale; Sw = # of switches; in the first column with all variables names, # 1 refer to the probe before practice, # 2 refer to the probe before experiment and #3 refer to the probe after experiment; B = state boredom, C = control, F = Frustration, M = Motivation, Ch = Challenge; With Bonferroni correction (*Italicised*): * $p < 0.01$, ** $p < 0.001$, *** $p < 0.0001$, **** $p < 0.00001$; without Bonferroni correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$

Appendix F: Additional analyses for study 5.1

Table F.1 Spearman correlations between study variables for full control condition (n = 109)

	1	2	3	4	5	6	7	8	9	10
1. Baseline boredom										
2. Boredom	*0.29***									
3. Challenge	-0.07	*-0.38****								
4. Control	0.04	*0.19*	-0.24*							
5. Frustration	0.16	*-0.09*	0.15	-0.22*						
6. Motivation	-0.27**	*-0.60*****	0.42****	-0.17	0.19*					
7. # of switches	-0.13	*-0.13*	0.16	-0.03	0.03	0.19*				
8. Task diff. level	-0.28**	*-0.32***	0.29**	-0.1	-0.01	0.34***	0.37****			
9. Time per level	0.15	*0.12*	-0.15	0.02	-0.03	-0.18	-0.98****	-0.37****		
10. Mean hits	0.08	*0.32***	-0.33***	0.22*	-0.21*	-0.30**	-0.24*	-0.45****	0.23*	
11. SBPS	0.21*	*0.1*	-0.02	-0.03	0.09	-0.01	-0.04	0.07	0.04	-0.15

End Frus = Frustration at the end of study. End Motiv. = Motivation at the end of study. Task diff. level = median difficulty level throughout game play. Time per level = median amount of time (in seconds) spent in each task difficulty level. Mean hits = proportion of apple catches throughout game play. SBPS = Boredom proneness scale. Without Bonferroni: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$. *With Bonferroni (italicized only)* * $p < 0.005$; ** $p < 0.001$; *** $p < 0.0001$; **** $p < 0.00001$

Table F.2 Spearman correlations between study variables for yoked condition (n = 106)

	1	2	3	4	5	6	7	8	9	10
1. Baseline boredom										
2. Boredom	*0.09*									
3. Challenge	-0.08	*0.03*								
4. Control	0.12	*-0.11*	-0.37***							
5. Frustration	-0.04	*0.08*	0.38****	-0.32***						
6. Motivation	-0.11	*-0.55*****	0.02	0.09	0.01					
7. # of switches	0	*0.08*	-0.01	0.1	-0.01	0.03				
8.Task diff. level	0.08	*-0.08*	0.29**	-0.23*	0.39****	0.08	0.32***			
9. Time per level	0	*-0.08*	0	-0.06	-0.01	-0.04	-0.98****	-0.33***		
10. Mean hits	-0.1	*0.05*	-0.42****	0.32***	-0.35***	0.01	-0.06	-0.70****	0.09	
11. SBPS	0.11	*-0.09*	-0.11	-0.04	-0.03	-0.07	0.14	-0.14	-0.15	0.20*

End Frus = Frustration at the end of study. End Motiv. = Motivation at the end of study. Task diff. level = median difficulty level throughout game play. Time per level = median amount of time (in seconds) spent in each task difficulty level. Mean hits = proportion of apple catches throughout game play. SBPS = Boredom proneness scale. Without Bonferroni: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$. *With Bonferroni (italicized only)* * $p < 0.005$; ** $p < 0.001$; *** $p < 0.0001$; **** $p < 0.00001$

Table F.3 Spearman correlations between study variables for single-choice condition (n = 111)

	1	2	3	4	5	6	7	8
1. Baseline boredom								
2. Boredom	*0.34***							
3. Challenge	-0.12	*-0.14*						
4. Control	0.01	*-0.17*	-0.36***					
5. Frustration	0.08	*0.12*	0.30*	-0.19				
6. Motivation	-0.22*	*-0.52*****	0.13	0.07	-0.07			
7. Task diff. level	-0.08	*-0.02*	0.47****	-0.31*	-0.03	0.04		
8. Mean hits	0.06	*-0.04*	-0.46****	0.33**	-0.08	0.01	-0.81****	
9. SBPS	0.2*	*0.07*	0.01	0.1	0.15	-0.30*	0	0.02

End Frus = Frustration at the end of study. End Motiv. = Motivation at the end of study. Task diff. level = median difficulty level throughout game play. Mean hits = proportion of apple catches throughout game play. SBPS = Boredom proneness scale. Without Bonferroni: * p < 0.05; ** p < 0.01; *** p < 0.001; **** p < 0.0001. *With Bonferroni (italicized only)* * p < 0.006; ** p < 0.001; *** p < 0.0001; **** p < 0.00001

Table F.4 Spearman correlations between study variables for no-choice condition (n = 103)

	1	2	3	4	5	6	7	8
1. Baseline boredom								
2. Boredom	*0.09*							
3. Challenge	-0.11	*-0.2*						
4. Control	0.02	*-0.1*	-0.34**					
5. Frustration	-0.02	*-0.08*	0.44****	-0.26				
6. Motivation	-0.05	*-0.55*****	0.09	0.22	0.15			
7. Task diff. level	-0.17	*-0.16*	0.75****	-0.41***	0.30*	0.05		
8. Mean hits	0.12	*0.11*	-0.73****	0.49****	-0.38***	0.01	-0.83****	
9. SBPS	0.15	*-0.12*	0.01	-0.02	0.13	-0.01	0.02	-0.05

End Frus = Frustration at the end of study. End Motiv. = Motivation at the end of study. Task diff. level = median difficulty level throughout game play. Mean hits = proportion of apple catches throughout game play. SBPS = Boredom proneness scale. Without Bonferroni: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$. *With Bonferroni (italicized only)* * $p < 0.006$; ** $p < 0.001$; *** $p < 0.0001$; **** $p < 0.00001$