Refining Flow: The Re-conceptualization And Measurement Of Flow As Deep Effortless Concentration

by

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Examining Committee Membership

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

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Author’s Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the 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.

Statement of Contributions

A version of Chapter 1 and Study 2.1 is available in Marty-Dugas, J., & Smilek, D. (2019). Deep, effortless concentration: re-examining the flow concept and exploring relations with inattention, absorption, and personality. *Psychological research*, *83*(8), 1760-1777. DOI: https://doi.org/10.1007/s00426-018-1031-6. In the present dissertation, reference to the relations between flow and the Big Five personality, as well as analyses of the Big Five Inventory have been removed. A version of Study 3.1 is available (data and analyses) in Marty-Dugas, J., & Smilek, D. (2020). The relations between smartphone use, mood, and flow experience. *Personality and Individual Differences*, *164*, 109966. DOI: https://doi.org/10.1016/j.paid.2020.109966. For the purpose of the present dissertation, I present a subset of the analyses which focus on the relation between flow (i.e Deep, Effortless Concentration) and well-being. Analyses of between smartphone use and well-being and between smartphone use and flow are not included in the present work. A version of Chapter 4 served as Laura Howes' Honours Thesis. The study was conceptualized by Jeremy Marty-Dugas, Laura Howes, & Daniel Smilek. Data collection was conducted by Jeremy Marty-Dugas & Laura Howes (with supervision from Jeremy Marty-Dugas). Data analysis was conducted by Jeremy Marty-Dugas. The present iteration of Chapter 4 was re-written by Jeremy Marty-Dugas for the purpose of this dissertation, and includes additional measures and analysis. The current iteration of Chapter 4 has been accepted for publication at Psychological Research. Chapter 5 is currently under review at Psychology of Consciousness: Theory, Research and Practice.

Abstract

The work reported in this dissertation includes a series of studies that have the broad goal of understanding and encapsulating the experience of flow. However, the concept of flow has a number of theoretical and measurement issues because of the broad and elastic definition of the concept. We explore these issues in Chapter 1, and present a re-conceptualization of flow that is focused its defining characteristic: the experience of deep, effortless concentration (DEC). Along with this re-conceptualization, an important related goal was to develop new measurement tools for assessing flow as deep, effortless concentration, which we address in Chapter 2. Importantly, re-conceptualizing flow as deep, effortless concentration means that flow experience can be examined in a broader range of circumstances than has previously been examined, such as the experience of flow in internal contexts. In Study 2.1, we present two new measurement scales for assessing DEC in both internal (such as thinking, remembering, and imagining) and external (such as sports or hobbies) contexts and examine the item characteristics of these new scales, their relation to one another, and their factor structure. In addition, we address the stability/consistency of the flow trait by examining the correlation of each scale with itself at several different test administrations, ranging from 2 to 26 months between administrations (Study 3.4).

Following the development of these measures, a third goal was to elucidate the precise relations between the defining characteristic of flow (i.e. DEC) and several conceptually relevant variables (such as sustained attention and well-being)—extending previous work which employed problematic "global" flow metrics. Using subjective report measures, we assessed the relations between flow and everyday sustained attention (Study 2.1 & 3.2), well-being and mood (Study 3.1 & 3.2), and psychological absorption (Study 2.1). In general, DEC was found to be positively correlated with better sustained attention, greater well-being, and the tendency to experience

absorption. We further examined the relation between DEC and sustained attention in Chapter 4, by examining the relation between DEC and sustained performance on a behavioural task (i.e. the Sustained Attention to Response Task; SART). Generally, these findings were consistent with previous findings that employed subjective reports (Study 2.1 & 3.2)—those who experience more flow during the behavioural task also made fewer attention errors on critical targets.

In Chapter 5, we explored a fourth goal of testing ways to facilitate the experience of deep, effortless concentration. Specifically, we examined the relation between flow and mindfulness using both correlational and experimental methods across three studies. In general, the results supported the notion that mindfulness may be an effective strategy for facilitation the experience of flow; trait mindfulness was associated with more frequent DEC in everyday life (Study 5.1) and predicted DEC during an experimental task (Studies 5.2 & 5.3); it was also found that engaging in novel mindfulness intervention (breath-counting; Levinson et al., 2014) prior to the experimental task facilitated the experience of DEC (at the beginning of the task), compared to an active control group (Study 5.2 & 5.3). Taken together, these results suggest that mindfulness as a strategy for facilitating flow is promising strategy for future research

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Firstly, I wish to express my gratitude to my supervisor Dr. Daniel Smilek for his infectious energy, his enthusiasm, and his encouragement over the course of my graduate career. Working closely with Dan has been both a pleasure and a privilege, and I can say without hyperbole that deciding to work with Dan was the best decision I've made in my entire life. Looking back, it is clear that over the past several years Dan Smilek has not only given me guidance; but purpose. For this, I am especially grateful. I would also like to thank my thesis committee members; Chris Fiacconi and Marcel O'Gorman for volunteering their time, and to thank Dr. Michael Dixon and Dr. Evan Risko for their helpful comments in the writing of this dissertation.

I also wish to thank the research assistants and honours thesis students, who I have worked with and have made my experience, my supervision, and my research all the better. I wish in particular to highlight Nina Psellas and Laura Howes, for their outstanding work.

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Last, but certainly not least, I'm eternally grateful to Alyssa Smith for being a wonderful and supportive partner, especially over the past few months as I finished my thesis. I'm particularly thankful to her for learning to be 'the cooker', while I was furiously writing.

Dedication

To my parents for teaching me to be curious, my siblings for exploring with me,

and to Chewie, who was the perfect friend.

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Chapter 1: General Introduction

The psychological experience of flow is characterized by the subjective experience of full engagement in what one is doing, to the point that attending to task-relevant stimuli seems effortless. Csikszentmihalyi (1975/1990) pioneered research on the flow experience, by observing the behaviour of artists during the creative process. The artists ignored hunger, sleep, fatigue, and distractions while remaining completely focused on the creation of their paintings. Since then, research on flow has been studied in multiple domains, most notably during sports (Catley & Duda, 1997; Crust & Swann, 2013; Jackson, Kimiecik, Ford, & Marsh, 1998; Jackson & Marsh, 1996; Jackson, Thomas, Marsh, & Smethurst, 2001; Stavrou, Zervas, Karteroliotis, & Jackson, 2007; Swann, Keegan, Piggot, & Crust, 2012).

In considering the conceptual aspects of flow, we believe it is important to also consider the way in which flow experiences have typically been measured. This is partly because measures of flow can reveal implicit or tacit definitions of the flow concept. Additionally, there is the possibility that after the initial development of the flow concept, further conceptual developments may have even been inadvertently influenced by the measures that were used to index the experience. In the extant literature, flow is typically characterized as a broad, global construct that incorporates nine facets (Jackson & Marsh, 1996; Jackson et al., 1998; Nakamura & Csikszentmihalyi, 2002; Swann et al, 2012). These facets include 1) a balance between the individual's skill and the challenge afforded by the situation (skill-challenge balance), 2) clear goals, 3) immediate and unambiguous feedback, 4) focused concentration, 5) a merging of action and awareness, 6) loss of self-consciousness, 7) a heightened sense of control, 8) time distortion, and 9) experiencing the activity as intrinsically rewarding (Csikszentmihalyi, 1988; Jackson & Eklund, 2002; Jackson & Marsh, 1996; Jackson et al., 2001; Macbeth, 1988; Nakamura &

Csikszentmihalyi, 2002). In many cases these facets are considered to play equal roles in flow experiences, and this is directly reflected in the way in which flow is commonly measured. In practice, flow is usually measured by collecting participants' ratings on the facets of flow and summing them to create a global score (e.g. Aherne, Moran, & Lonsdale, 2011; Fullagar & Kelloway, 2009; Scott-Hamilton et al., 2016; Ullén et al., 2012). This method of summing the facets implies that each one contributes equally to the flow experience. Problematic for the view that flow is an equal combination of the nine facets are 1) findings from qualitative studies showing that some facets of flow are more commonly reported as characteristic of flow states than others, with facets such as time distortion occurring quite rarely (Swann et al, 2012), and 2) the finding that some of the nine facets of flow only load weakly onto a global flow factor (Jackson & Eklund, 2002; Jackson & Marsh, 1996). Some investigators suggest that a better way to construe flow is as 'more than the sum of its parts' (Csikszentmihalyi & Csikszentmihalyi, 1988; Jackson & Eklund, 2002), which would seem to imply that flow is some sort of emergent property of the nine facets. However, in practice, the nine facets are simply summed (or simply evaluated individually), and the conceptualization of flow as being 'more than the sum of its parts' continues to elude empirical measurement and perhaps even conceptual clarity.

In contrast to the common view that flow is comprised of a combination of nine facets, we wish to advocate for the position that the experience of flow is best characterized by a single core concept, namely, the subjective experience of "deep, effortless concentration". By the term "deep" we mean the general experience of being fully engaged or completely focused on whatever one is doing; and by the term 'effortless' we meant the act of sustaining one's attention without 'forcing it' or experiencing strain while doing so. Indeed, Nakamura and Csikszentmihalyi (2002, p. 92) note: "The phenomenology of flow reflects attentional process. *Intense concentration, perhaps the* *defining quality of flow*, is just another way of saying that attention is wholly invested in the present exchange." (italics added). Csikszentmihalyi and Nakamura (2010, p. 182) make this point even more explicitly, stating: "…we realize that the definition of this signature quality of the flow state can be made more precise…it is specifically the experience of complete but also *effortless* attention that is associated with being in the enjoyable state of flow." Qualitative studies of flow are consistent with this conceptualization, with the findings of a recent meta-analysis showing that of 114 elite athletes who were interviewed, over 80% described concentration on the task as part of their experience—more than any other flow facet (Swann et al, 2012).

Assuming that "deep, effortless concentration" defines flow, how do the other aforementioned facets relate to this conceptualization of flow? One way to construe the other aforementioned facets (those aside from deep, effortless concentration) is to consider them to be either the *precursors* or the *consequences* of flow. The precursor facets would be those facets that, if modulated, make flow experiences more or less likely, or vary the depth of flow (e.g. skill-challenge balance, clear goals), while the consequences of flow would be those facets that change as a result of experiencing deep, effortless concentration (e.g. time distortion, loss of self-consciousness, action-awareness merging). This general conceptualization is in line with suggestions made by other researchers, who proposed that flow facets can be arranged into 'conditions' and 'outcomes' (e.g., Hamari & Koivisto, 2014; Schiefele, 2013; see also Landhäußer & Keller, 2012). It is worth noting, however, that there is not always agreement about which particular facets should be construed as conditions or outcomes (Hamari & Koivisto, 2014), and some have suggested that many of the facets of flow "are semantically different descriptions of the same state and do not represent different dimensions" (Schiefele, 2013, p. 529). Naturally, these considerations may have important implications for the measurement of flow, specifically, the common practice of summing responses across multiple facets of flow. When summing all of the facets, deep and effortless concentration is given no more weight than the other facets, which becomes problematic if one assumes flow *is* deep, effortless concentration.

Re-conceptualizing flow as deep, effortless concentration also impacts the interpretation of prior findings. Take for example, a study conducted by Aherne, et al., (2011) in which some athletes completed six weeks of mindfulness training (the mindfulness training group) while others did not (the control group). The flow measure (i.e., the Flow State Scale-2; Jackson & Eklund, 2002) was completed by both groups before and after the six-week period. Aherne et al., (2011) found that for the mindfulness training group, overall flow scores were higher after training than before the training; in contrast, the control group showed no improvement. The increase in overall flow scores associated with mindfulness training was driven by an increase in the facets of clear goals and the sense of control. Critically, while these findings are certainly straightforward and interesting, their interpretation could vary substantially depending on how flow is conceptualized. If flow is conceptualized as the summation of multiple facets, then Aherne et al.'s, (2011) findings could be legitimately taken as evidence that mindfulness training increases flow. However, if flow is conceptualized using the more specific definition of deep, effortless concentration, then the results do not provide any direct evidence that mindfulness training increases flow. This is because, clearly, participants in the study did not experience any measurable change in what some would consider to be the defining feature of the flow experience, namely, deep, effortless concentration.

To make a similar point, consider several recent studies of flow that involved experimental manipulations of skill-challenge balance (Ulrich, Keller, Hoenig, Waller, & Grön 2014; Ulrich, Keller, & Grön, 2016). In these studies, an adaptive algorithm was used to present participants with math problems that were either matched to their skill level (the optimal balance condition), below their skill level (underload condition), or above their skill level (overload condition)[1]. Flow was measured using a "flow index", which assessed 1) whether participants felt their skills were matched to the challenge, 2) whether they felt thrilled, and 3) whether participants would "love" to solve the math problems again.[2] The results showed that the items of this index were endorsed to a greater degree in the optimal balance condition, compared to the underload and overload conditions. Again, the interpretation of these findings depends on the way flow is conceptualized. If it is assumed that flow is the sum of the facets measured (as was done by the authors), then it can be concluded that the optimal balance condition produced greater flow than each of the other two conditions. As an aside, with such a conceptualization (which includes skill-challenge balance as a facet of flow), it might not be readily apparent that the same variable (skill-challenge balance) is being both manipulated and measured (though some have noted that including the facets and preconditions of flow in one measure is problematic; Schiefele, 2013). However, if flow is re-conceptualized in terms of deep, effortless concentration, then the findings do not unequivocally show that varying skill-challenge balance influences flow. This is precisely because none of the items in the flow index directly measured deep, effortless concentration.

Defining flow in terms of deep, effortless concentration has several important advantages. First, it makes the flow concept more specific (focusing on one facet rather than the combination of many), which has the added benefit of allowing for a more targeted measurement of the concept. Second, it allows for a clearer distinction of the flow concept from the precursors and consequences of the experience. This also has measurement implications. For example, defining and measuring

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[1] These conditions are often referred to as the 'flow', 'boredom', and 'anxiety' conditions, respectively, but we find the terms optimal balance, underload, and overload are less ambiguous about the level of skill-challenge balance

[2] Of the original nine items, three were selected for the flow index. These were "I would love to solve math calculations of that kind again" "I was thrilled" and "Task demands were well matched to my ability". The same items were also used in the 2016 paper.

flow as deep, effortless concentration would likely prevent one from manipulating skill-challenge balance (as a cause) and then also measuring skill-challenge balance as part of the flow concept. Third, defining flow in terms of deep, effortless concentration allows for flow to be assessed even in moments when some of the facets previously associated with flow do not seem to apply. For instance, as we will discuss shortly, flow, defined as deep, effortless concentration, can be measured during both external tasks (e.g., sports) and internal tasks (e.g., thinking). In contrast, measuring flow during internal tasks is awkward, if not impossible, under the multi-faceted view of flow, particularly when action and awareness merging is thought to be one of the key facets.

With the adoption of a more targeted definition of the flow concept, it is clear that what is needed is a more specific measure of flow; one that is more in line with the conceptualization of flow as deep, effortless concentration. Fortunately, just such a measure was created by Csikszentmihalyi and Nakamura (2010) in their re-analysis of historical experience sampling data. The data included responses from high school students who had been probed using pagers to report on a number of their experiences, including their levels of concentration ("How well were you concentrating?"), and effort ("Was it hard to concentrate?"). Those instances in which participants reported the co-occurrence of a high level of concentration and a low level of effort were considered effortless attention (i.e. experiences of flow). Interestingly, Csikszentmihalyi and Nakamura (2010) found that flow was more likely to occur when the students had freely chosen their own task, rather than when a task was mandatory. This is reminiscent of findings showing that fatigue seems to occur disproportionately during "have to", as opposed to "want to" tasks (Hockey, 2013; but see Csikszentmihalyi & LeFevre, 1989). A recent study (Harmat, de Manzano, Theorell, Högman, Fischer, & Ullén, 2015) used similar questions to measure flow while participants played Tetris at three different levels of difficulty (i.e. different levels of skill-challenge balance). It was found that high levels of concentration and low levels of effort co-occurred (i.e., the combination indicative of flow) most frequently when the challenge of the game was matched to the skill level of participants (e.g. an optimal balance condition). Studies such as these (i.e. those measuring deep, effortless concentration) allow one to draw more precise conclusions about flow because they measure flow with greater specificity. A primary goal of the present work was to build on these foregoing studies and create measures of flow that would specifically assess deep, effortless concentration.

The Present Investigations

The work reported in this dissertation includes a series of studies that have the broad goal of understanding and encapsulating the experience of flow. In this chapter (Chapter 1), I have laid out the theoretical and empirical rationales for understanding flow as the experience of deep, effortless concentration. The foregoing literature review also clearly suggests that a new subjective report measure of flow is needed, one that focuses on the concept of deep, effortless concentration.

Chapter 2 is dedicated to developing a new way to capture and assess the experience of flow. In Study 2.1, we develop and present two new instruments for assessing individual differences in the experience of flow at the trait level, in accordance with the re-conceptualization of flow we have outlined in the present chapter. These scales allow for the assessment of the core experience of flow—deep, effortless concentration—in both internal contexts, such as thinking, remembering and imagining (Deep, Effortless Concentration – Internal; DECI), and external contexts such as playing sports or instruments (Deep, Effortless Concentration – External; DECE). These scales were highly correlated, indicating that individuals prone to experiencing flow in external contexts are also prone to experience flow in internal contexts. Nonetheless, when we examined the factor structure of these scales, a measurement model construing internal and external flow as related but separate constructs was found to fit the data significantly better than a model where they were construed as a single construct. In addition, we examined the item characteristics of our new measures and found them to have good psychometric properties and high internal consistency reliability.

Next, we conduct a preliminary investigation on the relation between flow (assessed via DECI/DECE) and various forms of everyday inattention. While the flow literature has often suggested there is a relation between flow and attentional ability (Nakamura & Csikszentmihalyi, 2002), sometimes implying that those who are more likely to experience flow also have greater attentional control, little work has examined this relation empirically. In addition, we examine the relation between our new measures and an index of 'global flow' (i.e. the Swedish Flow Proneness Questionnaire; SFPQ) as well as the Tellegen Absorption Scale (TAS), an index of absorption. Among other things, we found that flow was negatively related to inattention, indicating that people who experience flow more frequently tend to experience relatively less inattention in everyday contexts.

In Chapter 3, we explore how flow—when defined as deep, effortless concentration—relates to other variables of theoretical interest. In Study 3.1 we examine the relation between flow and well-being. Flow is theorized to have a positive relation with well-being, and this has been demonstrated empirically in studies employing global flow measures (e.g. Tse et al., 2020). However, in light of the issues with the global flow conceptualization, it could be that the relation does not pertain to the specific experience of DEC, but rather one of the other extraneous facets included in a global flow score.

Also in Chapter 3, we investigate the consistency of flow experience, both by replicating our earlier findings in large samples to establish their consistency, and by investigating the trait stability of flow proneness as assessed using the DECI and DECE. In Study 3.2, we again investigate the relation between flow and inattention, as well as the relation between flow and well-being. In addition, we extend our earlier findings by examining the relation between flow and inattention using regression analyses. In particular, we investigate whether multiple measures of everyday inattention predict the experience of flow when used as simultaneous predictors. In Study 3.3, we examine the trait consistency or stability of flow proneness by examining the test-retest correlations of the DECI/DECE over several different time intervals ranging from 2 to 26 months.

In Chapter 4, we extend the work presented in prior chapters by exploring how the experience of flow relates to behavioural indices of sustained attention. In particular, in Study 4.1 we employed the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley & Yiend, 1997) to assess sustained attention ability. Sustained attention during the SART is typically assessed by commission errors, which are incorrect responses to infrequent critical targets; generally, better attention performance is characterized by fewer commission errors. Flow was indexed at the state level using DEC thought-probes, and at the trait level via questionnaires (i.e. DECI and DECE). Prior studies have linked reports of attention (i.e. indexed via everyday inattention measures) to both SART performance (Cheyne et al., 2006; Carriere, Cheyne & Smilek, 2008; Smilek, Carriere & Cheyne, 2010) and, in separate cases, to reports of deep, effortless concentration (see Chapter 2, Study 1). Given these two separate sets of findings, in addition to other studies which have documented a relation between flow and subjective reports of attention (Cermakova et al., 2010; Moore, 2013), it seems reasonable to expect that DEC measures might also be related to SART performance. In addition, we explored an interesting related question: Does the relation between flow and sustained attention changed over time? To assess this question, we examined whether the correlation between flow and commission errors differed when comparing the relation in the first and second half of the experiment.

A third goal of Study 4.1 was to examine the relation between DEC and the autotelic personality. The autotelic personality is a constellation of several attributes, including curiosity, persistence, the tendency to enjoy challenges, and high attentional control, and is thought to facilitate the experience of flow. While previous results provide some support for the claim that the autotelic personality facilitates flow (see Tse et al., 2018;), the studies examining the relation between the autotelic personality and flow have been limited by the use of global flow metrics. To test this claim more precisely, we examined the relation between the autotelic personality and measures of DEC at both the trait and state levels.

Finally, Study 4.1 addressed a fourth issue; whether trait measures of DEC predict the experience of state flow. We addressed this issue by examining the correlation between the DECI/DECE, which were collected in the mass testing survey prior to (and separated from) the experimental session, and state DEC measures collected during the SART. Our expectation was that those who experience DEC more frequently in their everyday lives would tend to experience more DEC during the SART as well.

Having established a means of measuring flow (i.e. via DEC) and having documented the relation between flow and sustained attention with multiple methods, we turned our attention to the question of how flow might be facilitated. In Chapter 5, we explored a possible strategy for facilitating flow experience—mindfulness. Mindfulness shares some similarities with flow; both concepts can be defined by deep focus on the present moment, and have positive associations with well-being. Across three studies, we investigated the relation between mindfulness and flow (i.e. deep, effortless concentration; DEC) using both correlational and experimental methods. In Study

5.1, we explore the relation between mindfulness and flow at the level of individual differences. Previous investigations of the relation between mindfulness and flow at the level of individual differences have produced somewhat mixed results; some studies have yielded positive relations between mindfulness and flow (Moore, 2013; Thienot et al., 2014), while others have yielded negative relations (Sheldon et al., 2014). To address this, we employ two measures of mindfulness and, critically, we assess the frequency of flow experience using more precise and specific measures of deep, effortless concentration (DEC) in two large samples (N > 1600). In Studies 5.2 and 5.3, we build on the results of Levinson et al (2014) and examine whether a brief mindfulness induction can facilitate the experience of deep effortless concentration. Across these two studies we vary the nature of the breath-counting instructions and the nature of the active control groups to assess the possible roles of task instructions, and the use of the term ‘mindfulness’ when introducing the breath-counting task. Furthermore, we examine whether breath-counting leads to improved performance on a game-like cognitive task. We also investigate whether trait mindfulness and/or trait flow predict the experience of state DEC during the experimental task and, lastly, whether the experience of state DEC is related to task performance.

Chapter 2

To reiterate, while flow has traditionally been conceived as a broad, multi-dimensional construct, there are a number of issues that arise as a result of this conceptualization, which were outlined in Chapter 1. As a way to address these issues, we presented an alternative conceptualization, whereby flow is conceived of as the experience of deep, effortless concentration—the defining characteristic of flow experience. This conceptualization offers several benefits for the study of flow experience; 1) it provides greater clarity in understanding factors that facilitate or result from flow, because of the specificity of concept provided by the DEC conceptualization; and, 2) it offers greater opportunity to measure and study flow in different situations—without the need to continually adjust and alter the measures. With global flow, certain facets apply clearly in some situations (e.g. sports with *action*-awareness merging), but not in others (e.g. during thinking or imagining). Thus, a particular advantage of the DEC conceptualization is that it allows for an investigation of the flow state in a broader range of settings meaning that one can study flow in both external and *internal* activities (such as thinking, remembering and imagining). In the present chapter, we develop two novel measures of DEC (i.e. flow) and examine their relations with several variables of interest, such as everyday inattention and absorption.

Study 2.1

In empirical investigations of flow, one context that has received relatively little attention is the experience of flow during internal thought (here referred to as 'internal flow'). As noted by Nakamura and Csikszentmihalyi (2002, p. 102): "Relatively little research has addressed the experience of flow when attention is trained on internal sources of information (e.g. in psychotherapy, life-planning, life-review, and other forms existential reflection; fantasy; spiritual experience)". One notable exception is a study by Csikszentmihalyi and LeFevre (1989), in which people reported they experienced flow while daydreaming.

Perhaps one reason for the paucity of studies examining internal flow is that some of the nine facets often believed to constitute the flow experience focus almost exclusively on external tasks and they seem to apply less clearly to internal thoughts. For example, two such facets are 'action-awareness merging' and 'skill-challenge balance', which are both most easily understood with reference to an external task. If these facets were to be construed as integral parts of the flow experience, as indeed they have been in the past, then one might even conclude that flow cannot occur during internal tasks, such as daydreaming. This apparent bias towards conceptualizing flow in the context of external tasks likely stems from the fact that historically, flow has been assessed primarily in the context of people engaging in external tasks, such as sports (Catley & Duda, 1997; Crust & Swann, 2013; Jackson & Marsh, 1996; Jackson et al., 1998; Jackson et al., 2001; Jackson & Eklund, 2002; Stavrou et al., 2007; Swann et al., 2012; Swann, 2016). As theory developed based on these observations, a reference to external tasks seems to have become integral to the conceptual development and measurement of flow.

As we noted earlier, one advantage of defining flow specifically in terms of the core characteristic of deep, effortless concentration is that it has the added benefit of breaking free from the current focus on external tasks. This is because the core concept of deep, effortless concentration can apply equally to both external and internal contexts. The other facets associated with flow (i.e., the precursors and consequences) are then free to vary across internal and external contexts without requiring a different definition or different measures of flow across contexts. Thus, using the more specific definition of flow (as deep, effortless concentration) allows for the examination of the flow state in a broader range of circumstances.

Based on the foregoing considerations, one of the main goals of the present study was to develop a measure of flow (defined as deep, effortless concentration) to index the experience flow during internal contexts. A secondary goal was to compare individual differences in the propensity to experience flow in internal tasks (internal flow) with the propensity to experience flow during external tasks (external flow). Accordingly, we created two matching subjective report scales, for assessing flow during both internal and external tasks.

Flow and Everyday Inattention

Given that flow can be characterized as the experience of peak attentional focus, it is not surprising that there have been attempts to examine the relation between flow and sustained attention ability. For instance, Ullén et al., (2012) examined the relation between scores on the Swedish Flow Proneness Questionnaire (SFPQ), which they used as a trait measure of flow, and scores on the Raven's Progressive Matrices (Raven, 1962; 1965), which they treated as an index of sustained attention. They found no correlation between scores on the SFPQ and performance on the Raven's Matrices and thus concluded that there is no relation between flow and sustained attention performance. However, a weakness of this study is that sustained attention was assessed using the Raven's Matrices, a measure that was not designed to specifically index sustained attention ability. In a more recent report, Ullén, Harmat, Theorell, and Madison (2016) found no relation between flow proneness and attention performance as indexed by a set of chronometric tasks, such as pressing the spacebar as quickly as possible after a target stimulus, responding in time with a metronome, and maintaining the rhythmic response after the metronome could no longer be heard. However, while performance on the tasks used in this study showed no relation to the measure of flow, it is not clear that these tasks are good measures of attention performance per se. Notwithstanding the problematic measurements of sustained attention, the foregoing results have been taken as support for the conclusion that effortless attention (experiences that include, but are not limited to, flow) and sustained attention are supported by different neural mechanisms (Ullén, de Manzano, Theorell, & Harmat, 2010; Ullén et al., 2012; Ullén et al., 2016). This conclusion is inconsistent with the intuition that a greater ability to sustain attention should relate to a higher likelihood of experiencing flow, as seems to be implied by flow theory (Csikszentmihalyi, 1978; Nakamura & Csikszentmihalyi, 2002)

In contrast to the foregoing findings, some researchers (Cermakova, Moneta, & Spada, 2010; Moore, 2013) have reported a positive correlation between dispositional flow and sustained attention abilities. For example, in a study assessing the association between academic outcomes and different kinds of motivation, Cermakova, Moneta, and Spada (2010) also examined the relation between dispositional flow, as indexed by the Dispositional Flow Scale-2 (DFS-2; Jackson & Eklund, 2002)[3], and attention control, as indexed by the Attentional Control Scale (ACS; Derryberry & Reed, 2002). Scores on these measures were significantly positively correlated ($r = .55$), suggesting that people with greater control over their attention also experience relatively more episodes of flow. As another example, Moore (2013) examined the relation between mindfulness, as indexed by the Cognitive and Affective Mindfulness Scale-Revised (CAMS-R; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007), and dispositional flow as indexed by DFS-2. Mindfulness (of which a key component is sustaining attention; see Bishop et al., 2004) and flow were found to have a significant positive correlation ($r = .50$), again suggesting that better sustained attention abilities may be conducive to flow experiences[4].

[3] for example items from an earlier version of the DFS-2, see Jackson & Marsh, 1996
[4] The astute reader may notice that the studies reporting a positive relation between flow and sustained attention (e.g. Cermakova et al., 2010; Moore, 2013) employ self-report measures, while those that do not (e.g. Ullén, et al., 2012) employ behavioural assessments. We address this in Chapter 4, where sustained attention is assessed behaviourally.

When taken together, the foregoing research reveals that the relation between trait flow and sustained attention ability is unclear as the available studies seem to point to conflicting conclusions. As such, a major goal of the present study was to better understand this relation. A unique aspect of the current investigation is that we examine the relation between flow, defined as deep effortless concentration, and everyday forms of *in*attention, such as absent-mindedness, attention-related errors (e.g. putting the milk in the pantry instead of the fridge), and mind-wandering. Importantly, while previous writings on the experience of flow have linked flow to attention (e.g. Nakamura & Csikszentmihalyi, 2002), it is important to note that they are not equivalent constructs. While they may be related, DEC is distinct from the everyday experience of attention/inattention. The absence of attention errors during the day, or a good performance during an activity is not an indication that one experienced DEC. For example, successfully pouring milk into one's coffee instead of juice, or correctly throwing one's socks in the laundry hamper instead of the toilet would *not* indicate that one has experienced flow. In other words, the perception of DEC does not imply an accurate assessment of the extent to which one is successfully attending to a task. Indeed, in some cases one might even make attention errors or perform a task poorly while experiencing DEC. At least one study has documented that the experience of flow can occur *while* daydreaming (Lefevre & Csikszentmihalyi, 1989). Given that daydreaming is a lay concept which shares a number of similarities with mind-wandering (Seli et al., 2018), it could be considered an episode of inattention. Our interest in the present study is in assessing whether (and to what extent) this subjective experience (i.e. DEC) tends to be related to the experience of sustained attention in everyday life.

Flow and Absorption

Flow is often defined as a peak attentional experience, whereby the individual experiences a state of complete and almost effortless focus. However, a very similar description is used to define the concept of absorption. In their seminal paper, Tellegen and Atkinson (1974) describe absorption as “a disposition for having episodes of ‘total’ attention that fully engage one’s representational…resources” as well as an “imperviousness to distracting events”. Often, absorption is even used as a way of defining the flow experience (Crust & Swann, 2013; Csikszentmihalyi, 1990; Csikszentmihalyi & Nakamura, 2002; Harari, 2008; Jackson et al., 1996; Jackson & Marsh, 1996; Jackson, Martin & Eklund, 2008; Martin & Jackson, 2008; Peifer, Schulz, Schächinger, Baumann, & Antoni, 2014; Ullén et al., 2010, Wright, Sadlo & Stew, 2006; Wright, Sadlo & Stew, 2007), with some even suggesting that many of the flow facets are “nothing more than alternative descriptions of absorption” (Schiefele, 2013, p. 529; see also, Scheifele & Raabe, 2011). For example, Jackson et al., (2001, p.18) state: “It [flow] is a state of concentration so focused that it amounts to absolute absorption in an activity.” In addition, in some studies, items asking participants about their level of absorption during an experimental task have even been included in indices of flow (Engeser & Rheinberg, 2008; Peifer et al, 2014). However, despite this high degree of conceptual similarity/overlap between flow and absorption, the literature on flow appears to have progressed more or less separately from the literature focusing on absorption.

One possible reason for the lack of integration between the flow and absorption literatures has to do with the nuances of the measures used to index the two constructs. In the absorption literature, perhaps the most prominent (i.e., gold standard) measure of absorption is the Tellegen Absorption Scale (TAS; Tellegen & Atkinson, 1974), which indexes absorption at the trait level.

A consideration of the items of the TAS[5] reveals that the scale might not simply index absorption in general, but rather that it might index a sort of over-engagement, which could be maladaptive, or even dissociative. In fact, the TAS is positively related to the Dissociative Experiences Scale (DES), which indexes abnormal dissociative experiences (Nadon, Hoyt, Register & Kihlstrom, 1991; Smyser & Baron, 1993). Interestingly, procrastination, an avoidance-based mood-regulation strategy, has been found to be positively related to the TAS as well (Sirois, 2014). Thus, the TAS does not match the overall character of flow measures, which seem to focus more on the experience of one's goals, actions, and values becoming aligned and leading to a feeling of ordered consciousness (Jackson & Marsh, 1996; Wright et al., 2007).

The foregoing considerations beg the question: How might indices of flow and indices of absorption be related at a measurement level? On the one hand, one might expect a positive correlation between flow and absorption measures because of the similarity at the cores of the two constructs (i.e. complete and effortless focus). On the other hand, as noted above, there are important nuanced differences in the measures, which could lead to the absence of a correlation. Perhaps the most likely outcome, which balances the foregoing considerations, is that the measures would be *modestly* positively correlated. Regardless, we endeavoured to check (and perhaps disconfirm) the possibility that our newly created scales simply recapitulated the gold standard measure of absorption (i.e., the TAS). To this end we examined the relation between the TAS and each of our internal and external flow scales.

The Present Study

Having advocated for the conceptualization of flow in terms of deep, effortless concentration (our first goal), we sought to address our remaining goals empirically, using an

[5] See Tellegen & Atkinson, 1974 for some example items

individual differences approach. Our second goal was to create two reliable scales with which to measure flow according to this reconceptualization. Furthermore, we sought not only to measure flow as deep, effortless concentration, but also to develop trait scales that tap the frequency of the flow experience in both internal (e.g. thinking) and external (e.g. a physical task) circumstances. We have termed these scales the Deep Effortless Concentration - Internal (DECI) and Deep Effortless Concentration - External (DECE), respectively. Related to this goal, using correlational and factor analyses we also examined whether internal and external flow should be construed as two distinct constructs, or as two manifestation of the same construct. We also included the Swedish Flow Proneness Questionnaire (SFPQ; Ullén et al., 2012) to document the relation between our new flow measures and the SFPQ. A third goal was to elucidate the relation between flow and everyday attention. To address this goal, we examine the relation between the flow measures, and four self-report measures of sustained attention ability in everyday life. These measures probe the frequency of inattentive behaviours such as mindless attention lapses (MAAS-LO), attention-related errors (ARCES), and mind-wandering, both spontaneous (MWS) and deliberate (MWD). A fourth goal was to examine the relation between our new flow scales and the TAS. Recognizing the similarity between the description of flow and absorption, we included the TAS, the gold standard measure of absorption, to verify that our new measures of deep, effortless concentration did not simply recapitulate the TAS.

Method

Participants

Three hundred and twenty-eight (328) participants were recruited from Amazon Mechanical Turk and compensated three dollars for completing a survey approximately 30 minutes in length. Following data collection, 22 participants were removed for either (a) failing an initial attention check (see below for details), (b) indicating they had responded to at least some portion of the survey randomly, or, (c) indicating they were not fluent in English. Seven participants were removed for not answering these questions. An additional two participants were removed for incomplete responses. This meant that data from 297 participants were analyzed. There was a relatively even distribution of males (165) and females (125), with two non-binary participants (i.e. one genderqueer and genderless)[6]. Participant age was relatively normally distributed, ranging from 18 to 69 years old with a mean of 35.37 (SD =10.01)[7]. The sample tended to be highly educated, with the majority of participants having completed at least some college or university (84%), and with most of the participants being employed outside Mechanical Turk (82%).

Measures

Deep Effortless Concentration – Internal (DECI) and External (DECE). In order to measure the prevalence of flow—defined according to the construct of deep, effortless concentration—in both internal and external contexts, it was necessary to create two novel questionnaires. One of these was designed to measure flow experiences during internal tasks such as thinking, imagining, or remembering; we refer to this measure as the Deep Effortless Concentration - Internal (DECI) scale. The other was designed to index flow during external tasks, such as sports, hobbies, and playing instruments; we refer to this scale as the Deep Effortless Concentration - External (DECE) scale. Each scale is preceded by a brief instruction statement that provides illustrative examples of either internal or external tasks, depending on whether the scale indexed internal (DECI) or external (DECE) flow. The items across the scales were matched for sentence structure, in order to reduce response differences due to surface characteristics. That

[6] Four participants listed the same value for their age and gender (e.g. Age = 29, Gender = 29), and one participant marked an ‘x’. As gender was not a variable of interest for the present study, no participants were removed from analysis on the basis of gender

[7] Skew = .94 Kurtosis = .24

is, the DECI and DECE were designed to be nearly identical, except for referring to internal or external experiences, and the instructions that precede the questions. Each measure consists of eight items that probe the frequency with which participants experience flow, with questions such as "I can perform an internal/external task so quickly and easily it seems to happen without effort" on a 1 (Never) to 7 (Always) Likert scale. We assume that when responding to these questions (as with any trait measure) participants consult their state experiences and report on how frequently they experience these states. The full set of items for the DECI and DECE are presented in Appendix A.

Mindful Attention Awareness Scale - Lapses Only (MAAS-LO). The MAAS-LO (Brown & Ryan, 2003; Carriere, Cheyne & Smilek, 2008) assesses the frequency with which individuals behave in an absent-minded or mindless fashion on a 12-item scale. Participants respond to items such as "I rush through activities without being really attentive to them" and "I find myself doing things without paying attention" on a 6-point Likert scale ranging from 1 (almost never) to 6 (almost always). The MAAS-LO has been demonstrated to have good internal consistency (i.e. above .8; Carriere, Cheyne, & Smilek, 2008; Ralph, Thompson, Cheyne & Smilek, 2014) and to predict performance on sustained attention tasks (Smilek, Carriere & Cheyne, 2010).

Attention Related Cognitive Errors Scale (ARCES). The ARCES (Cheyne, Carriere & Smilek, 2006) is a 12-item self-report measure designed to assess the frequency of everyday performance errors that result from lapses in sustained attention. Participants indicate their responses to statements describing everyday attention errors, such as "I fail to see what I am looking for even though I am looking right at it" or "I have gone to the fridge to get one thing (e.g. milk) and taken something else (e.g. juice)" on a 5-point Likert scale ranging from 1 (never) to 5 (very often). Higher scores on the ARCES have been demonstrated to predict poorer performance on the Sustained Attention to Response Task (SART; Cheyne et al., 2006). The ARCES has been consistently demonstrated to have high internal consistency (Cheyne et al., 2006; Ralph et al., 2014), and to predict errors of commission on a sustained attention task (Smilek et al., 2010).

Spontaneous and Deliberate Mind-Wandering (MWS and MWD). The Spontaneous Mind-Wandering Scale (MWS; Carriere, Seli & Smilek, 2013) and Deliberate Mind Wandering Scale (MWD; Carriere et al., 2013) are 4-item subjective report scales that measure individual differences in mind-wandering in everyday life. The MWS measures the tendency to experience unintentional/spontaneous episodes of mind-wandering, while the MWD measures the tendency to experience intentional/deliberative episodes of mind wandering. On the MWS, participants respond to statements such as “I find my mind wandering spontaneously”, whereas on the MWD, participants respond to statements such as “I allow my thoughts to wander on purpose”. For each scale, participants indicate the frequency with which they experience mind-wandering on a 7-point Likert scale, with response options ranging from 1 (Rarely) to 7 (A lot). Previous research has indicated there is a positive correlation between spontaneous and deliberate mind-wandering (Carriere et al., 2013; Seli, Carriere, & Smilek, 2015), but that these experiences are dissociable as well (for a review, see Seli, Risko, & Smilek, 2016). Each of these scales has been demonstrated to have high reliability (Carriere et al., 2013).

The Swedish Flow Proneness Questionnaire (SFPQ). The SFPQ (Ullén et al., 2012) assess individual differences in the tendency to experience flow in three domains: at work, during maintenance (i.e. household chores), or during leisure. For each domain, participants are presented with seven items (which are identical across each domain), to which they respond on a five-point Likert scale. The SFPQ measures flow using a global flow approach, such that the items each assess a unique facet of flow experience (i.e. concentration, skill-challenge balance, explicit goals, clear feedback, sense of control, enjoyment, and lack of boredom) and are then averaged together to create a global flow score (for sample items of the SFPQ, see Ullén et al., 2012). We adjusted the instructions for the work domain from "When you do something at work, how often does it happen that…?" to "When you do something at work or school, how often does it happen that…?" to include potential students. In the present study, we evaluated the SFPQ by combining the subscales in order to obtain a total flow score, as has been done previously (de Manzano, Cervenka, Jucaite, Hellenäs, Farde, & Ullén, 2013; Ullén et al, 2012;). The total flow score has been shown to have higher reliability than the individual subscales (Mosing et al, 2012).

Tellegen Absorption Scale (TAS). The TAS (Tellegen & Atkinson, 1974; University of Minnesota Press) is a 34-item scale that measures individual differences in absorption, the trait tendency to become deeply immersed in a task or event. The TAS was used with permission of the University of Minnesota Press, who provided the scale items. In administering the test, we followed the recommendations of Kihlstrom (2011), by labelling the TAS with a neutral title, and presenting the items on a 4-point Likert scale ranging from 0 (Never) to 3 (Always). While absorption can be broken down into several subscales (e.g. Enhanced Awareness, or Responsiveness to Engaging Stimuli), these subscales are highly inter-correlated, indicating the absorption is a relatively unidimensional construct (Tellegen, 1992). As such we computed only an overall absorption score.

Demographic Survey. Participants were also asked to complete a brief demographics survey following their completion of the other measures. The survey included questions regarding participants' age, education level and status, income, smartphone ownership, employment status, English fluency, and gender.

Attention Check Questions. We included two attention check questions at the end of the survey. In the first attention check participants are presented with a list of hobbies, but rather than indicating their actual interests, they are required to select 'other' and type "I have read the instructions". The second attention check asked participants to indicate whether they had answered any part of the survey randomly. The response to this question did not affect participant remuneration, and participants were informed of this in order to encourage honest responding.

Procedure

After providing informed consent, participants who agreed to take part in the study were provided with a link to the survey and a password to access it (the password was changed manually every 24 hours). Participants were presented with the DECI, DECE, ARCES, MAAS-LO, MWS, MWD, and SFPQ[8]. The order in which the scales were presented was randomized for each participant. Furthermore, when any given scale was presented, the order of the items within the scale was randomized as well. To conform with the internet use conditions for the TAS, this questionnaire was presented last to ensure only two items per page were visible at once. Thus, participants were always presented with the TAS following the other measures. Following the completion of the TAS, participants were presented with the demographics survey, and the two attention checks (described above).

Results

The results of the present study are described in three sections. In the first section we describe the psychometric properties of our measures, with a specific focus on our newly developed flow measures (DECI and DECE) [9]. In addition, we examine the factor structure of the

[8] The big five inventory was also included, but is not discussed here.
[9] We ran several previous iterations of this experiment during the development of the items for the internal and external flow scales. Each iteration varied in some way, either with the content of the items, the instructions, or the

DECI and DECE and compare two plausible models. In the second section we analyze the relations between the measures of flow and the measures of inattention (MAAS-LO, ARCES, MWS, MWD), and report the relation between flow experience and age. In the third section we examine the relations between the flow measures and the TAS (indexing absorption).

Psychometrics

Descriptive statistics for each of the scales used in the present study are presented in Table 1. In general, the measures used in the present study were demonstrated to have acceptable psychometric properties, with Cronbach's Alpha for the measures ranging from .80 to .95. The two new measures of flow (the DECI and the DECE) were each found to have a good Cronbach's

Table 1. Descriptive statistics for measures of flow and inattention (n = 297)

	Mean	SD	Skew	Kurtosis	α
DECI	4.89	1.216	-.50	-.08	.95
DECE	5.01	1.190	-.49	-.15	.95
SFPQ (Total)	3.57	.522	-.14	-.20	.87
TAS	2.22	.591	.34	.11	.95
MAAS-LO	2.71	.930	.22	-.44	.90
ARCES	2.52	.739	.59	.79	.93
MWS	3.59	1.467	-.02	-.77	.88
MWD	4.47	1.489	-.41	-.36	.90

Note. DECI = Deep Effortless Concentration – Internal; DECE = Deep Effortless Concentration – External; TAS = Tellegen Absorption Scale; SFPQ = Swedish Flow Proneness Questionnaire; MAAS-LO = Mindful Attention Awareness Scale – Lapses Only; ARCES = Attention Related Cognitive Errors Scale; MWS = Mind-Wandering Spontaneous; MWD = Mind-Wandering Deliberate. Skew SE = .141 Kurtosis SE = .282

number of other questionnaires participants were presented with, before we finalized the items and instructions for the present study.

alpha (i.e. above .8) (DECI =.95, DECE =.95) indicating these scales had strong internal consistency. The skewness and kurtosis values were also within a reasonable range (i.e. skewness < 2 and kurtosis < 4; see Kline, 1998), indicating a relatively normal distribution of scores. Item statistics for the DECI and DECE are presented in Table 2. As can be seen in the tables, the corrected item-total correlation for each item was high (greater than .9), which suggests the items are all tapping a common construct.

Table 2. Item statistics for internal flow (DECI) and external flow (DECE) measures (n = 297)

Item	Mean	SD	Corrected Item-Total Correlation	Item	Mean	SD	Corrected Item-Total Correlation
DECI 1	4.91	1.29	.820	DECE 1	5.00	1.25	.812
DECI 2	4.99	1.34	.811	DECE 2	5.10	1.31	.814
DECI 3	4.85	1.49	.736	DECE 3	4.96	1.43	.741
DECI 4	4.66	1.49	.865	DECE 4	4.77	1.45	.842
DECI 5	4.86	1.41	.876	DECE 5	4.94	1.39	.847
DECI 6	4.92	1.39	.832	DECE 6	5.02	1.38	.846
DECI 7	4.99	1.39	.820	DECE 7	5.09	1.38	.865
DECI 8	5.03	1.40	.841	DECE 8	5.20	1.36	.842

Confirmatory Factor Analysis

To examine the factor structure of the internal and external flow scales we compared two models using AMOS 24 (Arbuckle, 2016). One possibility was that the items of the internal and external flow scales, rather than being separate factors, could be explained by a single global flow variable. On the other hand, it could be that while correlated, internal and external flow should be considered separate constructs that each influence the responses to the items. To distinguish between these two possible factor structures, we tested two separate measurement models using

Confirmatory Factor Analysis (CFA) and examined the fit of each model using the Chi-Square, CFI, RMSEA, and PCLOSE. For each of the following models the error variances corresponding to the items of the DECI are labelled “e1” to “e8”, and the error variances corresponding to the items of the DECE are labelled “e9” to “e16”. To be clear, “e1” corresponds to the error for “DECI-1” and “e9” corresponds to “DECE-1”. Recall that the sentence structure of the items of the DECI and DECE were designed to match (i.e. DECI-1 matches DECE-1, DECI-2 matches DECE-2, and so on). As such, we included covariances between the errors for each pair of items in each of the models (i.e. DECI-1/e1 is correlated with DECE1/e9). This was done in order to account for any systematic error variance resulting from the surface characteristics of the items. The reader should note that in the depictions of each of these models (see Figures 1 and 2), the order of the items is reversed for the DECE, which was done to reduce the crossing of lines depicting the correlated errors.

To account for the possibility that all of the items from both the DECI and the DECE are influenced by a single flow factor, we tested a 1-factor measurement model (see Figure 1). This model was found to be of a poor fit ($\chi^2(96) = 1062.01$, CFI = .794, RMSEA = .184, PCLOSE = .000), indicating that a single flow factor influencing all 16 items is not an appropriate model of the data. In the second model (see Figure 2), we tested a 2-factor solution with internal and external flow as separate, correlated factors influencing the response to the items to the two scales.

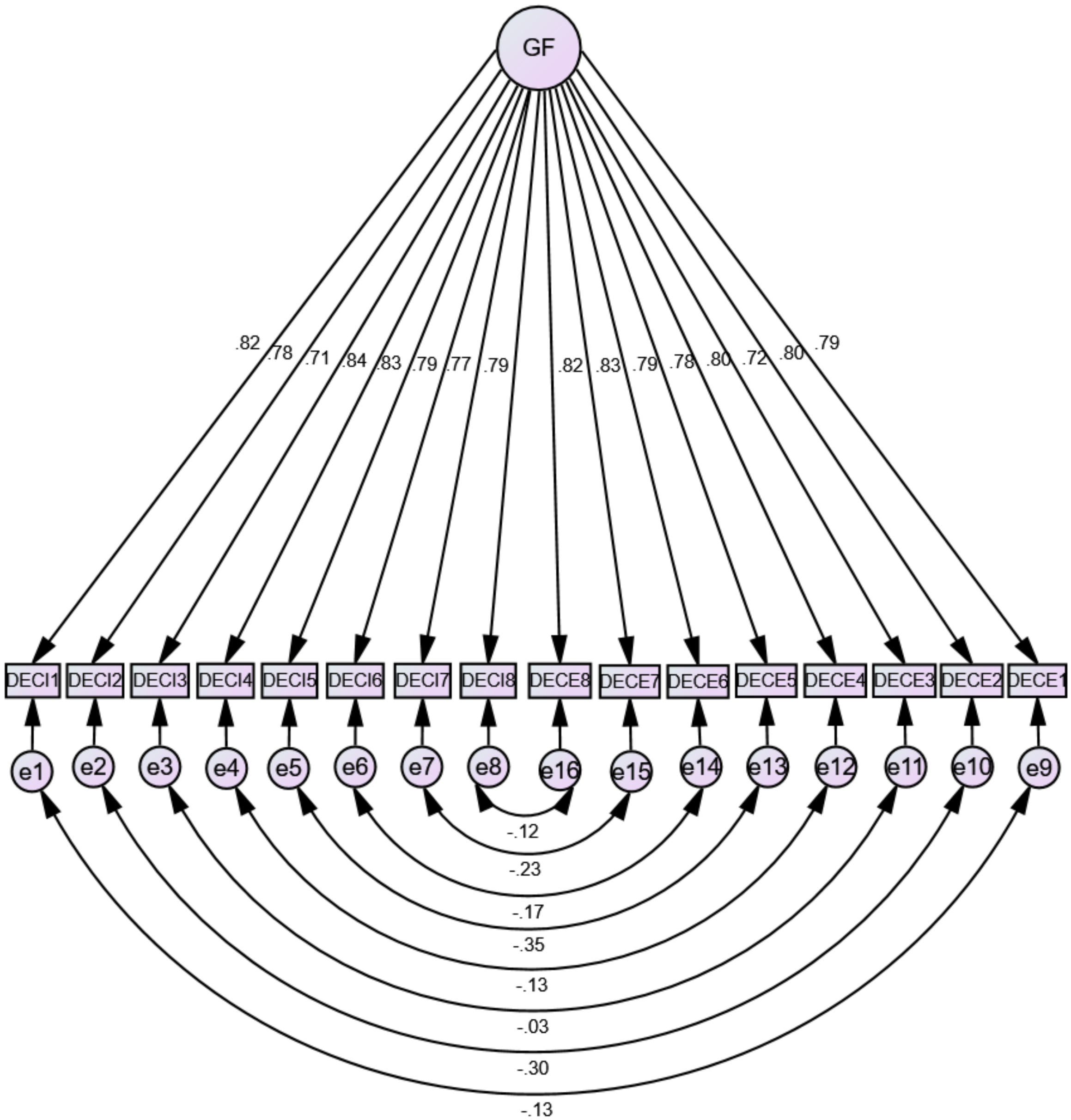

Figure 1. Items of internal and external flow modelled as tapping a single flow construct. Parameter estimates are in standardized form.

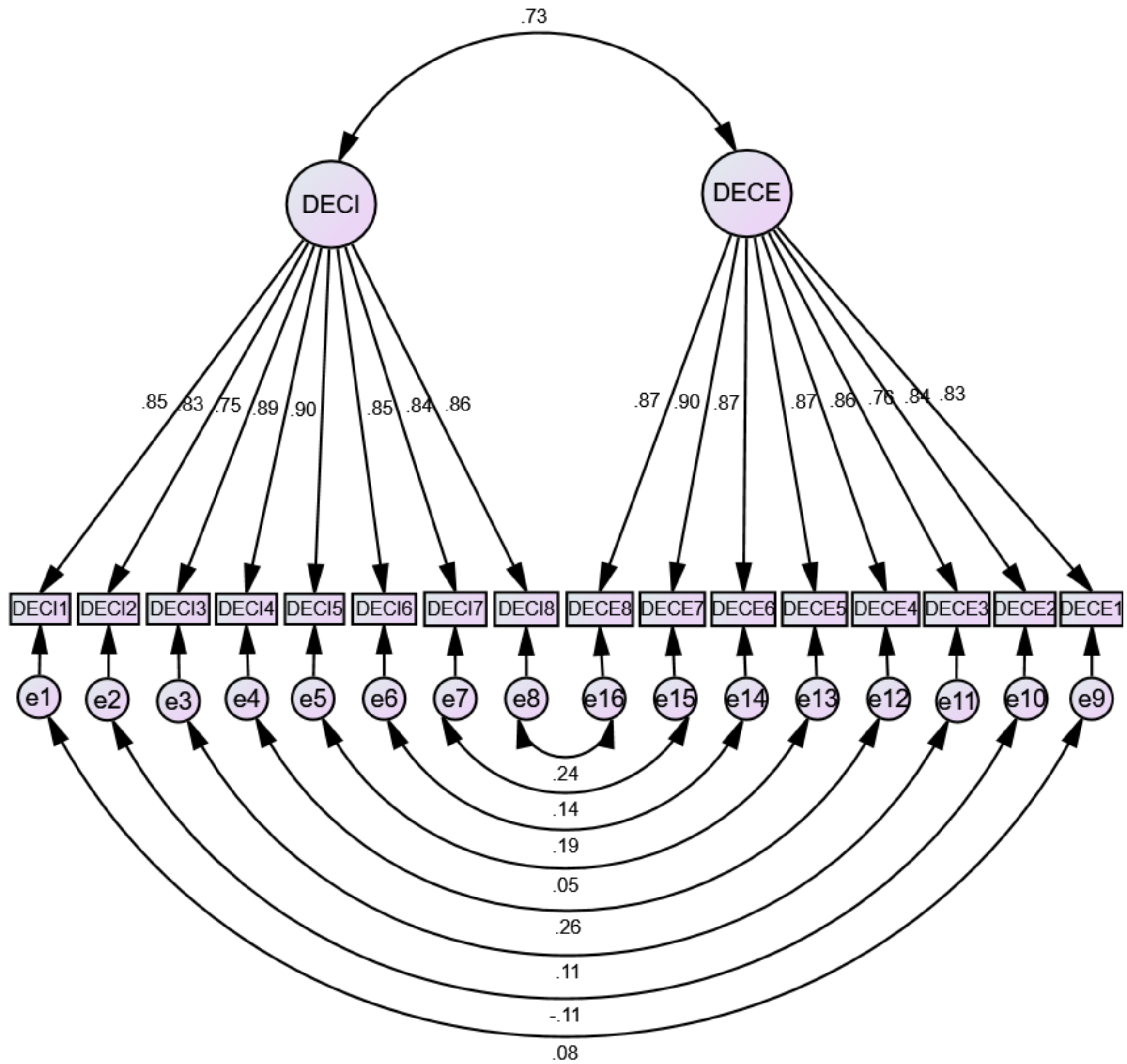

Figure 2. Items of internal and external flow modelled as tapping two correlated constructs (DECI and DECE). Parameter estimates are in standardized form.

This model was found to be a good fit to the data ($\chi^2(95) = 230.89$, CFI = .971, RMSEA = .070, PCLOSE = .003), suggesting that internal and external flow are, while correlated, independent constructs that uniquely influence responses to each of the scales. We compared these models directly using a chi-square test. The model with 2 correlated factors was found to fit the data significantly better than the model with a single global factor ($\chi^2(1) = 831.11$, $p < .01$). These results indicate a 2-factor model is preferable to a 1-factor model, and provided evidence that internal and external flow are distinct concepts. As such, going forward we treat the DECI and DECE as measures of two separate components of the flow experience.

The Relation between Flow and Inattention

In this section we examine the relations among the measures of inattention (MAAS-LO, ARCES, MWS, MWD) and three measures of flow, using both of our newly developed flow measures (DECI and DECE), and the SFPQ-total. The correlations can be viewed in Table 3. It is worth noting that both the DECI and DECE had a modest correlation with the SFPQ-total, indicating convergent validity between these constructs, but also that the new measures are not redundant with the SFPQ-total.

In general, the tendency to experience flow (as measured by all three scales) had a negative relation with inattention measures. The MAAS-LO, ARCES, and MWS were all significantly negatively correlated with each of the flow measures. An exception was the MWD, which was found to have no significant relation to either the DECI, DECE, or SFPQ. Unlike the other inattention measures, which focus primarily on involuntary types of inattention, scores on the MWD reflect a tendency to engage in inattentive behaviour on purpose, which may explain the non-relation to any flow measures. On the whole, these results seem to suggest that an increased propensity to experience flow is related to a decreased tendency to experience involuntary forms of inattention.

Table 3. Correlations among flow, inattention, absorption and age (n = 297)

	DECI	DECE	SFPQ	TAS	MAASLO	ARCES	MWS	MWD
DECI								
DECE	.703**							
SFPQ	.565**	.579**						
TAS	.191**	.224**	.062					
MAASLO	-.376**	-.320**	-.450**	.267**				
ARCES	-.362**	-.286**	-.365**	.387**	.650**			
MWS	-.356**	-.323**	-.410**	.333**	.547**	.590**		
MWD	.014	-.009	-.073	.448**	.233**	.285**	.512**	
AGE	.093	.122*	.219**	-.094	-.087	-.011	-.101	-.105

Note. DECI = Deep Effortless Concentration – Internal; DECE = Deep Effortless Concentration – External; SFPQ = Swedish Flow Proneness Questionnaire; TAS = Tellegen Absorption Scale; MAAS-LO = Mindful Attention Awareness Scale – Lapses Only; ARCES = Attention Related Cognitive Errors Scale; MWS = Mind-Wandering Spontaneous; MWD = Mind-Wandering Deliberate. ** $p < .01$ * $p < .05$ (2-tailed)

Absorption and Flow

Recall that we included the TAS to evaluate whether our new measures of flow are simply redundant versions of this well-accepted measure of absorption. Scores on the TAS had a significant, positive correlation with scores on the internal ($r = .191$) and external ($r = .224$) flow scales. Importantly, the fact that the correlations are relatively modest suggests that the new flow scales are not simply alternative or redundant versions of the TAS. Further evidence that our new measures of flow are distinct from the TAS comes from the relations among these measures and the measures of inattention. Recall that the relation between the flow measures and measures of inattention were generally *negative*. In contrast, the results showed that the relation between the TAS and each of the four measures of inattention were *positive*, with correlations ranging from

.267 (TAS and MAAS-LO) to .448 (TAS and MWD) (see Table 4). That our measures of flow and the measure of absorption had opposite patterns of relations with the inattention measures further reinforces the notion that DECI and DECE are distinct from the TAS, and establishes discriminant validity for these scales. Interestingly, the TAS did not have a significant relation with scores on the SFPQ (r = .062). The full set of correlations between absorption, flow, and inattention can be viewed in Table 3.

Discussion

In Chapter 1, we outlined our reasons for conceptualizing flow as deep, effortless concentration. A closely related goal was to create two reliable scales with which to measure flow according to this reconceptualization. More specifically, the two new flow scales assessed individual differences in the propensity to experience flow in internal contexts, such as while thinking (the DECI), as well as external contexts, such as playing a sport (the DECE). The development of the DECI was of particular interest, as flow in internal states (such as daydreaming), has been relatively ignored in the flow literature, possibly because certain facets do not readily translate across different contexts. The results of the present study demonstrated that these scales have excellent psychometric properties and that the measured concepts of internal and external flow are highly correlated. This suggests that individual differences in the propensity to experience flow are consistent across internal and external contexts. Further, the DECI and DECE had a similar pattern of relations with another measure of flow (the SFPQ), as well as with measures of inattention, and absorption. While the foregoing findings might suggest that internal and external flow are identical constructs, using confirmatory factor analysis we found that a model treating the DECI and DECE as two separate but correlated factors was a significantly better fit to the data than a model with a single factor underlying both scales. Thus, the results of the factor analysis suggested internal and external flow are better conceived as correlated, but separable constructs.

Importantly, the major difference between our new scales and other measures of flow proneness (such as the SFPQ and DFS-2) is in the fundamental strategy used to assess flow. While the SFPQ and DFS-2 attempt to measure flow by assessing multiple putative facets of flow and averaging across the facets to create a global flow score, the DECI and DECE index flow by measuring the frequency with which participants endorse the single experience of deep, effortless concentration. As we noted in Chapter 1, we believe our approach has several key advantages: Specifically, our conceptualization 1) treats flow with more specificity (as a single experience rather than an ever shifting combination of multiple facets), 2) allows for a cleaner separation of flow from the causes and consequences of flow and 3) allows for the possibility of measuring flow across a wider range of contexts (e.g., both external and internal contexts).

In addition to the foregoing benefits, our approach also avoids several thorny conceptual/measurement issues that arise with prior multi-faceted global flow conceptualizations/measures. For instance, a potential drawback of prior multi-faceted global measures of flow is that participants could achieve a high global flow score by experiencing each flow facet frequently, but not simultaneously[10]. Critically, high global flow scores would not clearly indicate the presence of flow even according to the multi-faceted global flow view, because, for flow to be present, this view requires most (if not all) of the facets be experienced simultaneously. Another potential drawback of multi-faceted global flow measures is that they may be used to index flow even when the researchers might define flow (either implicitly or

[10] This is considerably more problematic for a trait scale, where individuals could experience each facet in entirely different contexts. For example, a frequent experience of clear goals at work, a frequent loss of self-consciousness while driving, and action-awareness merging while doodling.

explicitly) primarily in terms of the core facet of deep, effortless concentration. The summing of scores across multiple facets would make it unclear whether differences in the summed global flow score truly measure changes in the assumed core facet of flow. Indeed, there could be changes in 'global flow' without there being changes in deep, effortless concentration, simply because there were changes in all of the other putative facets of flow. Our suggestion of both explicitly conceptualizing flow as deep, effortless concentration, and then directly measuring this experience clearly avoids these potential pitfalls[11].

Our third goal was to address how individual differences in the tendency to experience flow related to the experience of everyday inattention. Previous research into the relation between flow and sustained attention has led to conflicting conclusions, with some claiming there is no relation between flow and sustained attention ability (Ullén et al, 2010; 2012; 2016), while other research suggests superior sustained attention abilities are positively related to flow (Cermakova et al, 2010; Moore, 2013). Uniquely, the present study examined the relation between flow and *everyday* inattention. The results demonstrated that flow, whether measured according to the key facet of deep, effortless concentration (i.e. using our DECI and DECE scales) or the sum of multiple facets (SFPQ), was negatively related to general absent-mindedness, attention-related cognitive errors, and spontaneous mind-wandering. Thus, those individuals who experience flow more often seem to be more focused, and less prone to attention errors (such as pouring their orange juice into their coffee), or allowing their thoughts to wander away from the task at hand.

[11] While internal and external flow are assessed via separate scales, we do not conceive of them as a dichotomy. Many activities have both physical and mental components (e.g. the 'mental side of the game' in various sports). By 'internal' and 'external' flow, we are referring to flow when it occurs in activates that have more prominent internal elements (e.g. remembering/imagining) or more prominent external elements (e.g. sports), respectively.

Our fourth goal was to assess whether our new measures of flow (DECI and DECE) were simply re-capitulating the gold standard measure of absorption, namely, the TAS (Tellegen & Atkinson, 1974). Our results showed that the DECI and DECE both have a modest positive correlation with the TAS, suggesting that these measures capture some common variance, but importantly, that they are not redundant. Another way in which these measures are distinct is in their relations to everyday attention. Those who score higher on the DECI and DECE reported that they experience relatively *less* absent-mindedness, fewer attention-related errors, and less spontaneous mind-wandering in their everyday lives. In contrast, those who scored higher on the TAS experienced relatively *more* of each of these types of inattention, while also engaging in deliberate mind-wandering more frequently. Thus, our new measures of flow (i.e. the DECI & DECE) are clearly not redundant with the TAS.

Beyond describing the relations among flow and absorption measures, it might be useful if we speculated about the conceptual interpretations of the measures and their relations. Any such speculations, however, would depend on the assumptions that are made about the definitions of flow and absorption, as well as the assumptions that are made about the validity of the measures used. On the one hand, one could assume that each of the measures are reasonably valid indices of their respective constructs. Based on this assumption the pattern of findings in the present study could be interpreted as showing that flow and absorption are distinct, but related constructs. On the other hand, one could assume that flow and absorption are in fact the same construct, which is an assumption that seems to be endorsed in the flow literature (Crust & Swann, 2013; Csikszentmihalyi, 1990; Csikszentmihalyi & Nakamura, 2002; Harari, 2008; Jackson & Marsh, 1996; Martin & Jackson, 2008; Peifer et al., 2014; Ullén et al., 2010, Wright et al., 2006; Wright et al., 2007). Based on this rather different assumption, one would conclude that at least some of the measures are not valid indices of the underlying concepts. For example, the lack of a significant correlation between the SFPQ and the TAS would indicate that one or both of these measures is a poor index of the underlying flow/absorption construct.

Perhaps one way to move forward with these measurement and conceptual issues is to posit that the various measures of flow and absorption (DECI, DECE, SFPQ, & TAS) reflect different aspects of a general flow/absorption experience. This might partly be due to the different measurement strategies employed by the various measures. To remind, the TAS measures absorption indirectly, by assessing a variety of different experiences, some of which seem to focus on dissociative or negative absorptive states. In contrast, the SFPQ measures flow by assessing multiple facets, such as having clear goals, feeling in control, and avoiding boredom, which all seem to focus on more positive absorptive states. Finally, the DECI and DECE measure flow by directly assessing the frequency of deep, effortless concentration, without specific reference to positive or negative manifestations of this deep level of engagement. Thus, it could be that the DECI and DECE tap the general construct of deep, effortless concentration, the TAS taps some of this general construct, but also a variety of other mostly negative states, and the SFPQ taps the general construct (with virtually no overlap with the TAS), plus other mostly positive experiences (i.e., perhaps positive precursors and consequences of positive engagement states). However, it is important to keep in mind that these distinctions are only speculative at this time.

Chapter 3

Following the development of the DECI and DECE, in Chapter 3 we examine how flow—when measured as Deep, Effortless Concentration—relates to several variables of theoretical interest. First, in Study 3.1 we examine the relation between flow and well-being, a concept with which flow is thought to have a positive relation (Seligman & Csikszentmihalyi, 2000). However, the relation between flow and well-being has typically been assessed using global flow measures. Keeping in mind the issues with the global flow conceptualization, it could be that well-being is not related to DEC per se, but rather to one of the other extraneous facets included in global flow scores.

Next, we investigate the consistency of flow experience, by replicating our earlier findings in large samples, as well as by investigating the stability of the flow trait (as assessed by the DECI and DECE). In Study 3.2, we again investigate the relation between flow and inattention, as well as the relation between flow and well-being. Furthermore, we extend our earlier findings by investigating whether measures of everyday inattention predict the experience of flow when used as simultaneous predictors. In Study 3.3, we examine the trait consistency or stability of flow proneness by examining the test-retest correlations of the DECI/DECE over time intervals that range from 2 to 26 months.

Study 3.1

While Csikszentmihalyi (2010) and Harari (2008) have described the amorality of flow experience, it has nonetheless been linked with a number of positive correlates, such as intrinsic motivation (Jackson, Martin & Eklund, 2008; Eisenberger, Jones, Stinglhamber, Shanock & Randall, 2005) and desirable qualities such as mental toughness (Swann et al., 2013), commitment to one's goals, and greater confidence in one's abilities (Catley & Duda, 1997; Martin & Jackson, 2008). Flow has also been linked with various measures of psychological well-being and mental health (Asakawa, 2010; Bassi, Steca, Monzani, Greco & Delle Fave, 2014; Clarke & Haworth, 1994; Haworth & Evans, 1995; Haworth & Hill, 1992; Hirao, Kobayashi, Okishima & Tomokuni, 2011; Steele & Fullagar, 2009). For example, students who experience flow in their academic work tended to have better mood, and greater psychological & physical health (Fullagar & Kelloway, 2009; Steele & Fullagar, 2009) and flow is negatively related to feelings of guilt and self-disgust in undergraduates (Hirao & Kobayashi, 2013). Further, flow experience is related to higher life satisfaction (Asakawa, 2010; Fritz & Avsec, 2007; Tse, Nakamura & Csikszentmihalyi, 2020), and several studies have found that flow in sport is related to lower anxiety (Jackson, Ford, Kimiecik & Stein, 1998; Jackson, Martin & Eklund, 2008).

When assessing affect as separable positive and negative dimensions, several studies have indicated that flow experience is related to more positive affect and to less negative affect (Collins, Sarkisian & Winner, 2009; Fritz & Avsec, 2007; Rogatko, 2007). For example, it was found that flow experience while waiting (over the course of several weeks) to hear the results of one's performance on the Bar exam (or a job offer) was associated with more positive affect and less negative affect (Rankin, Walsh & Sweeney, 2018). Similar results were obtained in a study of Slovenian music students, those higher in trait flow tended to experience more positive affect and less negative affect (Fritz & Avsec, 2007). Rankin et al (2018) found that state flow was correlated with more positive emotion and less negative emotion after 10 minutes of Tetris (when controlling for baseline levels of negative emotion). In one study investigating the relation between flow and affect, the experience of flow was assessed using the flow questionnaire (Bassi et al., 2014). In the flow questionnaire, participants are presented with three statements describing the experience of flow, and asked to identify whether or not they have ever had such an experience. On the basis of their responses, participants were divided into two groups, those who had experienced flow at some point in their lives, and those who had never experience flow. To assess mental well-being, scores on the PANAS were used to calculate 'hedonic balance' (i.e. the difference between positive affect and negative affect), with higher scores indicating a greater ratio of positive to negative affect. The results indicated there was a small to moderate relation between flow and hedonic balance, such that those who had never experienced flow were lower in mental well-being. One case study has even suggested the tantalizing possibility that flow might causally impact well-being and offer therapeutic mental health benefits (Delle Fave & Massimini, 1992). In this case study, occupational therapists were able to treat a young woman with agoraphobia by helping restructure her life around activities where she could find flow (Delle Fave & Massimini, 1992). While most of the work on flow and well-being has been cross-sectional, the literature on flow clearly indicates a positive relation between flow and mental well-being and would seem to validate the notion proposed by flow theory—that flow engenders positive experiences and mental well-being.

However, there is reason to suspect that the relation between flow and well-being is not as clear as it seems at first glance. One important limitation of the prior literature concerns the measures that have typically been used to assess flow. For example, some studies that have been taken as demonstrations of a relation between flow and well-being actually did not include a measure flow *experience* at all (e.g. Clarke & Haworth, 1994; Haworth & Hill, 1992; Haworth & Evans, 1995; Eisenberger et al., 2005). Instead, these studies examined the relation between well-being and optimal skill-challenge balance. However, because of the assumed relation between skill-challenge balance and flow experience, these studies equated optimal skill-challenge balance with flow.[12] This equating of constructs can be a source of confusion because it makes it appear as though there is a relation between well-being and flow experience, even when flow experience is not being measured and a precursor facet (i.e. skill-challenge balance) is being measured instead[13]. Many other studies on the relation between flow and well-being have been based on global flow metrics which include the conflation of multiple facets in the measurement of flow (e.g. Fritz & Avsec, 2007; Fullagar & Kelloway, 2009; Jackson et al., 1998; Jackson et al., 2008; Rankin et al., 2018; Tse et al., 2020; Steele & Fullagar, 2009). Thus, it is possible that the relation between flow and mental well-being could have possibly been driven, or at least influenced, by any one of a number of extraneous facets included in the measure. Thus, rather than being related to flow per se (i.e. deep, effortless concentration) it could be that well-being is positively related with precursor facets of flow, such as skill-challenge balance, clear goals, and unambiguous feedback, or with consequences of flow, like a sense of control. Accordingly, it still remains unclear whether well-being is related to DEC, the defining experience of flow.

The Present Study

Building on prior work, in the present study, flow was defined as the experience of deep, effortless concentration and was assessed using measures of deep, effortless concentration (i.e. the DECI & DECE) to measure both internal and external flow. In particular we examined the relation between these measures and different indices of mood, both negative and positive, in two large university samples (n > 1500). We construe negative mood as including experiences of stress,

[12] While the exact criteria differ from study to study, studies of this sort essentially dichotomize a measure of skill challenge balance into a number of different ‘channels’, such as flow or boredom. However, the labels for these channels are not based on empirical data documenting these subjective experiences, instead they are inferred from flow theory. For example, the ‘boredom’ channel is assumed when skill and challenge are both low, but the experience of boredom is not actually assessed. Ironically, subjective experience of the ‘boredom’ channel is often quite pleasant, suggesting that the label for this channel (and perhaps others) is not appropriate.
[13] For example, Steele & Fullagar (2009) report that several of these studies show a relationship between flow experience and psychological well-being.

depression, and anxiety (as indexed by the Depression, Anxiety, Stress Scales; DASS, Antony, Bieling, Cox, Enns & Swinson, 1998) as well as negative affective states (as measured by the Positive and Negative Affect Schedule; PANAS, Watson, Clark & Tellegen, 1988); positive mood is defined as the frequency with which people experience positive affective states (as assessed by the PANAS, Watson, Clark & Tellegen, 1988). As flow is generally thought to be positively associated with well-being and has even been suggested to act as a buffer against mental illness (Seligman & Csikszentmihalyi, 2000) we expected to find higher levels of trait flow (i.e., DEC) to be related to lower levels of depression, anxiety, stress, and negative mood, and higher levels of positive mood.

An interesting element of the present study was that we assessed the frequency of flow experience in both internal and external contexts. Much of the previous work assessing a relation between flow and well-being has been examined participants' flow experience during sports or other physical activities (e.g. Jackson et al., 1998; 2008), while flow in internal contexts has been relatively ignored (Nakamura & Csikszentmihalyi, 2002). While we anticipated that internal flow would be associated higher levels of well-being, it is possible that internal and external flow will relate to well-being in different ways. Indeed, some have reported that mental/internal and physical/external flow had a differing pattern of relations with various personality traits (Ross & McIntyre, 2018—though the authors did not assess flow as deep, effortless concentration. Relative to classic flow theory, the DEC conceptualization is agnostic with regard to the emotional quality of flow (i.e. deep effortless concentration/flow does not have to be positive), so it is possible that participants may experience deep, effortless concentration during rumination—and as such, it is conceivable that the DECI (which might index flow during internal rumination) could have a weaker (or even a negative) relation with well-being compared to the positive relation we expected to see between DECE and well-being. While a global flow conceptualization would seem to rule this possibility out by definition (flow is meant to be positive and enjoyable), under the DEC conceptualization it becomes an empirical question.

Methods

Participants

Data for the study was collected as part of a pre-term mass screening survey. After providing informed consent, undergraduates at the University of Waterloo filled out the mass screening survey in exchange for partial course credit. In Sample 1 (collected in Fall of 2017) we included those participants who fully completed our questionnaires of interest (see below) a total of 2088 participants. The sample included 1548 females, 525 males and 15 individuals with another gender identity. Sample 2 was collected in the 2019 Winter Term and consisted of 1501 participants (1064 females, 420 males and 17 individuals with another gender identity). Participants who were included in both samples (n = 451) were removed from Sample 2.

Measures

Deep Effortless Concentration – Internal (DECI) and External (DECE). To measure individual differences in the propensity to experience flow we used two scales: the Deep Effortless Concentration - Internal (DECI) scale—designed to measure flow experiences during internal tasks such as thinking, imagining, or remembering—and the Deep Effortless Concentration - External (DECE) scale—which indexes flow during external tasks, such as sports, hobbies, and playing instruments (see Appendix A). A brief instruction statement (which provides illustrative examples of either internal or external tasks, respectively) precedes each scale. Each scale contains eight items that probe the frequency of participants' flow experiences, using questions such as "I can perform an internal/external task so quickly and easily it seems to happen without effort" on a 1 (Never) to 7 (Always) Likert scale.

Depression, Anxiety, Stress Scale (DASS-21). To measure perceptions of depression, stress, and anxiety, we used the 21-item Depression, Anxiety and Stress Scale (Anthony, Bieling, Cox, Enns & Swinson, 1998). The DASS can be further divided into three subscales that index unique features of depression (low positive affect), anxiety (hyper-arousal), and stress (tension). Each subscale consists of seven items which are answered on a 4-point Likert scale, where higher responses indicate a greater level of symptomatology. Some sample items from the scale include "I felt that life was meaningless", "I felt I was close to panic", and "I found it difficult to relax".

Positive and Negative Affect Schedule (PANAS). The Positive and Negative Affect Schedule (PANAS), is a 20-item scale designed to measure two major dimensions of emotional experience (Watson, Clark & Tellegen, 1988). Participants are presented with a list of 20 mood adjectives and asked to indicate the extent to which they experience each one on a 5-point Likert scale ranging from "1 – Very Slightly or Not at All" to "5 – Extremely". The PANAS can be divided into two subscales to measure positive affect and negative affect. Those high in positive affect are "alert", "enthusiastic", and "active", while those low in positive affect tend to feel sad, and lethargic. Conversely, those high in negative affect are frequently "distressed", "irritable", and "nervous", while those low in negative tend to be calm or serene. The PANAS has been found to have high internal consistency and test-retest reliability using a variety of difference instructions. In the present study, we used the instructions that ask participants to indicate how often they experience each emotion in general to measure trait-level positive affect and negative affect.

Results

The results of the present study are presented in two sections. First, we report the descriptive statistics for each of the questionnaires (DECI, DECE, DASS and PANAS). In the second section, we report the correlations between flow experience (DECI & DECE) and the various mood measures (DASS & PANAS). All measures were collected in both samples with the exception of the PANAS, which was only included in Sample 1. Statistical analyses were conducted using R (R Core Team, 2019).

Psychometrics

The descriptive statistics for each measure collected in Samples 1 and 2 can be found in Tables 4 and 5, respectively. The measures in both samples were found to have good internal consistency reliability, ranging from .85 to .96. Skew and kurtosis values were found to be within an acceptable range (i.e. skewness < 3 and kurtosis < 10; see Kline, 1998) for each of the measures, indicating that the scores came from a relatively normal distribution.

Table 4. Descriptive statistics for Sample 1 (n = 2088)

	Mean	SD	Skew	Kurtosis	α
DECI	4.17	1.25	.06	-.30	.96
DECE	4.22	1.27	-.04	-.38	.96
Depression	12.59	5.16	1.00	.22	.92
Anxiety	11.75	4.44	1.08	.64	.86
Stress	13.56	4.57	.61	-.20	.85
Negative Affect	2.29	.78	.52	-.18	.89
Positive Affect	3.09	.71	-.21	-.17	.88

Note. DECI = Deep Effortless Concentration – Internal; DECE = Deep Effortless Concentration – External.

Table 5. Descriptive statistics for Sample 2 (n = 1501)

	Mean	SD	Skew	Kurtosis	α
DECI	4.32	1.21	-.09	-.24	.95
DECE	4.47	1.28	-.14	-.29	.96
Depression	12.72	5.08	.89	-.03	.91
Anxiety	11.78	4.46	1.03	.35	.85
Stress	13.29	4.60	.69	-.02	.86

Note. DECI = Deep Effortless Concentration – Internal; DECE = Deep Effortless Concentration – External.

Deep, Effortless Concentration and Mood

To follow up on the development of the DECI and DECE (see Study 2.1), we examined the correlations between these scales and the mood variables assessed by the DASS and the PANAS. Pearson correlations are presented in Table 6. In line with theoretical expectations, both the DECI and DECE were found to be negatively correlated with depression, anxiety, and stress in both samples, indicating that those who experience flow more often tend to experience fewer symptoms of depression, anxiety and stress. Furthermore, we also found that the DECI and DECE were negatively correlated with negative affect as measured by the PANAS, which was only assessed in Sample 1. Finally, we also examined our flow measures in relation to positive affect, as measured via the PANAS in Sample 1. Both the DECI and DECE were positively correlated with the experience of positive affect, such that those who experience flow more frequently tend to experience emotions such as excitement, pride, and enthusiasm to a greater extent. Taken together,

Table 6. Pearson correlations between Flow and Affect in Sample 1 (n = 2088; below diagonal) and Sample 2 (n = 1501; above diagonal)

	1	2	3	4	5	6
1 DECI	-	.484**	-.151**	-.101**	-.154**	-
2 DECE	.533**	-	-.196**	-.196**	-.205**	-
3 Depression	-.230**	-.256*	-	.721**	.753**	-
4 Anxiety	-.199**	-.183*	.690**	-	.780**	-
5 Stress	-.234**	-.207*	.735**	.775**	-	-
6 Negative Affect	-.220**	-.196*	.595**	.627**	.639**	-
7 Positive Affect	.297**	.365*	-.361**	-.151**	-.160**	-.066*

Note. The PANAS (positive and negative affect) was included only in Sample 1.
** $p < .001$ * $p < .01$ (2-tailed).

these results suggest that, those who tend to experience deep, effortless concentration more frequently also tend to have positive affective experiences more frequently, and negative affective experiences less frequently.

Discussion

In the present study, we examined the relations between well-being and two newly developed measures of the flow (i.e. the DECI & DECE) and demonstrated that those individuals who tend to experience deep, effortless concentration more frequently, also tend to have greater well-being—as assessed through measures of positive and negative mood. In particular, in two large samples, we found that those who experience more flow reported fewer symptoms of depression, anxiety and stress. While there are some small fluctuations in the size of these correlations (i.e. the estimates were slightly larger in Sample 1 than in Sample 2), the direction of the relations is consistent in both samples; in both of the present samples, the results indicate a small negative correlation between flow and symptoms of depression, stress, and anxiety.

In addition, in the first sample, we were also able to examine the relation between flow and scores on the PANAS, which is used to assess negative and positive affect, respectively. In line with our expectations, we found a negative relation between flow and negative affect, such that those who experience flow more often experience less of negative emotions, such as nervousness, irritability, and fear. We also observed that flow had a positive relation with positive affect—that is, in addition to experiencing less negative affect, flow was also associated with life-affirming emotions, such as feeling enthusiastic, active and alert.

Overall, this pattern of results is consistent with the broader literature on flow and well-being, however, our study also has several particular strengths which make it an important contribution to the literature. The first concerns our use of the DECI and DECE as specific measures of flow, which allowed us to demonstrate that well-being is related specifically to deep, effortless concentration. Previous work in the area has tended to use measures of global flow (Fritz & Avsec, 2007; Fullagar & Kelloway, 2009; Jackson et al, 1998; 2008; Rankin et al., 2018; Steele & Fullagar, 2009; Tse et al., 2020), which are typically summed to create a global flow score (with which we outlined a number of issues in Chapter 1), while other work failed to assess the subjective experience of flow at all (Clarke & Haworth, 1994; Haworth & Hill, 1992; Haworth & Evans, 1995; Eisenberger et al., 2005). While various flow-related facets may indeed be related to well-being, the present results show that well-being is specifically related to deep, effortless concentration—the defining characteristic of flow experience. In other words, our results demonstrate that DEC still has a positive relation with well-being when it is considered on its own. Another strength is the large samples we used to assess the relation between flow and well-being, which allow for us to be more confident in our conclusions about the relationship between flow and well-being. Furthermore, for the metrics that were included in both samples (i.e. the DASS), the relations were consistent across samples, which further strengthens our conclusions. Finally, an interesting element of the present study was our examination of internal flow. While Csikszentmihalyi has stated that flow can occur in any context, few studies have examined flow during internal events (Nakamura & Csikszentmihalyi, 2002). A possibility was that internal flow could be related to processes such as rumination, which are characteristic of depression and generally thought to occur automatically, and thus, have a negative relation with well-being. However, across our analyses, the DECE and DECI had a consistent pattern of relations with well-being indicating that both external and *internal* flow are related to greater well-being.

It may be worth examining how the interpretation of the present study would change depending on whether one favours a DEC or a 'global flow' conceptualization of flow. Each conceptualization has an underlying set of assumptions which impact the interpretation of the present results. If one defines flow as the experience of deep, effortless concentration (e.g. see Chapter 1; Csikszentmihalyi & Nakamura, 2010; Harmat et al., 2015), then one could say that previous work examining the relation between flow and well-being has not clearly demonstrated that it is flow per se (i.e. DEC) that is related to well-being. Indeed, the relations could be driven by (or at least boosted by) a relation between subjective well-being and the extraneous facets typically included in global flow measures (such as skill-challenge balance or clear goals). As such, the present results provide more decisive empirical support for the claim that flow is related to mental well-being—because they demonstrate that deep effortless concentration (i.e. the defining experience of flow) in particular is related to greater well-being.

For those maintaining a global flow framework, the results of the present study might be simply viewed as a validation of the DECI and DECE scales. That is, based on prior work (Asakawa, 2014; Bassi et al., 2014; Crust & Swann, 2013; Tse et al., 2020), and claims that flow is a buffer to mental illness (Seligman & Csikszentmihalyi, 2000), measures of flow and well-being are by definition assumed to be positively correlated. Given that the DECI and DECE show the expected pattern of relations, the present results would serve to further establish the DECI and DECE as valid measures of flow experience. While global flow theorists may prefer a measure with additional facets, even proponents of global flow express that it is deep, effortless concentration in particular that is the signature quality of flow (Nakamura & Csikszentmihalyi, 2002; Csikszentmihalyi & Nakamura, 2010).

Regardless of which conceptualization one prefers, the results of the present study—which defined and measured flow as the experience of deep, effortless concentration—were consistent with previous work examining the relation between flow and subjective well-being. In particular, we found that flow was consistently related to fewer symptoms of depression, stress and anxiety and that flow is related to less negative affective, and to more positive affect. Taken together these results demonstrate that the frequency of deep, effortless concentration (both internal and external) in everyday life is related to greater subjective well-being.

Study 3.2

In the present study, our main goal was to examine the replicability of our prior findings. In particular, we re-examine the relation between flow and everyday inattention, as well as the relation between flow and well-being. To accomplish these goals, we drew data from a recent mass testing survey, which included four measures of everyday inattention (i.e. the MAAS-LO, ARCES, MWS & MWD) and an index for symptoms of depression, anxiety & stress (i.e. the DASS). In addition, we extended our prior findings by predicting flow in a regression using the four measures of inattention. This allowed us to examine the relation between flow and everyday inattention collectively, and to evaluate the possible unique contributions of the inattention measures when used together as simultaneous predictors of flow experience.

Data Cleaning

Before conducting our analyses, we began with a data cleaning procedure to ensure high quality data in participant responses. That is, the Mass Testing survey is long, and many participants may not be fully attentive over the course of the survey. In addition, we aimed to address the possibility that some participants may employ assistive technology, or ‘bots’, to help them receive their participation credit with less time and effort. After selecting the relevant items for each set of analyses (i.e. inattention, well-being, and stability), we used Qualtrics timing data to help identify suspicious data. We examined three aspects of the data: Specifically, we examined 1) the clicking data, 2) the response timing data, and 3) the number of items completed for each the scale.

First, we examined the participants clicking behaviour, which logged the number of clicks a participant made on each page of the survey (each of our scales of interest was presented on a single page). If the number of clicks a participant made was less than the number of scale items on a page, their response was flagged as suspicious. This method caught three types of responses; 1) Participants who did not answer the scale at all (e.g. they answered none of the items on the DECI, resulting in 0 clicks), 2) Participants who answered most, but not all, of the items in a scale (e.g. they answered seven out of eight items in the scale, resulting in 7 clicks and 1 NA), and 3) Participants who had too few clicks, but nonetheless had a score for every item (e.g. four clicks, eight scores, and 0 NA responses). We considered this third type of response to be suspicious—it is impossible to answer eight questions with four clicks—and an indicator that the participant may have been assisted by a bot when filling out the scale. As such, we discarded the data from the participants with this third type of response (i.e. those with suspicious clicking behaviour).

Next, we examined participants' timing data for each scale. We decided that participants would need to have *at least* one second per item of a scale in order to read and answer the items appropriately. For each scale, we calculated the time taken to complete the scale by subtracting the time of their first click from the time of their last click on the page (i.e. the click to submit their responses for that scale). Participants whose time taken to complete the scale was equal to or less than the number of items in the scale (e.g. a participant who took six seconds to answer an eight-item scale such as the DECI) were flagged as 'too fast'. Participants who were found to be too fast on 50% or more of the scales they answered were removed from the analyses. For the dataset examining flow and inattention, this included six scales (DECI, DECE, MAAS-LO, ARCES, MWS, MWD)[14]. For the dataset examining flow and well-being, this included five scales (DECI, DECE, Depression, Anxiety and Stress). In addition, we examined whether participants first and last click on the scale took place simultaneously. If a participant answered all the items simultaneously (i.e. the first and last click were simultaneous and the participant had no NAs for the scale), this may indicate the use of a bot. However, no additional participants were flagged via this method.

Finally, we examined whether participants total scale scores were based on a minority of the items; that is, whether they left most of the items of the scale blank (e.g. if participants answered one item of a scale and left the rest blank, this one item would become their 'mean' score for the scale). If, for example, a participant answered only two of the 12 items on the MAAS-LO,

[14] In this term, there were two versions of the mass testing survey. The DECI, DECE, MAAS-LO, and ARCES were included in both versions, while the MWS and MWD where only included in one. The 50% threshold was applied according to the number of scales the participants were presented with. For a subset of our participants (n = 454), the 50% threshold was based on four scales (DECI, DECE, MAAS-LO & ARCES) instead of six.

their score for the MAAS-LO would be less accurate than someone who answered all 12. We examined the data to ensure that the mean scale scores were not based on mostly non-responses. However, after the first three steps of data cleaning, there was only one participant with a scale score based on a minority of items (e.g. they answered three of seven items in the anxiety subscale of the DASS), indicating that this was not an issue. This individual was included in the analyses.

Results

Flow and Everyday Inattention

After completing the data cleaning on the dataset, and ensuring the current sample was completely independent from the samples we analyzed in Study 3.1, there were 1458 participants in the sample[15]. Participants were also required to have answered both the DECI and DECE. We began by examining the descriptive statistics for each of the scales (DECI, DECE, MAAS-LO, ARCES, MWS, MWD). As can be seen in Table 7, each of the scales was found to have good psychometric properties and internal consistency reliability (i.e. Cronbach's alpha greater than .80).

Table 7. Descriptive statistics for flow and inattention measures (n = 1964)

	Mean(SD)	Median	Skew	Kurtosis	SE	Alpha
DECI	4.14(1.24)	4.12	.05	-.30	.03	.96
DECE	4.25(1.28)	4.15	.01	-.40	.03	.96
MAAS-LO	3.20(.79)	3.25	-.09	.22	.02	.88
ARCES	2.89(.67)	2.83	.30	.33	.02	.90
MWS	4.22(1.35)	4.25	-.18	-.19	.04	.88
MWD	4.23(1.45)	4.25	-.24	-.51	.05	.89

Note. DECI = Deep Effortless Concentration – Internal; DECE = Deep Effortless Concentration – External.

[15] There were two versions of the Mass Testing survey and the mind-wandering scales were only included on one of these forms. As such, only a subset of our sample (n = 1004) completed the MWS and MWD.

To replicate the findings from our prior study (i.e. Study 2.1), we examined the correlations between each of the two flow measures (DECI & DECE) and each of the four inattention measures (MAAS-LO, ARCES, MWS, MWD). As can be seen in Figure 3, the pattern of correlations was such that those who experienced flow more frequently tended to experience everyday inattention less often. That is, those who were more prone to experiencing flow experienced fewer episodes of absent-mindedness, fewer attention-related errors, and less spontaneous mind-wandering. Notably, though significant, the relation between flow and deliberate mind-wandering was very weak for both the DECI (r = .019) and the DECE (r = .02). Taken together, these results replicate our initial findings (see Study 2.1) and provide support for our hypothesis that flow is associated with greater sustained attention ability.

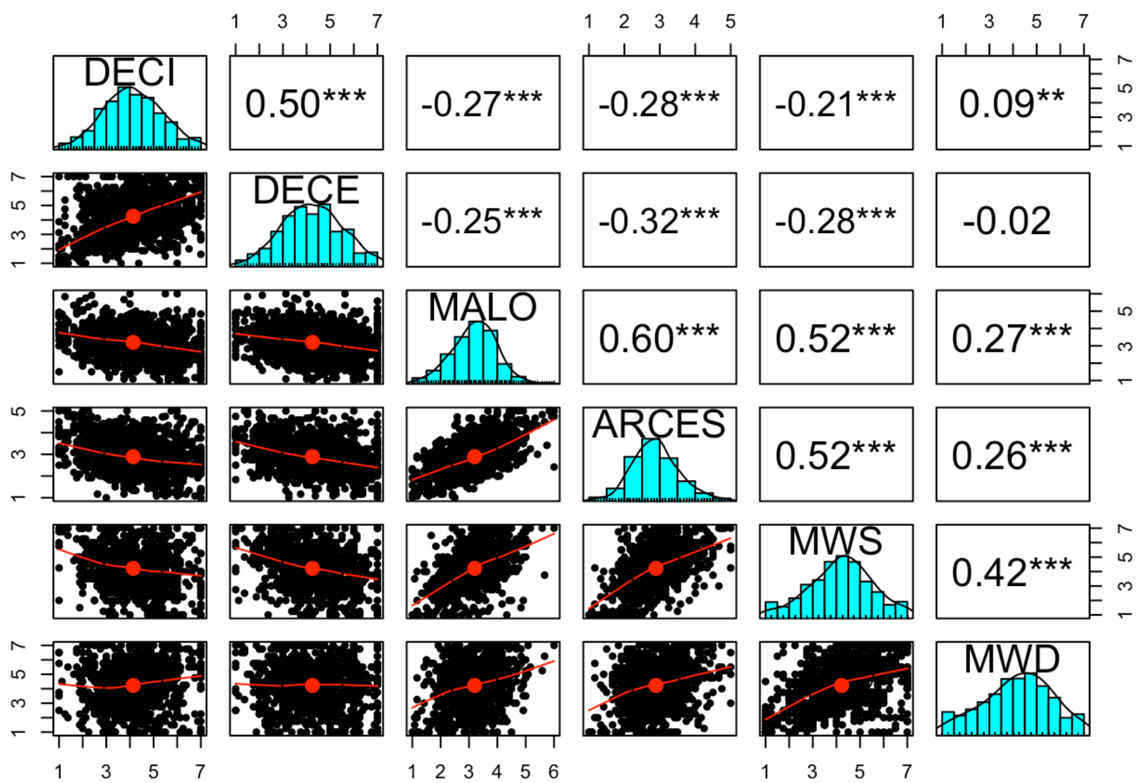

Figure 3. Relations among measures of flow and everyday inattention

To expand these findings, in the present sample, we further explored the relation between everyday inattention by examining the relation between flow and sustained attention in a regression. In particular, we predicted each of the DECI and DECE using the four predictors of everyday inattention (MAAS-LO, ARCES, MWS, MWD) as simultaneous predictors, to see how much variance in flow proneness could be explained by sustained attention in everyday life. The regression model indicated that everyday sustained attention accounted for 11% of the variance in the DECI (see Table 8), and 12% of the variance in the DECE (see Table 9). As such, these results provide additional support for the notion that flow is related to greater sustained attention ability.

Table 8. Regression results using DECI as the criterion

Predictor	*b*	*b* [95% CI]	*beta*	*beta* [95% CI]	*r*
(Intercept)	5.22**	[4.86, 5.59]			
MAAS-LO	-0.15*	[-0.27, -0.02]	-0.09	[-0.17, -0.02]	-.21**
ARCES	-0.23**	[-0.37, -0.09]	-0.12	[-0.20, -0.05]	-.22**
MWS	-0.18**	[-0.24, -0.11]	-0.20	[-0.27, -0.12]	-.21**
MWD	0.19**	[0.14, 0.24]	0.23	[0.17, 0.30]	.09**

$R^2 = .109$, $F(4, 999) = 30.57$, $SE = 1.13$, $p < .001$

Note. A significant *b*-weight indicates the beta-weight is also significant. *b* represents unstandardized regression weights. *beta* indicates the standardized regression weights. * indicates $p < .05$. ** indicates $p < .01$.

Table 9. Regression results using DECE as the criterion

Predictor	*b*	*b* [95% CI]	*beta*	*beta* [95% CI]	*r*
(Intercept)	5.95**	[5.57, 6.34]			
MAAS-LO	-0.06	[-0.18, 0.07]	-0.03	[-0.11, 0.04]	-.23**
ARCES	-0.40**	[-0.55, -0.25]	-0.20	[-0.28, -0.13]	-.30**
MWS	-0.20**	[-0.27, -0.13]	-0.21	[-0.28, -0.13]	-.28**
MWD	0.12**	[0.06, 0.17]	0.13	[0.07, 0.20]	-.02

$R^2 = .123$, $F(4, 999) = 35.05$, $SE = 1.20$, $p < .001$

Note. A significant *b*-weight indicates the beta-weight is also significant. *b* represents unstandardized regression weights. *beta* indicates the standardized regression weights. * indicates $p < .05$. ** indicates $p < .01$.

Interestingly, not all of the measures were significant predictors for both types of flow. In particular, the MAAS-LO was a significant predictor of internal flow (i.e. the DECI), but not external flow (i.e. DECE). Further, while the ARCES was a significant predictor of both internal and external flow, the beta was nominally larger when predicting the DECE (.40), than when predicting the DECI (.23). When controlling for the shared relation between MWD and the other inattention measures (MAAS-LO, ARCES, and MWS), deliberate mind-wandering was found to be a significant *positive* predictor of both internal and external flow. In other words, when controlling for its relation with the other inattention variables, deliberate mind-wandering was associated with more frequent experiences of both internal and external flow.

Flow and Well-Being

After completing the data cleaning on the flow and well-being data, there were 1458 participants in the sample.[16] Participants were also required to have answered both the DECI and DECE. We examined the descriptive statistics for each of the scales (DECI, DECE, Depression, Anxiety and Stress). As can be seen in Table 10, the scales were found to have generally good psychometric properties and good internal consistency reliability (i.e. higher than .80).

Table 10. Descriptive statistics for flow and well-being measures (n = 1458)

	Mean(SD)	Median	Skew	Kurtosis	SE	Alpha
DECI	4.11(1.25)	4.00	.10	-.28	.03	.95
DECE	4.25(1.26)	4.12	.04	-.38	.03	.96
Depression	.86(.76)	.71	.88	-.08	.02	.91
Anxiety	.76(.67)	.57	.96	.29	.02	.86
Stress	.95(.68)	.86	.63	-.23	.02	.86

Note. DECI = Deep Effortless Concentration – Internal; DECE = Deep Effortless Concentration – External.

[16] Three participants who did not complete the DASS were removed.

Next we examined the correlations between the DECI, the DECE, and each of the measures of the DASS. As can be seen in Figure 4, both measures of flow were negatively correlated with the measures of the DASS, indicating that those who experience flow more often tend to experience fewer symptoms of depression, anxiety and stress. However, as indicated by the histograms on the diagonal, the measures of well-being were not normally distributed, with each showing a positive skew. As such, we conducted Spearman-Brown rank-order correlations to account for this non-normality. These correlations are presented in Figure 5. Notably, there is no meaningful change in the magnitude of the correlations when conducting Spearman correlations instead of Pearson correlations, and as such our interpretation of these results is the same—those who experience flow more often tend to experience fewer symptoms of depression, anxiety and stress.

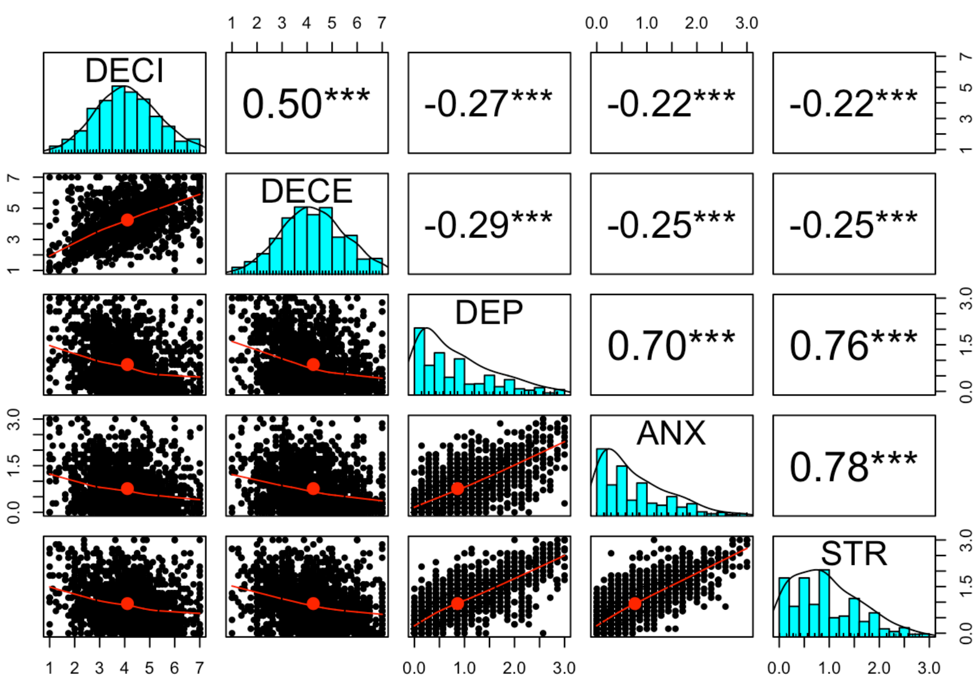

Figure 4. Pearson correlations between flow and symptoms of depression, anxiety & stress.

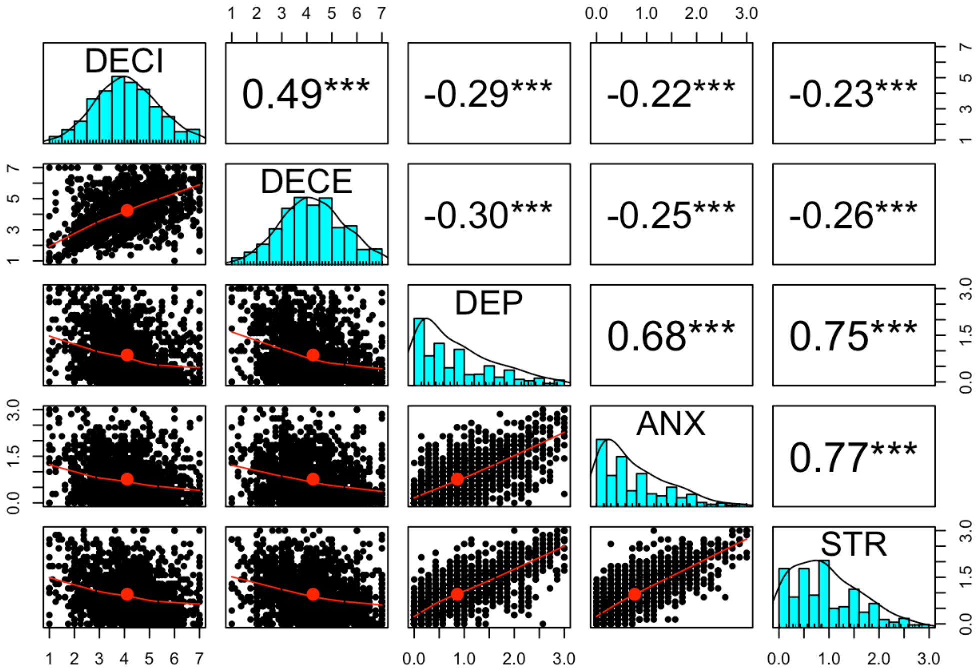

Figure 5. Spearman correlations between flow and symptoms of depression, anxiety & stress.

Discussion

In the current study we found a significant negative relation between flow and everyday inattention, such that those who experience flow more frequently tend to be less absent-minded, make fewer attentional errors, and to experience fewer episodes of spontaneous mind-wandering. These findings replicate our prior work examining the relation between flow and inattention (see Study 2.1) in a larger sample and in a different population (i.e. a university population). Furthermore, we also replicated our prior findings on the relation between flow and well-being (see Study 3.1). In particular we found that there was a significant correlation between flow and well-being, such that those who experience flow more often tend to have better mental well-being. Importantly, these results also demonstrate the relation between flow and well-being is not driven by the extraneous facets included in 'global flow' measures (see Study 3.1 for a discussion of this issue). While the various precursors and consequences of flow might also be related to well-being, the current findings help to further confirm that deep, effortless concentration in particular (i.e. the core concept of flow), has a positive relation with well-being.

In addition, we extended our prior work by examining the relation between everyday inattention and flow using regression analyses. Interestingly, while inattention predicted a similar amount of *overall* variance in the DECI and DECE, the contribution of individual predictors shifted somewhat depending on whether the criterion was internal flow or external flow. When predicting the DECI, each of the MAAS-LO, ARCES, MWS and MWD were found to be significant independent predictors. When predicting the DECE, however, the MAAS-LO did not make a significant contribution and the beta for the ARCES increased relative to when it was predicting the DECI. The MAAS-LO reflects an internal form of inattention, while the ARCES indexes attentional errors in the external world thought to result from absent-mindedness (Cheyne, Carriere & Smilek, 2006; Smilek, Carriere & Cheyne, 2010). So, when controlling for the shared relation of inattention measures, absent-mindedness is negatively related to flow in internal contexts (i.e. the MAAS-LO is a significant predictor of the DECI), but not related to flow in external contexts[17], which is consistent with the targeted focus of these measures on the internal/external dimension.

The two regressions predicting flow also revealed a second interesting finding; deliberate mind-wandering was found to be a unique *positive* predictor of flow in both models. That is, when controlling for its shared relation with the other inattention measures, more deliberate mind-wandering was associated with significantly more deep, effortless concentration. A possible explanation for the divergence between deliberate mind-wandering and the other measures of inattention could be that the MWD reflects a different attentional process than the other

[17] However, it should be noted that the MWS and MWD, other indicators of internal inattention, were significant unique predictors of both internal and external flow.

instruments. While attention errors, absent-mindedness, and spontaneous mind-wandering represent a discrepancy between intentions and results—they more clearly represent failures of attention—deliberate mind-wandering reflects a more intentional (perhaps strategic) form of disengagement that occurs when one chooses to direct their attention elsewhere (see Wammes, Boucher, Seli, Cheyne & Smilek, 2016). One can even imagine how deliberate mind-wandering might be employed as strategy to experience flow when it would not otherwise be possible. For example, if one were to find themselves in a boring, mandatory situation (such as working on a line, or sitting in an uninspiring lecture), they could tune out the external world and choose to become absorbed in pleasant fantasy instead—and in some cases, perhaps so absorbed that they begin to experience flow. In fact, in one experience sampling study[18] a small proportion of participants actually reported experiencing flow while daydreaming (Csikszentmihalyi & Lefevre, 1989).

Given how intuitive the foregoing imaginary possibility is, it is interesting then that deliberate mind-wandering was found to be a significant predictor of *external* flow as well. While this could indicate a true relation between deliberate mind-wandering and flow in external situations (perhaps those who employ deliberate mind-wandering as a means to alleviate boredom are also able to find creative external activities as a means to experience flow), it could also be the case that the MWD is related to the external flow through the shared between the DECI and DECE. A finding that offers some support for this latter interpretation is that the contribution of the MWD was nominally larger when predicting the DECI than when predicting the DECE. However, we did not test the difference statistically. Future research may be able to address this question more

[18] In an experience sampling study, participants are contacted during their everyday lives and asked to report on their in-the-moment experiences. In modern iterations, participants are usually contact via smartphone. In this particular study participants were given a pager and survey booklets to complete.

formally through the use of structural equation modelling. In either case however, the current findings suggest that the relation between flow and deliberate mind-wandering is a promising area for future work, especially when considered in conjunction with historical findings on the relation between flow and daydreaming in everyday life.

Finally, another notable finding is that the DECI and DECE were found to be strongly correlated (r = .50), but that this correlation was not so high as to suggest the two measures are redundant. Despite the similarity in the scale items, there nonetheless seems to be unique (non-shared) variance between the two scales. Furthermore, as can be seen in Figure 3, the measures of flow are more strongly correlated with one another than with the measure of everyday inattention. Likewise, the measures of everyday inattention (e.g. MAAS-LO, ARCES, MWS, MWD) are more strongly correlated with one another than with measures of flow. That is, the correlations within each construct (e.g. the correlation between all the measures of flow, or all the measures of inattention) are stronger than the correlations across constructs (e.g. the correlations between measures of flow and measures of inattention)—as would be expected if the measures truly represented separate constructs. Thus, the present findings help to further reinforce that notion that while flow is correlated with everyday inattention, they are nonetheless separate constructs. The same pattern is also true of the relations between flow and well-being (e.g. the measures of well-being are more highly correlated with each other than with flow and vice versa), indicating that they are also related, but separate constructs.

Study 3.3

It has been recognized since the inception of flow research that some individuals may experience flow more frequently than others (Csikszentmihalyi, 1975/2000). The term "autotelic personality" was introduced to refer to those individuals who experience flow most frequently.

Curiosity, persistence, and low-self centeredness are three of the personality traits thought to comprise the autotelic personality and allow people to enter flow states more easily (Nakamura & Csikszentmihalyi, 2002). However, many researchers have also used terms such as 'flow proneness' and 'flow disposition' to describe those who experience flow more often. Various measurement tools have also been developed to assess flow proneness, such as the Swedish Flow Proneness Questionnaire (SFPQ; Ullén et al., 2012) and the Dispositional Flow Scale (DFS-2; Jackson & Eklund, 2002), which assess the frequency of global flow experiences (i.e., as a combination of a series of facets such as skill-challenge balance, clear goals, unambiguous feedback, action-awareness merging, concentration on task, loss of self-consciousness, time transformation & autotelic experience). Despite the differing terminology, the concepts of autotelic personality and flow proneness (or flow disposition) overlap highly—at the most basic level both have been defined as the frequency of flow experience (Asakawa, 2010). Similarly, our measures of trait flow (i.e. DECI and DECE) index trait flow by assessing the frequency of flow experience—though our measures specifically assess deep, effortless concentration in particular, the characteristic which is often thought as being the core of flow experience.

However, while there are several measures for assessing trait flow, little work that has examined whether trait flow is consistent over time. One recent study found that the autotelic personality was highly stable over a period of three weeks (Tse, Lau, Perlman & Mclaughlin, 2018). Notably, this study employed the Autotelic Personality Questionnaire (APQ; Tse, 2018), which directly assesses the personality traits of the autotelic personality—rather than the frequency of flow experience. Other evidence suggesting that trait flow is somewhat stable—at least over short periods—comes from studies showing an association between self-report measures of trait flow and reports of state flow in subsequent tasks. For example, the APQ predicted state flow in everyday life (assessed via experience sampling) over the ten days following survey completion (Tse, Nakamura & Csikszentmihalyi, 2020). In one study, the APQ was administered prior[19] to a word unscrambling task; those with high APQ scores experienced more state flow when unscrambling words that those with low APQ scores (Tse et al., 2018). Flow proneness (assessed immediately prior to the task via the SFPQ) was found to predict state flow in pairs of students completing puzzles, but only when completing difficult (and not easy or medium) puzzles (Tse, Fung, Nakamura & Csikszentmihalyi, 2018). Flow disposition within a particular sport (assessed via early versions of the DFS-2) has also been positively correlated with state flow during that same sport—when both measures were completed in the same week (Marsh & Jackson, 1999). Thus, despite the differing terminologies and approaches, several studies (Marsh & Jackson, 1999; Tse et al., 2018; see also Chapter 4, Study 5.2 & Study 5.3) have found that various measures of 'flow personality' or individual differences in flow predict the experience of state flow in subsequent tasks—but usually only over short periods of time (e.g. trait and state measures of flow (or autotelic personality) are assessed within the same week or same experimental session). Together, these findings suggest that flow proneness may be a stable trait—but the degree to which trait flow is stable, and how long this stability persists over time (e.g. over longer time intervals), remains an open question.

As such, we endeavoured to examine the stability of the flow trait over time by examining data from several terms of a large screening survey administered at the beginning of each term at the University of Waterloo, in which students from various psychology courses can participate for partial course credit (The Mass Testing survey). The survey contains a wide array of scales submitted by various different research labs in the psychology department. Our goal was to

[19] While the study did not specify precisely when the APQ was administered, it appears to have been given to participants via MTurk and in the same experiment session as the word unscrambling task.

investigate the stability of trait flow (as measured by DECI/DECE) by examining retest correlations over several time intervals. The DECI and DECE scales were routinely in the Mass Testing surveys across multiple semesters spanning from the Fall of 2017 to the Winter of 2020. This allowed us to examine the stability of flow over time intervals ranging from at least two months between administrations to just over two years between administrations. Data was collected from the Fall 2017, Winter 2018, Fall 2018, Winter 2019, Fall 2019 & Winter 2020 surveys.

Data Preparation

To clean the data in Study 3.3, we followed a similar procedure as implemented in Study 3.2. Again, we examined participants' clicking behaviour, timing data, and whether they had answered the majority of the items in each scale. In addition, participants who failed to answer both the DECI and DECE were removed. These procedures were performed on the data from all Mass Testing surveys simultaneously. In the present study, each participant could have completed up to six surveys (one from each of six different semesters). If a participant had suspicious behaviour on a given survey, we removed only that particular survey (rather than all of the surveys completed by that participant). This is because while a participant may have answered too quickly during one during one survey, the remaining surveys may have been answered diligently. Thus, suspicious behaviour from one survey led to the removal of that particular survey, but not other surveys completed by the same participant. Of 12989 initial surveys, only 874 were removed during our data cleaning procedure, less than 7% of the total sample.

For each comparison of scale scores at two time points, we drew the overlapping participants from the two relevant samples to examine the test-retest correlations (following data cleaning). For example, across the Fall 2017 and Winter 2018 terms, there were 632 participants who contributed data at both time points (and thus were included in our analyses). Next, for each of the DECI and DECE scales, we conducted a series of test-retest correlations allowing us to estimate the relation between scale scores at two different test administrations. For each scale, there were 14 correlations, ranging from 2 to 26 months between administrations (at 4-month intervals). The resulting test-retest correlations (and their corresponding sample sizes) are depicted in Figure 6.

Results

The test-retest correlations for each possible time interval are depicted in Figures 6 (DECI) and 7 (DECE). Estimates of the correlation are depicted by a central dot, with the lines representing 95% confidence intervals. The numeric values for the correlations are shown in Table 11. As can be seen in the figures and the table, the test-retest correlations are quite large, indicating that trait flow is relatively stable over at least the span of a year. From 2 to 14 months between test administrations, the estimated relation between scores is strikingly similar. In this time period, there is considerable overlap among the confidence intervals for the majority of the correlations. However, the magnitude of the correlations (and thus the stability of trait flow) begins to drop around the 1-year mark. Nevertheless, the test-retest correlations were still positive and significant even for the longer intervals, suggesting that trait flow is relatively stable over time.

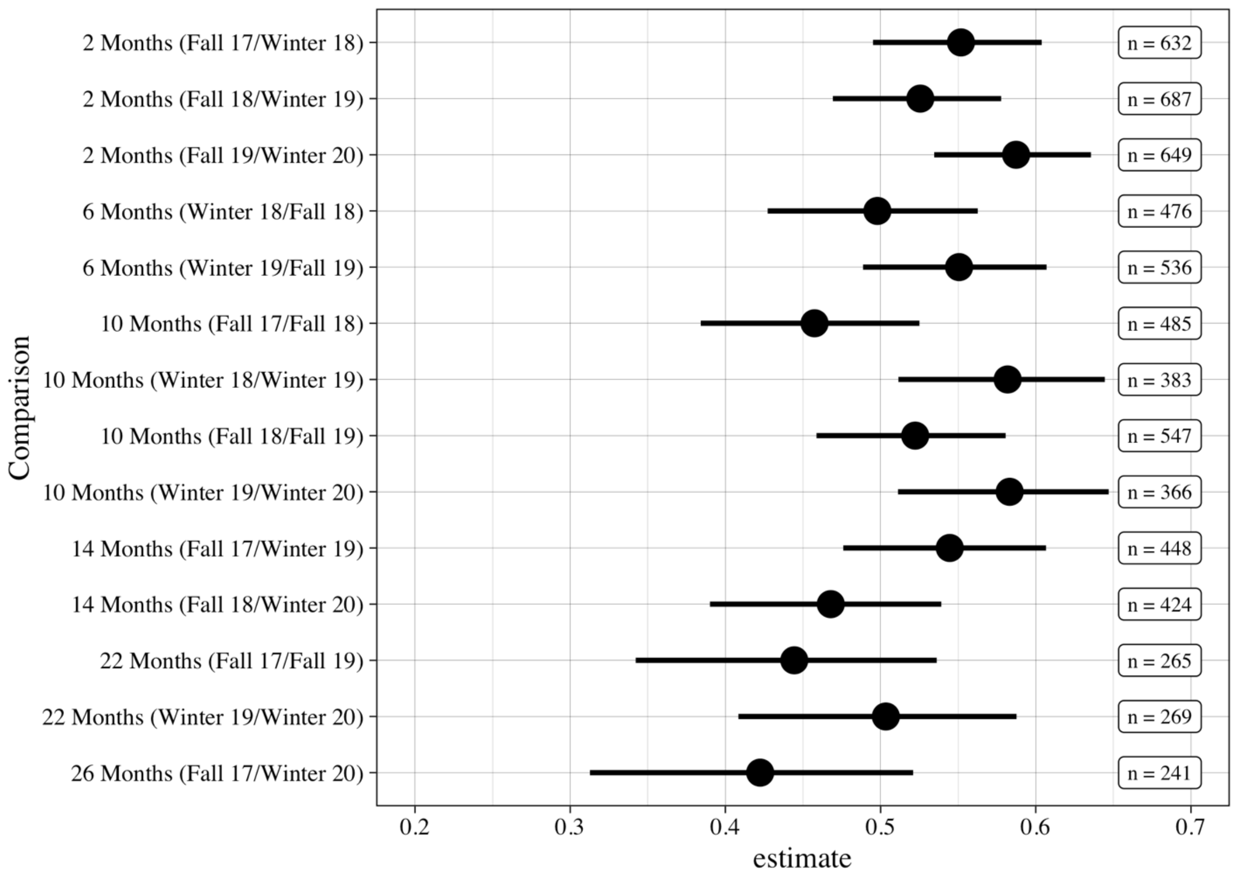

Figure 6. Retest correlations of Deep Effortless Concentration – Internal (DECI)

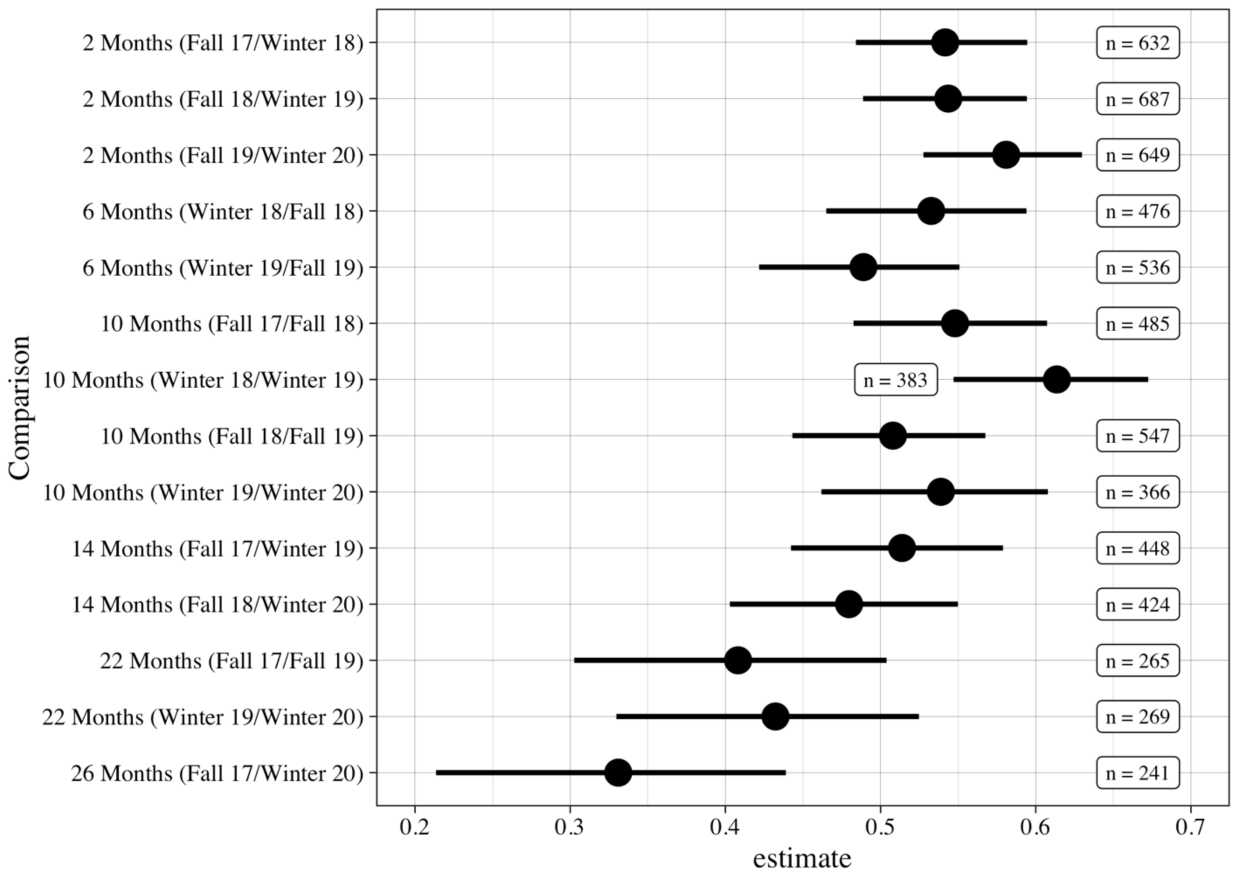

Figure 7. Retest correlations of Deep Effortless Concentration – External (DECE)

Table 11. Retest correlations of trait flow (DECI & DECE) across multiple time intervals

Comparison	n	Scale	Pearson [95% CIs]	Spearman [95% CIs]
2 Months (Fall 17/Winter 18)	630	DECI	0.55 [0.50, 0.60]	0.53 [.47, .58]
2 Months (Fall 17/Winter 18)	630	DECE	0.54 [0.48, 0.59]	0.54 [.48, .59]
2 Months (Fall 18/Winter 19)	685	DECI	0.53 [0.47, 0.58]	0.52 [.46, .57]
2 Months (Fall 18/Winter 19)	685	DECE	0.54 [0.49, 0.59]	0.54 [.49, .59]
2 Months (Fall 19/Winter 20)	647	DECI	0.59 [0.53, 0.64]	0.56 [.51, .61]
2 Months (Fall 19/Winter 20)	647	DECE	0.58 [0.53, 0.63]	0.56 [.51, .61]
6 Months (Winter 18/Fall 18)	474	DECI	0.50 [0.43, 0.56]	0.51 [.44, .57]
6 Months (Winter 18/Fall 18)	474	DECE	0.53 [0.46, 0.59]	0.54 [.47, .60]
6 Months (Winter 19/Fall 19)	534	DECI	0.55 [0.49, 0.61]	0.52 [.46, .58]
6 Months (Winter 19/Fall 19)	534	DECE	0.49 [0.42, 0.55]	0.48 [.41, .54]
10 Months (Fall 17/Fall 18)	484	DECI	0.46 [0.38, 0.53]	0.45 [.38, .52]
10 Months (Fall 17/Fall 18)	484	DECE	0.55 [0.48, 0.61]	0.54 [.47, .60]
10 Months (Winter 18/Winter 19)	381	DECI	0.58 [0.51, 0.64]	0.56 [.49, .63]
10 Months (Winter 18/Winter 19)	381	DECE	0.61 [0.55, 0.67]	0.60 [.53, .66]
10 Months (Fall 18/Fall 19)	547	DECI	0.52 [0.46, 0.58]	0.50 [.44, .56]
10 Months (Fall 18/Fall 19)	547	DECE	0.51 [0.44, 0.57]	0.49 [.42, .55]
10 Months (Winter 19/Winter 20)	364	DECI	0.58 [0.51, 0.65]	0.55 [.48, .62]
10 Months (Winter 19/Winter 20)	364	DECE	0.54 [0.46, 0.61]	0.49 [.41, .56]
14 Months (Fall 17/Winter 19)	446	DECI	0.54 [0.48, 0.61]	0.51 [.44, .58]
14 Months (Fall 17/Winter 19)	446	DECE	0.51 [0.44, 0.58]	0.51 [.44, .58]
14 Months (Fall 18/Winter 20)	422	DECI	0.47 [0.39, 0.54]	0.44 [.36, .51]
14 Months (Fall 18/Winter 20)	422	DECE	0.48 [0.40, 0.55]	0.47 [.39, .54]
22 Months (Fall 17/Fall 19)	263	DECI	0.44 [0.34, 0.54]	0.41 [.31, .51]
22 Months (Fall 17/Fall 19)	263	DECE	0.41 [0.30, 0.50]	0.41 [.31, .51]
22 Months (Winter 19/Winter 20)	267	DECI	0.50 [0.41, 0.59]	0.50 [.41, .58
22 Months (Winter 19/Winter 20)	267	DECE	0.43 [0.33, 0.52]	0.41 [.31, .50]
26 Months (Fall 17/Winter 20)	239	DECI	0.42 [0.31, 0.52]	0.40 [.29, .50]
26 Months (Fall 17/Winter 20)	239	DECE	0.33 [0.21, 0.44]	0.33 [.21, .44]

Discussion

Given that relatively little is known about the stability of flow, the present results provide new insights into the stability of flow experiences over time. The experience of deep, effortless concentration tends to be quite stable in the short term, as we observed strong correlations between scores at several times intervals ranging from two months to 14 months. Notably, this was the case in both the DECI and the DECE, indicating that both internal and external flow experiences are relatively stable. However, the magnitude of the test-retest correlations began to drop after 14 months, suggesting that trait flow might be less stable as time goes on.

While these results suggest a strong relation between the frequency of flow experience at one test administration and the next, it is worth considering how the stability of flow compares with the stability of personality traits in general. That is, is the stability of trait flow higher or lower than that of typical personality traits?

First, it is important to note that the stability of flow may also be influenced by the age of our samples. In the present study, we examined university students, who experience change at relatively frequent intervals; From term to term, many students take entirely different courses, or may switch back and forth between study and work co-op terms. As shown by Roberts and Delvecchio (2000), trait stability tends to be lower in 'college age' adults—in their meta-analyses, trait stability coefficients for this age group tended to fall between .50 and .52—and to increase with each successive decade. When holding age constant (i.e. at age 20), they found that the average trait consistency was .55 over a 1-year period[20] (Roberts & Delvecchio 2000). With these results in mind, trait flow seems to be about as stable/consistent as the average personality trait, at least over a 1-year time interval.

In addition, the size of retest correlations of flow in the current study (e.g. typically around .5) were of a similar magnitude to meta-analytic estimates of the test-retest correlations of the Big Five personality traits (Openness, Conscientiousness, Extraversion, Agreeableness & Neuroticism), which also tended to fall around .5 (Roberts & Delvecchio, 2000)[21]. While their

[20] In addition, average trait consistency was estimated as .52 at over a 5-year period, .49 over a 10-year period, .41 over a 20-year period, and .25 over a 40-year period.
[21] Some have indicated that the estimates for personality traits are much higher, though this is after applying various corrections that assume the questionnaires have perfect measurement of the traits (see Conley, 1984).

meta-analysis also included longer time intervals and multiple methods of assessment (e.g. self-report measures), this heterogeneity of assessment did not appear to have a substantial impact on estimates of trait stability. Indeed, the test retest correlations were similar across the different methodologies and the average trait consistency of self-report measures was near .50[22]—again very similar to our estimates of stability for flow.

However, the stability of flow *after* the 1-year mark seems to be lower than the average personality trait. As a comparison, Roberts and Delvecchio (2000) reported an average trait consistency of .52 over a 5-year period, and .49 over a 10-year period, when examining traits such as those in the Big Five taxonomy[23]. Notably, the stability of flow was estimated to below .45 in five out of six estimates at the 22-month and 26-month time intervals. While our current data cannot speak to what the stability of flow may be over a 5-year period, it is interesting to note that, even at time intervals which are less than half this length, the stability of flow is lower than the stability of average trait. As such, it appears that trait flow becomes less stable over time, perhaps to a greater degree than other personality traits. However, determining whether this trend would continue over time will require conducting test-retest correlations of flow over longer time intervals. Interestingly, the concept of absorption (assessed via the Tellegen Absorption Scale) has been found to have relatively high stability ($r = .687$) over a period of 10 years (McGue, Bacon & Lykken, 1993). The autotelic personality also has a relatively high test-retest correlation (though over the much shorter time interval of three weeks; Tse et al., 2018). A possible explanation for the higher stability of these measures is that unlike the DECI and DECE, both the APQ and the

[22] Age and time interval did not appear to have much of an impact on this estimate. When age and time interval were controlled for the stability was .51. When they were not controlled for the stability was .52

[23] These traits were estimated using a variety of different measures, and also included measurements of Type A personality and femininity/masculinity. In addition, these estimates were calculated while holding constant the effect of age.

TAS assess personality traits related to flow experience, rather than flow experience per se. That is, it could be that these personalities are more stable than trait flow/flow proneness. Examining how stability differs for measures of flow, absorption, and the autotelic personality—as well as how the correlations between these measures differ over time—may be an interesting and fruitful avenue that brings additional clarity to understanding the flow concept.

One issue worth noting is that participants over our longer time intervals may have answered the DECI and DECE multiple times between Time 1 and Time 2. That is, for long intervals participants might have completed the scale multiple times in between; this might have influenced the test-retest correlations at the different intervals. For example, as time goes on and participants complete a scale multiple times, they may become more familiar with the items, and attempt to answer the scale the same way as they 'usually do'. Importantly, this tendency might become stronger across successive testing sessions impacting correlations conducted over longer intervals more than those conducted over shorter intervals. It is possible that this sort of behaviour may lead to an increase in magnitude of test retest correlations (though if this were the case, one might expect the estimates to be larger than we observed in the current study). Future research may be able to account for this issue by examining test-retest correlations when participants do and do not complete the scale in between intervals. For example, one possible study would be to have two groups of participants complete the DECI and DECE at baseline and again two years later. Participants could then be randomly assigned to either complete the DECI and DECE several times in the intervening period, or to complete other unrelated questionnaires, but not the DECI or DECE. Such a design may be able to speak to the impact that familiarity with the scale has on the magnitude of test retest correlations.

The current work establishes that flow is a relatively stable trait, even over longer periods of time. Now that this more basic question has been addressed, researchers can begin to address follow-up questions. For example, one key question is whether the observed stability of trait flow results more from stable personality traits, or from a stable/consistent environment. On the one hand, stability may result from the possession of certain, stable personality traits that allow for one to find flow in many different circumstances, both favourable and extremely trying. However, it could also be the case that the stability of trait flow is largely dependent on the stability of one's environment, rather than of one's dispositional factors (Fullagar & Kelloway, 2009). For example, if one is consistently in situations that offer the right level of skill-challenge balance (e.g. a well-fitting job, or taking courses one enjoys) one could experience flow relatively frequently. However, if this situation were to change (and their skills were suddenly found wanting) the frequency with which the experience flow may drop dramatically)[24]. In the current study, retest correlations were observed in the university population, where change may occur relatively more frequently—course loads and subject material may vary dramatically from term to term, and many students switch back and forth between academic study and co-op employment in their field. If the stability of flow depends more upon a stable environment than on personality traits, then the observed retest correlations (i.e. our marker of stability) may be lower in this population than in the population in general[25]. Given the generally strong correlations between retest correlations in the present study, in a sample that may tend to experience more frequent changes, these results might be interpreted as evidence that flow is driven by personality factors. However, the degree of

[24] Of course, it is also possible that certain personality traits would allow one to interpret even the most difficult circumstances as interesting challenges—and allow one to maintain the optimal level of skill-challenge balance even in the face of very difficult tasks.

[25] It's also possible that this is why trait measures of stability tend to be lower in college age students and to increase in the following decades

change from term to term was not measured in the present study—our goal was only to make an initial assessment of the stability of trait flow—meaning that such an interpretation may be premature and should be made with caution. For example, it is also possible that undergraduate students have more stable environments than the foregoing argument assumes. Nonetheless, attempting to tease these two possibilities apart, in studies that are specifically designed to do so, presents an interesting opportunity for future work.

Chapter 4

Several descriptions of flow experience imply that those who are prone to flow also have greater sustained attention abilities (Csikszentmihalyi, 1978; Nakamura & Csikszentmihalyi, 2002). However, interestingly, relatively little work has examined empirically the relation between the experience of flow and sustained attention abilities (de Sampaio Barros, Aruju-Moreira, Trebelin & Radel, 2018). Here we build on prior work (Cermakova, Moneta & Spada, 2010; Schiefele & Raabe, 2011; Ullén et al., 2012; Ullén et al., 2016; see also Study 2.1 and 3.2) to further explore the relation between flow and sustained attention using more refined and targeted measures of both flow and sustained attention.

When considering this relation, it is important to recognize that flow and sustained attention are not equivalent constructs. Flow is characterized by the phenomenological experience of deeper or more focused concentration, which simultaneously feels effortless (Csikszentmihalyi & Nakamura, 2010; see Chapter 1)—and as such is best indexed directly, using subjective reports rather than performance metrics (which are typically agnostic to the experience of effort). Sustained attention, however, refers to the extent to which an individual is focused on their task as time unfolds and can be assessed by various kinds of measures, including subjective reports and behavioural indices. In many cases sustained attention involves strenuous or effortful attention, something which—at least in the moment—is antithetical to flow. Accordingly, since flow and sustained attention are distinct constructs, we should take care not to simply assume that improvements in sustained attention performance will always be associated with increases in flow.

Prior research into the relation between flow and sustained attention has led to mixed conclusions. Some researchers have reported that individuals with more frequent flow experiences are also better able to sustain attention (Cermakova et al., 2010; Moore, 2013; see Studies 2.1 and

3.2). For instance, Cermakova, Moneta and Spada (2010) reported a moderate positive correlation between dispositional flow (indexed via the Dispositional Flow Scale-2; Jackson & Eklund, 2002) and attentional control (indexed by the Attentional Control Scale; Derryberry & Reed, 2002). Specifically, they found those who experience flow more often reported having greater control over their ability to switch between tasks and maintain focused attention. In contrast others have claimed that there is no association between flow and effortful attention (Ullén, de Manzano, Theorell & Harmat, 2010; Ullén et al., 2012; Ullén et al., 2016). For example, Ullén and colleagues (2012) found that flow (as measured by the Swedish Flow Proneness Questionnaire or SFPQ; Ullén et al., 2012) had no relation to scores on the Raven's progressive matrices (Raven, 1962, 1965), which were interpreted as a measure of effortful attention. Further, a later study by Ullén and colleagues (2016) found no relation between trait flow (again indexed via the SFPQ) and performance on a number of chronometric tasks which were assumed to be indexing effortful attention. One such task required participants to respond in time with a metronome and maintain the rhythmic response after the metronome had stopped. While Ullén et al. did not refer to 'sustained attention' explicitly, sustained attention does fall into the category of "form(s) of effortful attention typically studied in attention paradigms" (Ullén et al., 2016, p. 281). Given their conclusion that there is no relation between flow and effortful attention, perhaps the authors would also conclude that there is no relation between flow and sustained attention.[26]

The discrepancy between these sets of studies could be explained, at least in part, by the different measures used to assess sustained attention. In general, studies that found a relation between flow and sustained attention relied on subjective-report measures of attention (i.e., Cermakova et al., 2010; Moore, 2013; see Study 2.1 and Study 3.2), while studies revealing no

[26] Clearly, the authors' findings support the conclusion that flow is not related to intelligence. However, it is less clear that the same measures can be interpreted as measures of 'effortful' or 'sustained' attention.

such relation employed behavioural measures of attention (Ullén et al., 2010; Ullén et al., 2012; Ullén et al., 2016). While one may be inclined to put more weight on the studies that included behavioural assessments of attention, the behavioural metrics used in the aforementioned studies are not particularly well-suited for indexing sustained attention. For example, the Raven's Progressive Matrices (Raven, 1962, 1965) are typically used to assess intelligence rather than sustained attention[27]. Thus, concluding that flow and sustained attention are unrelated might be unwarranted given the limitations of the behavioral sustained attention measures used. What is needed are studies assessing sustained attention using tasks that more clearly and specifically indexes sustained attention.

It is also possible that the lack of a relation between flow and behavioural assessments of sustained attention is due to the particular measures used for assessing individual differences in flow. That is, when they did not find a link between flow and attention (i.e. performance on a task of effortful attention/intelligence), Ullén et al., used *trait* measures of flow (in particular, the Swedish Flow Proneness Questionnaire or SFPQ; Ullén et al., 2012). A possible limitation of this approach is that while some people may be more prone to flow in their everyday lives than others (i.e., have higher *trait* flow scores), this does not necessarily mean that they will experience flow during a particular experimental session. The reason for this becomes clear when one considers the possible interpretations of a high score on a measure of flow proneness. One interpretation is that flow proneness is a stable personality characteristic, such that a person who scores highly on the measure is more likely to experience flow in any situation. Yet, it could also be the case that a measure of flow proneness is simply indexing how often someone is in a situation that is flow

[27] We do not mean to imply that intelligence and sustained attention abilities are orthogonal—merely that there are other available metrics which are perhaps better suited for assessing sustained attention (i.e. that have been designed specifically to assess sustained attention abilities) than an intelligence test.

inducing for them. When put in a different situation (e.g. an experimental task), such a person may be no more likely to experience flow than anyone else. Thus, when trait measures of flow are used in conjunction with behavioural assessments of sustained attention, any possible relation between the two constructs might be underestimated or difficult to observe. Given this rationale, it seems possible that a relation between flow and sustained attention in a given task might be detectable if flow were to be assessed at the *state* level during the sustained attention task. However, none of the aforementioned studies assessed flow at a state level during a behavioural sustained attention task, a limitation acknowledged by Ullén et al., (2016).

An exception in the literature on flow and sustained attention is a study conducted by Schiefele and Raabe (2011), which provides some evidence of a relation between flow and a behavioural assessment of sustained attention. In the study, 89 participants completed the ‘d2’ test (Brickenkamp, 2002) at the outset of the experimental session and reported on their experience of state flow in a subsequent task[28]. In the d2 test participants are asked to scan 14 rows, each containing a random sequence of the letters ‘d’ and ‘p’. One or two dashes appear above and/or below each of these letters. Participants are given 20s per row to mark all of the d’s with two dashes, meaning the task is just under five minutes in length. Performance on this task (correctly marked letters – wrongly marked letters) was found to have a small positive correlation with state flow in a subsequent task. However, given that sustained attention is characterized by maintaining attention over long periods of time, it is important to examine the relation between flow and performance in a longer sustained attention task. In particular, the conclusions that flow is related to sustained attention could be made more strongly if a similar pattern were to emerge when using

[28] Following the completion of the d2 test, participants completed four five-minute blocks of Raven’s Matrices and reported their experience of flow after each block. However, the authors did not examine the correlation between the experience of state flow and performance on the Raven’s matrices.

alternative and longer sustained attention tasks. Thus, there is a clear need for additional studies to collect converging evidence to examine the relation between flow and appropriate sustained attention measures.

It is important to note that a limitation of much of the prior work on flow and sustained attention arises from the definition (and measurement of) the flow concept. Particularly problematic is the characterization of flow as a broad, global construct which incorporates a diverse array of facets (Jackson & Marsh, 1996; Nakamura & Csikszentmihalyi, 2002), such as skill-challenge balance (where the individual's skill is matched with the difficulty of a task), clear goals, and time distortion to name a few. In practice, scores on measures of these dimensions are combined (see Aherne, Moran & Lonsdale, 2011; Ullén et al., 2012 for examples), ostensibly to index flow as an experience that is 'more than the sum of its parts' (Csikszentmihalyi, 1988; Jackson & Eklund, 2002). However, it would seem that the experience of 'deep and effortless concentration' is nonetheless given implicit priority among the facets, and is sometimes described as the defining quality of flow (Csikszentmihalyi & Nakamura, 2010). This raises an important problem: flow has been characterized mostly as deep, effortless concentration but the inclusion of other facets during measurement has diluted the measure's ability to assess this core experience specifically. As a result, there is the possibility that some of the more extraneous facets included in global flow measures might have obscured the relation between the core aspect of flow and sustained attention.

To address these and several related measurement issues, we recently called for the re-conceptualization of flow as 'deep, effortless concentration' (DEC; See Chapter 1) and developed subjective report measures to assess this experience at the trait level (see Study 2.1). Specifically, we developed a measure to assess deep effortless concentration in internal contexts, such as thinking, remembering or imagining (Deep Effortless Concentration – Internal; DECI), and one that assess deep effortless concentration in external contexts such as engaging in sports, playing instruments, or working on one's hobbies (Deep Effortless Concentration – External; DECE). In our initial report, we examined the relations between our two measures of DEC, and four measures of everyday inattentiveness: the Attention-Related Cognitive Errors Scale (ARCES; Cheyne, Carriere, & Smilek, 2006), the Mindful Awareness of Attention States scale - Lapses Only (MAAS-LO; Brown & Ryan, 2003; Carriere, Cheyne, & Smilek, 2008), and the Mind Wandering: Spontaneous (MWS) and Deliberate scales (MWD; Carriere, Seli & Smilek, 2013). The results showed that those who experienced DEC more frequently tended to report better sustained attention ability, in that they reported experiencing fewer episodes of inattentiveness and attention-related errors in their everyday lives. Specifically, those who experienced deep effortless concentration—in either internal or external contexts—tended to report making fewer attention-related errors, less absent-mindedness, and fewer episodes of spontaneous mind wandering.

In the present study, our main goal was to build on the prior literature by assessing sustained attention with a suitable behavioural measure and by measuring flow as DEC at both the trait and the state levels. In particular, we employed the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) to behaviorally assess sustained attention ability. In the SART, participants are presented with a series of digits (i.e. 1-9) one at a time and required to respond by pressing a key as quickly as possible following each stimulus presentation, except for when a critical target digit (in our case the digit 4) is presented. Sustained attention is typically assessed by commission errors, which are incorrect responses to the infrequent critical targets. Several other metrics can also be used to assess performance during the SART, and these include mean response time to non-target digits, the variance of those response times, omitted responses on non-target trials, and keypresses in anticipation of—rather than in response to—non-target trials (i.e. those < 100ms; see, Cheyne, Solman, Carriere & Smilek, 2009). Generally, improved attention performance is characterized by fewer commission errors, and higher mean response times, as well as less variance in response times, fewer omissions, and fewer anticipations (see Cheyne et al., 2006; Cheyne et al., 2009; Johnson, Kelly et al., 2007; Johnson, Robertson et al., 2007). Among all these metrics, commission errors are the most frequently used and well-established measure of sustained attention (Cheyne, Carriere & Smilek, 2006; Cheyne et al., 2009; Robertson et al., 1997; Smilek, Carriere & Cheyne, 2010). To index flow at the *state* level, we used thought-sampling probes (based on our previously developed DEC measures) to intermittently assess participants' deep, effortless concentration while they completed the SART. We also measured flow at the *trait* level, using the DECI and DECE scales. Importantly, in the present study, participants performed the SART for approximately 20 minutes. Thus, compared to earlier studies, the present study allows us to examine the relation between flow and sustained attention using a task that is both longer (e.g. Schiefele et al., 2011) and more appropriate (e.g. Ullén et al., 2012; 2016) than those which have typically been employed.

Our main hypothesis was that scores on the DEC measures would be related to SART performance such that more frequent and higher levels of DEC (primarily at the state level, but also perhaps at the trait level) would be associated with better attention performance in the SART. This hypothesis was primarily based on prior studies showing a relation between flow measures and subjective reports of attention (Study 2.1 and Study 3.2; Cermakova et al., 2010; Moore, 2013), and one study which reported a correlation between state flow and a brief sustained attention task (Schiefele & Raabe, 2011). We expected that including a more direct measure of sustained attention might reveal the elusive relation between flow and behavioral measures of sustained attention. In addition, our hypothesis was based on the fact that prior studies have linked reports of attention (i.e., indexed by the ARCES and the MAAS-LO) to both SART performance (Cheyne et al., 2006; Carriere, Cheyne & Smilek, 2008; Smilek, Carriere & Cheyne, 2010) and, in separate cases, to reports of deep, effortless concentration (see Study 2.1 and Study 3.2). Given these two separate sets of findings, it seems reasonable to expect that DEC measures might also be related to SART performance.

An interesting and related question (which emerged during the analyses of the data from the first sample in the current investigation) is whether the relationship between DEC and sustained attention changes over time. Much of the prior work on sustained attention has demonstrated a time-on-task effect, where task performance decreases as a function of time such that performance tends to wane in the second half of the task (see Davies & Parasuraman, 1993; Dember, Galinsky & Warm, 1992; Mackworth, 1948; Szalma & Hancock, 2006; Warm, 1984). As time elapses during the SART, participants tend to make more errors (both commissions and omissions; Johnson, Kelly et al., 2007; Johnson, Robertson et al., 2007; Seli, Cheyne & Smilek, 2012), show more absent-minded responding (Johnson, Kelly et al., 2007) and have more variability in their responses (Johnson, Kelly et al., 2007; Seli et al., 2012). Decrements in sustained attention have also been demonstrated during more ecologically valid tasks such as learning from video lectures (Risko, Anderson, Sarwal, Engelhardt & Kingstone, 2012; but see Wammes, Boucher, Seli, Cheyne & Smilek, 2016). Thus, a secondary goal was to investigate whether the relation between DEC and sustained attention changed as a function of time-on-task. To this end, we first conducted exploratory analyses on the data from our initial sample, and then repeated the same analyses to confirm our findings in a second sample (see Results for details).

A third goal was to examine the relation between DEC and the autotelic personality. The autotelic personality is a constellation of several attributes, including curiosity, persistence, the tendency to enjoy challenges, and high attentional control, thought to facilitate the flow experience. However, rather than measuring these attributes directly, the autotelic personality has instead often been assessed using instruments that measure the frequency of flow experiences, such as the Flow Questionnaire (see Asakawa, 2010; Csikszentmihalyi, 1975/2000; Han, 1988). This presents two interrelated issues: 1) it becomes difficult to distinguish between the autotelic personality and flow proneness, given that both are based on measures of flow frequency and 2) The autotelic personality is assessed through a reverse inference, whereby the autotelic personality is thought to facilitate flow, and so those who experience flow frequently (as assessed by the Flow Questionnaire) are assumed to have the autotelic personality. Fortunately, recently Tse and colleagues (2018) have addressed these issues by developing the Autotelic Personality Questionnaire (APQ) to directly measure the autotelic personality. They found that scores on the APQ were positively correlated with flow proneness and predicted the experience of state flow while participants completed a word unscrambling task. While these results provide some support for the claim that the autotelic personality facilitates flow, a limitation is that flow was assessed using a global flow measure (i.e. the Swedish Flow Proneness Questionnaire; Ullén et al., 2012 & the Flow State Scale-2 or FSS-2; Jackson & Eklund, 2002). Given the aforementioned issues with measures of global flow (see Chapter 1 for a more detailed discussion), a more stringent test of this claim would be to examine how the APQ relates to DEC measures (which, unlike global flow measures, are not confounded by extraneous facets). As such, we examined the relation between the APQ and DEC at both the trait (indexed via DECI & DECE) and state (indexed via thought-probes) levels.

The present design also allowed us to address a fourth issue. Namely, because we measured DEC at both the trait level (with the DECI and the DECE) and at the state level (while people performed the SART), we were able to examine the relation between trait and state levels of DEC. We expected that those who experience DEC more frequently in general would also experience more DEC while completing the SART, and that this would be reflected in a positive relation between trait and state measures of deep effortless concentration.

Method

Participants

Data was gathered in two samples, collected in the Fall 2018 (Sample 1) and Winter 2019 (Sample 2) terms respectively. Seventy-Six (76) participants (24 Males, 52 Females) from the University of Waterloo were recruited from the university's SONA system for undergraduate research experience during Fall 2018 for Sample 1. Ninety-Seven (97) additional participants (20 Males, 74 Females, 1 Gender non-conforming)[29] were recruited in the Winter 2019 term for Sample 2. Participants were required to have completed the mass screening survey prior to the experimental session.

Questionnaires

Deep Effortless Concentration – Internal (DECI) and External (DECE). We used the Deep Effortless Concentration Scale - Internal (DECI) and Deep Effortless Concentration Scale - External (DECE) to assess individual differences in the propensity to experience flow in everyday life. These measurement scales are designed to index the frequency with which participants experience deep, effortless concentration during internal tasks, such as thinking and imagining (via the DECI; e.g., "I feel like I don't have to force myself to keep fully engaged with my thoughts")

[29] There were two participant who either declined to answer or left the question blank

and external tasks, such as playing sports or instruments (via the DECE; e.g., “I get in the zone and don’t have to force myself to concentrate on the task I am doing”). Each scale consists of 8-items, which are rated on a 7-point Likert scale ranging from “1 - Never” to “7 - Always”.

Autotelic Personality Questionnaire. The Autotelic Personality Questionnaire (APQ; Tse et al., 2018) indexes the seven attributes of the autotelic individual: curiosity and interest in life (e.g., “I am curious about the world“), persistence (e.g., “I complete tasks even when they are hard“), low self-consciousness (e.g., “I am easily affected by others’ impressions of me, intrinsic motivation (e.g. “What matters most to me is enjoying the things that I do“), enjoyment and transformation of challenges (e.g. “I enjoy playing difficult games“), enjoyment and transformation of boredom (e.g., “I am able to find pleasure even in routine types of work“), and attentional control (e.g., “It is hard for me to stay on task“). Participants are asked to answer these questions on 7-point Likert scale that ranges from Strongly Disagree (1) to Strongly Agree (7).

Experimental Task (The Sustained Attention to Response Task; SART)

During the SART (Robertson et al., 1997), participants were presented with a string of digits (e.g. 1-9) one at a time and were instructed to make a response by pressing the spacebar as quickly and accurately as possible whenever a digit appeared—with the exception of the critical target digit 4. Participants were instructed to withhold their response whenever this critical digit appeared. On each trial, a single digit was presented in the center of the screen for 250ms followed by a 900ms double-circle mask. The task was divided into blocks of nine trials and within each block, a single digit was chosen without replacement. The font size of each digit was randomly selected, with equal sampling for each of the five font sizes (48, 72, 94, 100, or 120). The digits were presented in white font on a black background. After completing 18 practice trials (with two critical digits presented), the participants completed 900 experimental trials, of which 100 presented the critical target digit. The SART (and associated probes, see below) were programmed using Python 2.6 (Python Software Foundation, http://www.python.org). The program was run on an Apple Mini with Bootcamp Windows 7 running 2.4 GHz Intel Core 2 Duo processor and presented on a 24-inch monitor.

State Deep Effortless Concentration (DEC)

While completing the SART, participants were periodically presented with thought probes to assess their level of deep effortless concentration. In between SART trials the probe screen would interrupt the task by popping up on the screen. The probe consisted of three questions ("I got in the zone and didn't have to force myself to concentrate" and "I seemed to reach a level of deep focus almost effortlessly") and was presented at pseudo-random intervals during the SART task. Participants used the mouse to answer the questions with reference to their current task on a 7-point Likert scale ranging from 1 - Never to 7 - Always. Ten DEC probes were presented throughout the experiment at pseudo-random intervals. Once participants answered the probe, the pressed the 'g' key to resume the SART.

Procedure

Data in this study was collected in two separate stages. First, trait level data was collected as part of a large mass screening survey, where participants completed a series of questionnaires. Participants who completed this survey were eligible to sign up to participate in the (separate) laboratory session of the study, which was conducted at a different time. During this in-lab session they completed the behavioral task (the SART) together with thought-probes assessing their state-level DEC. For the first sample, the DECI and DECE questionnaires indexing trait flow were collected online via the mass screening survey and the APQ was administered during the laboratory session, just prior to completion of the SART. For the second sample, the DECI, DECE, and APQ were administered during the mass screening survey and participants completed only the SART (with thought-probes assessing their levels of DEC) during the (separate) laboratory session.

During the laboratory session, participants were tested in groups of one to four. Participants wore noise-cancelling earmuffs while completing the task to minimize distraction caused by sounds (e.g., key presses) generated by others.[30] Upon entering the laboratory and completing the informed consent process, participants followed the on-screen instruction for the SART and completed 18 practice trials. The experimenter then provided the opportunity for participants to ask questions. After any needed clarifications, participants were asked to put on a pair of noise cancelling earmuffs. In Sample 1, participants completed the 26-item APQ prior to the SART task. In Sample 2, participants simply started the SART task immediately after signing the consent form. Participants then completed 900 trials of the SART task (approximately 20 minutes in length). During the SART, participants were probed ten times at pseudo-random intervals to assess their level of deep, effortless concentration. Upon completion of all tasks, participants were debriefed and provided the chance to ask questions about the experiment.

Results

The results for the study are reported in four sections. In the first section we examine the relation between state flow (as indexed by thought probes) and performance on the SART using both correlational and regression analyses. In the second section, we analyze whether the relation between sustained attention and flow differs across the first and second halves of the experiment. In the third section we examine the relation between trait measures of flow (DECI and DECE) and SART performance, as well as the relation between the APQ and SART performance. Finally, in

[30] Four participants from Sample 1 and six participants from Sample 2 removed their earmuffs at some point during the experiment and are noted in the associated R script. These participants are included in all our analyses.

the fourth section we examine the relations among the flow measures, first addressing the relation between trait and state flow, and then examining the inter-relations of the trait measures.

Table 12. Descriptive statistics for self-report measures

	Scale	N	Mean	SD	Median	Skew	Kurtosis	SE	Alpha
Sample 1									
	State DEC	76	4.33	1.25	4.23	0.01	-0.82	0.14	.95
	DECI	76	4.51	1.43	4.69	-0.25	-0.48	0.16	.97
	DECE	76	4.34	1.36	4.56	-0.46	-0.35	0.16	.97
	APQ	76	4.69	0.49	4.62	0.10	0.58	0.06	.74
Sample 2									
	State DEC	97	4.30	1.26	4.23	.17	-.68	.13	.95
	DECI	95	4.61	1.15	4.88	-.09	-.17	.12	.96
	DECE	96	4.55	1.12	4.62	-.47	.66	.11	.96
	APQ	96	4.56	.46	4.56	.22	.84	.05	.74

In the first, third, and fourth sections, we report separate analyses of the two samples, as well as analyses of the samples combined. In the second section, we present the data from Sample 1 (our exploratory analyses) and Sample 2 (our confirmatory analyses) separately and do not combine the data. In particular, we keep the samples separate for these analyses separate to keep the exploratory and confirmatory analyses independent from one another. Descriptive statistics for the self-report measures and the SART metrics for Sample 1 and Sample 2 are reported in Tables 12 and 13, respectively. Statistical analyses were conducted using R and RStudio. The analyses files and associated data are available at: https://osf.io/cgvfk/

Table 13. Descriptive statistics of SART measures

	Scale	N	Mean	SD	Median	Skew	Kurtosis	SE
Sample 1								
	Commission Errors	76	49.63	20.44	51.50	-0.14	-0.90	2.34
	Go RT	76	396.32	85.35	373.94	0.52	-0.06	9.79
	Omissions	76	21.76	24.90	12.50	1.88	3.26	2.86
	Anticipations	76	38.88	55.73	16.00	2.34	5.32	6.39
	RT cv	76	0.36	0.13	0.33	1.44	2.17	0.01
Sample 2								
	Commission Errors	97	45.11	23.14	43.00	.10	-.98	2.35
	Go RTs	97	397.54	95.01	379.27	.72	-.18	9.65
	Omissions	97	22.19	36.84	8.00	3.29	12.92	3.74
	Anticipations	97	29.41	42.25	10.00	1.79	2.65	4.29
	RT cv	97	.32	.13	.28	.96	.60	.01

State Flow and SART Performance

Commission errors. State flow—as measured by the Deep Effortless Concentration probes—was compared with performance on the SART (see Figure 8). Deep, effortless concentration during the SART was found to be negatively correlated with commission errors in Sample 1 $r(74) = -.13$, $p = .282$, though this relation did not reach statistical significance. However, this relation did reach significance in Sample 2 $r(95) = -.40$, $p < .001$, and the relation remained significant when the data from the two samples were combined $r(171)$, $= -.29$, $p < .001$. Thus, the direction of the relation was consistent across both samples: those who experienced more deep, effortless concentration, during the task also made fewer commission errors. Taken together, then, the data from the two samples provide evidence that flow at the state level is correlated with better sustained attention performance.

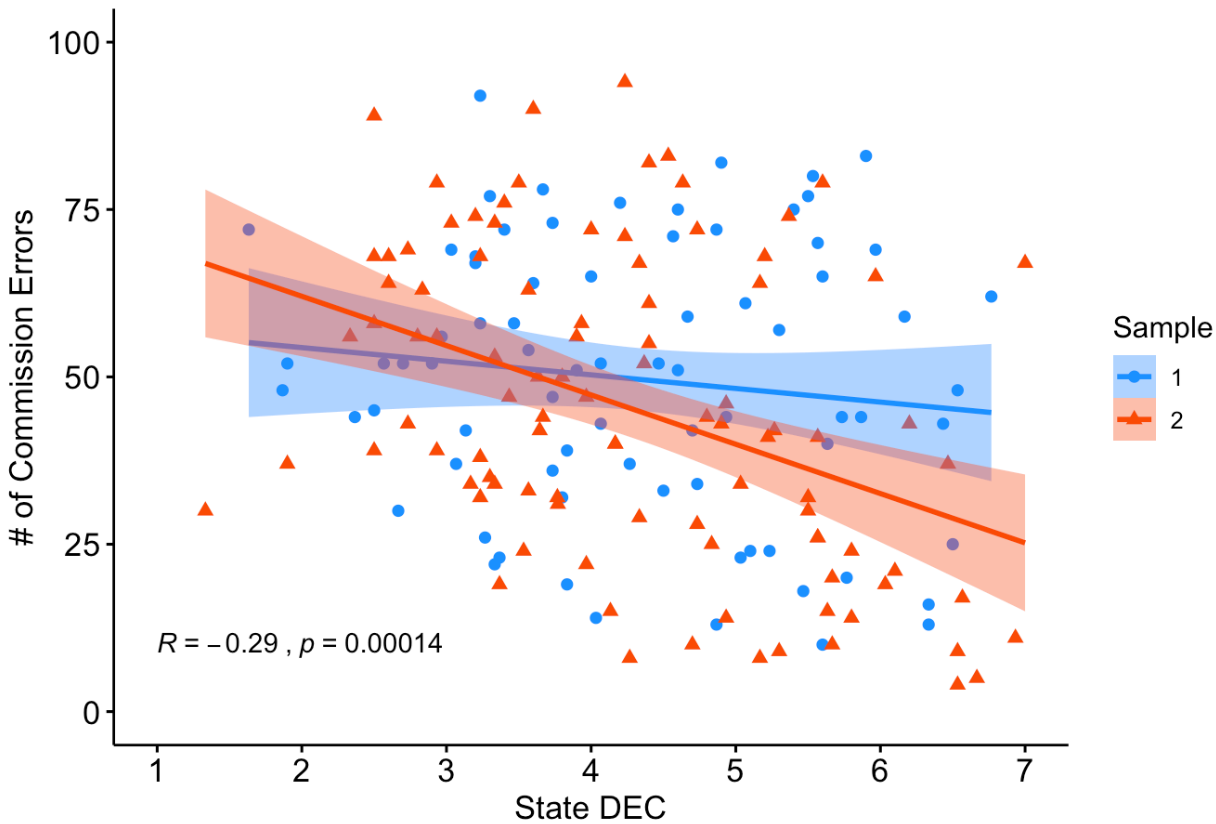

Figure 8. State DEC and Commission Errors across Samples 1 and 2.

Response Times (RTs). Speeded responding on non-target trials can be taken as an indicator of absent-minded responding during the SART task, as speeded response times (RTs) are associated with more commission errors (Cheyne et al., 2006; Cheyne et al., 2009; Smilek, Carriere & Cheyne 2010) as well as with moments of inattention (Smallwood et al., 2004; Smallwood, McSpadden & Schooler, 2007). In both samples, we found that state DEC (indexed by DEC probes) had a positive, but non-significant, correlation with RTs (Sample 1 – $r(74) = .15$, $p = .202$; Sample 2 - $r(95) = .14$, $p = .173$), and this relation remained non-significant when collapsing across samples $r(171) = .14$, $p = .060$. While the relation is small and non-significant, the magnitude of the relation was consistent across the samples, which suggests (albeit very weakly) that participants who experience more DEC tended to respond more slowly. With caution, we note that this might indicate that increased levels of state DEC are related to less absent-minded responding and improved sustained attention performance.

Response Time Variability (RT CV). To further investigate the relation between DEC and sustained attention performance, we examined the relation between state DEC (i.e. indexed by DEC probes) and variability in RTs on non-target trials. Specifically, we used the RT coefficient of variation—the RT variability on non-target trials divided by the mean RT—as the index of response variability (RT CV; see Cheyne et al., 2009). Higher RT CV indicates a pattern of responses to targets that alternate between being very fast or very slow, which is indicative of less attentiveness (Cheyne et al., 2009).

In Sample 1, there was no relation between RT CV and state DEC $r(74) = .029$, $p = .803$. However, in Sample 2, this relation was negative and significant, $r(95) = -.38$, $p < .001$. When the data from the two samples were combined, RT CV and state DEC had a significant and negative correlation $r(171) = -.19$, $p = .011$. Overall, then, the general trend is that those who experienced more flow during the SART show significantly less variability in their RTs on non-target trials. Since the association between DEC and RT CV was evident only in one sample and when the samples were combined, we cautiously conclude that those who experienced more DEC during the SART tended to have less variability in their responses and thus tend to be more attentive during the SART.

Omissions. Omissions in responding on non-target trials during the SART can also be taken as indicators of sustained attention performance, as they reflect moments in which the continuous responding required by the task ceases (see Cheyne et al., 2009). In the present study the relation between state DEC and omissions was found to be negative, but nonsignificant, in both

Sample 1 $r(74) = -.13$, $p = .27$ and Sample 2 $r(95) = -.12$, $p = .232$. When the samples were combined, the relation between state DEC and omissions continued to be negative and non-significant $r(171) = -.12$, $p = .111$.

Anticipations. Anticipations on non-target trials (i.e. RTs < 100ms) occur when participants' key presses are too fast to have occurred in response to the presentation of the stimulus. These events can be interpreted as an indicator of poor sustained attention, such that more anticipations are associated with poorer sustained attention performance (Cheyne et al., 2009). In Sample 1, we found no evidence of a relation between state DEC and anticipations $r(76)= .05$, $p = .688$. However, in Sample 2, this correlation was significant and negative, $r(95)= -.27$, $p = .008$, indicating that those who experienced more state flow had fewer anticipations—and thus better sustained attention performance—on the SART task. However, when the two samples were combined, the correlation between state DEC and anticipations was negative, but non-significant, $r(177)= -.10$, $p = .170$. Thus, it seems that if a relation between state-level DEC and anticipations exists, it is not very robust.

Flow and sustained attention over time. To investigate how the relationship between DEC and SART performance may change over time, we explored whether the correlation between DEC and commission errors differed in the first and second half of the experiment, first using the data from Sample 1. Specifically, we split the data from each participant into two bins based on whether the events occurred in the first half of the SART task (i.e. <= 450 trials) or the second half of the task (i.e. > 450 trials). Our focus in this analysis was particularly on commission errors, as these are typically taken as the primary index of inattention in the SART. In the first half of the SART, we found that the relation between state DEC and commission errors was nearly zero $r(74)= -.02$, $p = .841$. However, in the second half of the SART, the magnitude of the relation increased, such that the correlation between state DEC and commission errors was significant and negative $r(74)= -.25$, $p = .032$ (see Figure 9).

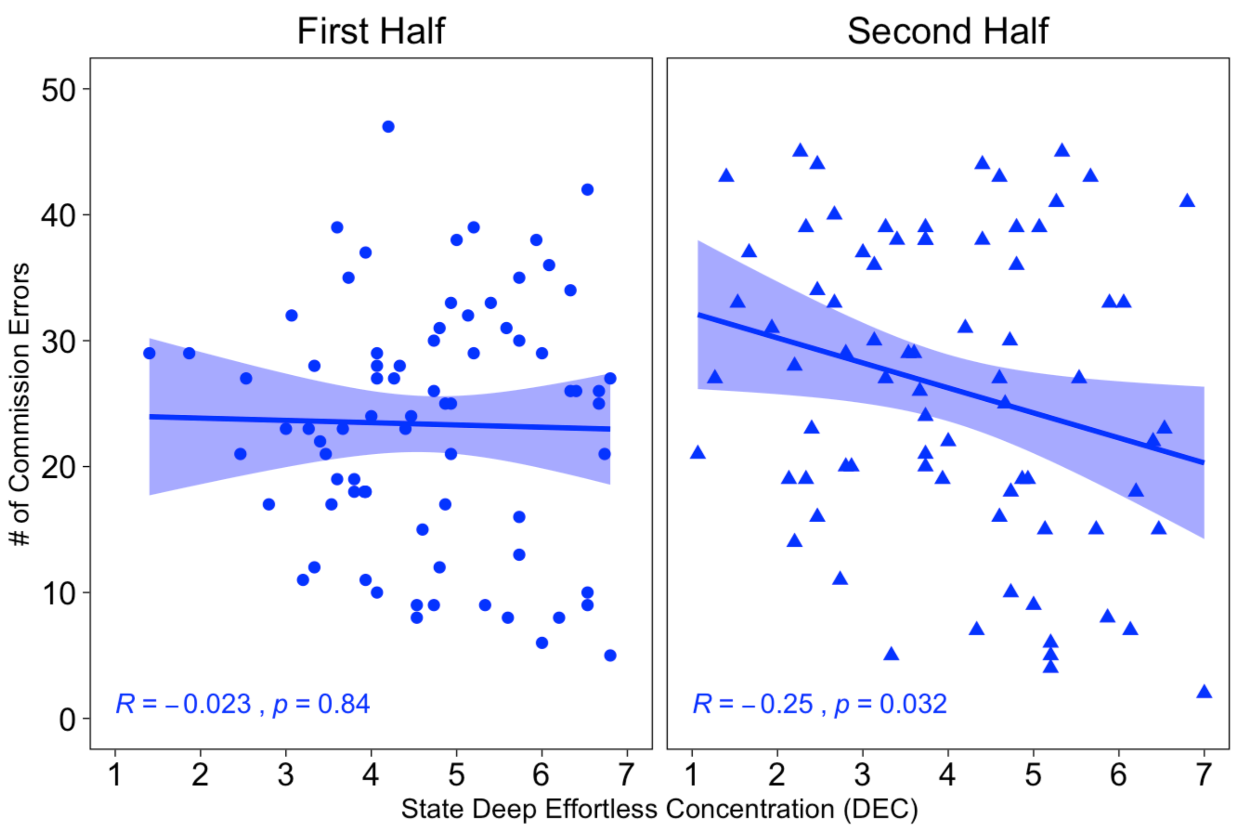

Figure 9. State DEC and Commission Errors in the first and second half of the SART (Sample 1).

Furthermore, this correlation was also significantly larger than it had been in the first half of the experiment $Z = 2.09$, $p = .037$ (see Lee & Preacher, 2013). These results suggest that the experience of DEC was associated with improved sustained attention performance in Sample 1, but only in the second half of the experiment (recall that the overall relation between state DEC and commission errors did not reach significance in Sample 1).

Having explored the data in Sample 1, we predicted the same pattern would emerge in Sample 2. Analyses of Sample 2 revealed that there was a significant negative correlation

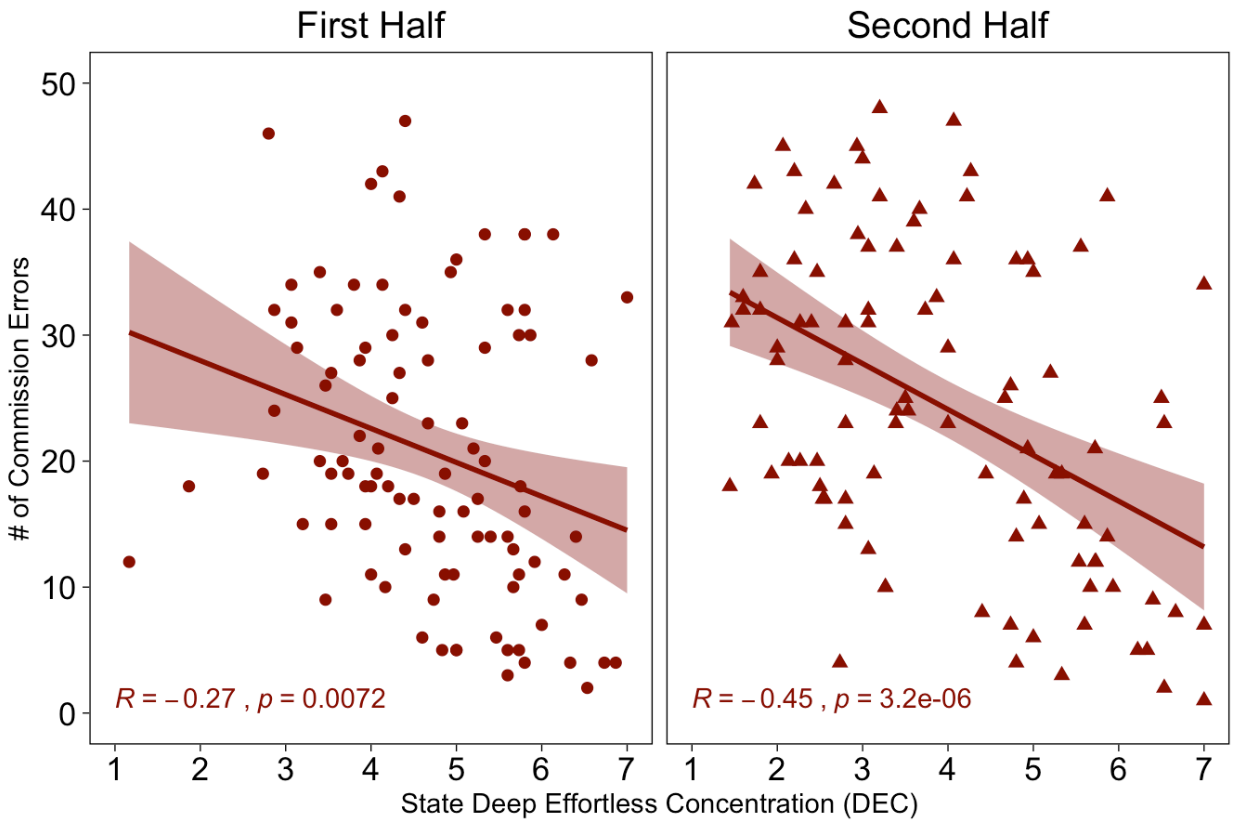

Figure 10. State DEC and Commission Errors in the first & second half of the SART (Sample 2).

between DEC and commission errors in the first half of the experiment $r(95) = -.27$, $p = .007$, indicating that those who experienced more DEC made fewer errors. Critically, however, this correlation increased in magnitude in the second half of the experiment $r(95) = -.45$, $p < .001$ (see Figure 10), and, once again, was found to be significantly stronger in the second half than it had been in the first half $Z = 2.32$, $p = .021$. In sum, while DEC may be associated with fewer commission errors throughout the experiment, the strength of this relation was significantly larger in the second half of the experiment for both samples.

Regression Analyses. An important consideration for research in sustained attention is to account for the possibility of speed-accuracy trade-offs (Seli, Cheyne & Smilek, 2012). Given that state DEC was found to have a relation with both commission errors and non-target RTs, one possibility was that the improvements in sustained attention associated with DEC (i.e. the reduction in commission errors associated with increased flow) could be explained simply through response slowing (i.e. increased RTs). To investigate this possibility, we regressed commission errors and RTs onto scores of state DEC for each of Sample 1, Sample 2 and also the combined data from both samples. In Sample 1, neither commission errors, nor RTs were found to be significant predictors of DEC (see Table 14). In Sample 2, both commission errors and RTs were found to be negatively related to DEC, but only commission errors was a significant unique predictor (see Table 15). Finally, when the samples were combined, it was once again only commission errors that were a significant negative predictor of state DEC, indicating that commission errors are related to DEC independently of reaction time (see Table 16). Thus, our general conclusion, that there is a relation between state DEC and sustained attention performance (i.e. primarily indexed by commission errors), is not compromised by a speed-accuracy trade-off.

Table 14. Multiple regression predicting state DEC by commission errors and RT in Sample 1 (n = 76)

Predictor	b	β	*t*	*p*	Zero-order correlation
Commission Errors	.002	-.07	-.39	.696	-.13
RT	-.003	.14	.79	.430	.15
R^2 = .024, F(2, 73) = .90, SE = 1.26, p = .412					

Table 15. Multiple regression predicting state DEC by commission errors and RT Sample 2 (*n* = 97)

Predictor	b	β	*t*	*p*	Zero-order correlation
Commission Errors	-.026	-.61	-4.21	<.001	-.40
RT	-.002	-.18	-1.26	.211	.14
$R^2 = .175$, $F(2, 94) = 9.95$, SE = 1.156, $p = < .001$					

Table 16. Multiple regression predicting state DEC by commission errors and RT (collapsed across Sample 1 and Sample 2; *n* = 172)

Predictor	b	β	*t*	*p*	Zero-order correlation
Commission Errors	-.018	-.39	-3.39	<.001	-.29
RT	-.001	-.05	-.42	.675	.14
$R^2 = .082$, $F(2, 170) = 7.62$, SE = 1.21, $p = < .001$					

Trait Flow and SART performance

In addition to examining the relation between SART performance and state-level DEC, we also investigated whether trait-level flow measures were related to SART performance. Given that greater sustained attention ability is reportedly a feature of the autotelic personality, we examined the correlations between SART performance and the APQ as well. The correlations between these self-report measures and the SART performance metrics are presented in Table 17. As can be seen in the table, none of the SART metrics were found to have a reliable relation with any of the trait measures of flow (DECI, DECE, or the APQ). Significant relations were still not observed when the samples were combined, indicating that *trait* level differences in deep, effortless concentration are not strongly (if at all) related to SART performance.

Table 17. Correlations between DECI, DECE, APQ and SART Performance

Sample	Commission Errors	RTs	Omissions	RT CV	Anticipations
Sample 1 (n = 76)					
DECI	-.13	.09	-.04	-.10	-.06
DECE	-.19	.12	-.08	-.11	-.03
APQ	.06	.07	.12	.07	.08
Sample 2 (n = 96)					
DECI	.01	-.05	-.05	-.11	-.09
DECE	.04	-.19	-.04	-.08	-.04
APQ	-.04	.04	-.12	-.14	-.11
Combined (n = 172)					
DECI	-.06	.02	-.05	-.11	-.08
DECE	-.07	-.05	-.05	-.10	-.04
APQ	.02	.05	-.04	-.02	.00

Note. In Sample 2 and the combined sample, there is one fewer participant (n = 95) contributing to the correlations with the DECI scale.

Relations between Trait and State Flow

In this last section we report our examination of the relations between our measures of flow (both trait and state), and also of the relations between flow and the autotelic personality questionnaire. The correlations among these measures are presented in Table 18 (Sample 1 and Sample 2 separately) and Table 19 (the combined samples).

First, we investigated whether flow at the trait level was associated with the state-level experience of DEC during the SART. In Sample 1, the DECI was found to have a significant positive relation with state DEC, indicating that those who tend to experience deep, effortless concentration more often in their everyday lives also experienced deep effortless concentration more frequently during the SART task. This pattern was consistent across Sample 1 and Sample 2 (see Table 18), and when collapsing across samples (see Table 19). However, the relation between state DEC and the DECE was smaller and non-significant in all analyses.

Table 18. Correlations among state and trait flow measures in Sample 1 (n = 76; below diagonal) and Sample 2 (n = 96; above diagonal)

	State DEC	DECI	DECE	APQ
State DEC	--	.24*	.18	.22*
DECI	.28*	--	.55**	.56**
DECE	.08	.62**	--	.48**
APQ	.22	.43**	.38**	--

Note. There is one fewer participant for the DECI ** $p < .001$ * $p < .05$ (2-tailed)

The APQ was also significantly associated with state DEC, both in Sample 2 (see Table 18) and in the combined samples (see Table 18), such that those with higher scores on the APQ experience more DEC during the SART. While this relation was short of significance in Sample 1 ($p = .057$), it was the same magnitude and direction (positive) as it was in Sample 2. These findings indicate that those higher in autotelic personality traits experienced more deep, effortless concentration during the SART.

Finally, we examined the relation between trait DEC measures (i.e. DECI, DECE) and the APQ. As can be seen in Table 18, in Sample 1 the APQ was found to have significant positive correlations with both DECI and the DECE, indicating that those who score higher in autotelic personality traits tend to experience more deep, effortless concentration in everyday life. We observed a similar pattern of results in Sample 2 (see Table 18) and when the samples were combined (see Table 19). In addition, we found a strong positive correlation between the DECI and DECE, consistent with prior findings (i.e. Study 2.1 and Study 3.2).

Table 19. Correlations among state and trait flow measures combined across samples (n = 172)

	DEC state	DECI	DECE
DECI	.26**		
DECE	.13	.59**	
APQ	.22*	.49**	.42**

Note. There is one fewer participant for the DECI ** $p < .001$ * $p < .01$ (2-tailed)

Fortunately, because the APQ was included in mass testing survey, we were able to examine the relation between these measures in a much larger sample that went substantially beyond the participants tested in the laboratory that were part of Sample 2. When examining the larger sample (n = 2029)[31], the APQ is again positively related to both the DECI $r(2027) = .42$, $p < .001$, as well as the DECE $r(2027) = .44$, $p < .001$, a similar magnitude to the results from Sample 2. Thus, across all of our samples, the APQ was consistently related to both the DECI and DECE, suggesting that those who are higher in the autotelic personality traits also tend to experience DEC more frequently in everyday life. In addition, within this large sample, we again found a positive but moderate correlation between the DECI and DECE $r(2023) = .49$, $p < .001$, consistent with our previous findings suggesting that the two scales are related but not completely redundant.

Discussion

Building on prior work which found a relation between flow and *self-reported* inattention (Study 2.1 and Study 3.2; Cermakova et al., 2010; Moore, 2013), as well as with sustained attention in a short behavioural task (Schiefele & Raabe, 2011), in the present study we investigated the relation between the experience of flow and *behavioural* measures of sustained attention performance. Importantly, flow was assessed—at both the state and trait level—using measures of

[31] Including the 97 participants who participated in the laboratory portion of the study

deep, effortless concentration, which offer a more precise and direct index of the defining feature of flow experience (i.e. deep, effortless concentration; DEC). Furthermore, DEC and sustained attention performance were assessed during a longer sustained attention task than has previously been used (i.e. more than 4x longer than in Schiefele & Raabe, 2011). In general, the data from our two samples suggest that the experience of *state* flow (i.e. during the SART) is related to better sustained attention performance on the SART. For some metrics however (i.e. commission errors, RT CV, and anticipations), the size of the correlations varied considerably across our two samples. Importantly, the relation between flow and our primary measure of sustained attention performance—SART commission errors—was consistently negative in both samples, despite differing in magnitude. To more accurately estimate the magnitude of all the relations (i.e. by increasing the number of observations), we collapsed across our two samples. In the combined data, flow experience was found to have a small and significant relation with commission errors and RT CV and smaller, non-significant relations with anticipations, omissions errors, and reaction times. Thus, although there was some variation across our two samples, the balance of evidence supports the conclusion that *state* DEC was related to superior sustained attention performance during the SART, particularly when indexed by commission errors and response time variability (RT CV). When considered in light of previous findings suggesting that sustained attention in a short behavioural task is positively associated with flow (i.e. Schiefele & Raabe, 2011), the present study, which assessed sustained attention using a different and longer task, provides important converging evidence.

An interesting question that emerged during data analysis was whether the relation between flow and sustained attention performance differed across the first and second halves of the experiment. Since performance tends to decline as time elapses during a task (Davies &

Parasuraman, 1993; Dember, Galinsky & Warm, 1992; Mackworth, 1948; Szalma & Hancock, 2006; Warm, 1984), it stands to reason that the relation between sustained attention and state flow could also change as the task unfolds[32]. In both samples we found that the relation between state flow and commission errors was significantly larger in the second half of the experiment than in the first half of the experiment. A possible interpretation of this finding is that most participants perform reasonably well in the first half of the experiment, regardless of their level of DEC (i.e. when performance is good, flow/DEC does not offer an additional benefit). However, as sustained attention wanes in the second half of the experiment, those in flow (i.e. experiencing more DEC) may be better able to maintain higher levels of performance than those who are not in flow (i.e. experiencing less DEC)[33]. It is possible that the differences in magnitude from the first half to the second half could simply be due to sampling variation, rather than indicating a substantive difference. Even so, the fact that this pattern (i.e. a significantly larger correlation in the second half) replicated in a second, independent sample suggests that investigating how the relation between flow and sustained attention evolves over time could be an interesting avenue for future work.

While state DEC was related to performance on the SART, the trait level flow metrics (i.e. DECI and DECE) had no consistent relation with sustained attention performance during the SART. In this sense, the present findings are consistent with the behavioural work of Ullén et al., (2012; 2016), who found no relation between trait flow and behavioural performance on tasks requiring effortful attention. Based on these prior findings, and that the current study (using more precise measures of sustained attention) shows no relation between trait flow and behavioural

[32] Indeed, this further highlights the importance of assessing sustained attention in longer task than had been used in prior studies.
[33] For a preliminary exploration of this possibility, see Appendix C.

performance, one might conclude that trait flow is not predictive of performance on cognitive tasks. However, the present data cannot account for the possibility that a relation between trait flow and behavioural measures of sustained attention might be observed if participants were to perform multiple sessions of the SART. Repeated measurements of SART performance could provide more accurate estimates of participants' sustained attention ability and may reveal a relation with trait flow measures.

We should also note that while trait flow (i.e. the DECI and DECE) was not consistently related to SART performance, the DECI consistently predicted the experience of state flow during the SART. Specifically, those who report experiencing deep, effortless concentration more frequently during their everyday lives also reported more flow during the task. This is an important finding because it demonstrates that trait measures of flow in everyday life are able to predict the experience of flow in a given moment.

Another goal of Chapter 4 was to evaluate whether the autotelic personality is linked to the experience of deep, effortless concentration (i.e. flow). Our work was designed to extend the recent findings of Tse et al (2018a), who reported a positive association between the autotelic personality and flow. A strength of Tse et al.'s (2018a) contribution was the development and introduction of the APQ scale—a scale which clearly measures the autotelic personality by assessing its defining trait with items high in face validity. However, their study was limited by their use of global flow metrics, which make it difficult to tell whether the autotelic personality is related to the defining experience of flow (i.e. deep, effortless concentration) or whether the relation is driven by the more extraneous facets of flow such as a sense of control, or precursors to flow experience such as clear goals or skill-challenge balance. For example, it could be that those with an autotelic personality are better at setting clear goals for themselves and that this drives the relation. To overcome this problem, we leveraged the benefits of the APQ, while also including a measure of flow that specifically targeted the experience of deep, effortless concentration (i.e. the DECI, DECE and state DEC). Accordingly, our findings that individuals higher in the autotelic personality also experience more frequent bouts of deep, effortless concentration (i.e. the defining quality of flow; Csikszentmihalyi & Nakamura, 2010) at both the trait and state level, provide clear evidence of a positive relation between the autotelic personality and flow experience, a result consistent with the conclusions of Tse et al., (2018a).

As researchers who study flow, we are often asked whether there are ways to increase the likelihood of experiencing flow. Surprisingly, this question remains largely unanswered. Given the presently documented link between flow and sustained attention, we suggest that this issue might be addressed by considering whether strategies that improve sustained attention also facilitate the experience of flow. For example, it is known that motivation manipulations can improve sustained attention performance and reduce mind-wandering (Mackworth, 1948; Mrazek et al., 2012; Seli, Schacter, Risko, Smilek, 2019; Wammes & Smilek, 2017). As such, it seems possible that increasing a person's motivation to perform a task might facilitate the experience of flow. Indeed, prior work has suggested that motivation and flow are closely linked (Nakamura & Csikszentmihalyi, 2002). Intrinsic motivation is sometimes considered to be a dimension in global flow measures. However, more work remains to be done to identify which type of motivators will have the desired effect of increasing flow states. It seems conceivable, if not likely, that different types of motivators could have different effects and some may facilitate sustained attention performance, but not the experience of flow. Motivators such as monetary rewards (e.g. Mrazek et al., 2012), for example, can reduce mind-wandering, but are extrinsic in nature and could potentially interfere with flow experience—similar to what is observed in the 'over-justification effect', wherein extrinsic motivators reduce intrinsic motivation to engage in an activity (Deci, 1971; Lepper, Greene & Nisbett, 1973).

Another potential strategy worthy of investigation is that of mindfulness meditation, which is already gaining momentum among professional athletes in several major sports (Kutz, 2016; Jaynes, 2019; Joseph, 2018). Mindfulness shares a number of characteristics with flow, such as a singular focus on the present moment. One possibility is that mindfulness may provide the opportunity to practice maintaining one's focus, making it easier to maintain focus during flow. Another possibility is that mindfulness could help assuage negative thoughts and emotions which might interfere with or prevent flow experiences from occurring (Kaufman, Glass & Pineau, 2018). While some have found that mindfulness may facilitate flow (Chen, Tsai et al., 2019; Scott-Hamilton, 2016), the evidence is somewhat mixed (Sheldon, Prentice & Halusic, 2014) and most of the experimental studies have relied on small samples and global flow measures. Thus, whether mindfulness can facilitate deep, effortless concentration remains an open question—one which we explore in the next chapter.

In conclusion, when the present findings are considered in combination with previous findings a clearer picture begins to emerge. At the trait level, flow (i.e. DEC) is related to reports of better sustained attention in everyday life (Marty-Dugas & Smilek, 2019) and, as demonstrated in the present study, DEC at the state level is related to better performance on a sustained attention task. Now that the relation between flow and sustained attention has been demonstrated using both self-report and behavioural measures, researchers can begin to elucidate the specific factors that have similar or disparate influences on flow and sustained attention.

Chapter 5

The experience of "flow" is defined by the subjective experience of deep, but simultaneously effortless concentration on the task at hand. Flow is often described as a highly enjoyable or rewarding experience and has been linked with intrinsic motivation (Csikszentmihalyi & Nakamura, 2002; Nakamura & Csikszentmihalyi, 2002). Furthermore, as we saw in Study 3.1 and Study 3.2, flow is often associated with positive well-being and better mental health (Asakawa, 2010; Peifer, Syrek, Ostwald, Schuh & Antoni, 2019), such that those who experience flow more frequently tend to experience less negative affect and stress, fewer symptoms of depression and anxiety and more positive affect. The experience of flow (i.e. deep, effortless concentration) has also been linked with better sustained attention in both everyday life (Cermakova, Moneta & Spada, 2010; see Study 2.1 and Study 3.2) and in laboratory tasks (see Chapter 4). Clearly, flow is a desirable state and it seems reasonable to assume that facilitating flow could have benefits in a variety of different contexts. However, at present there is a dearth of studies demonstrating ways that flow states can be induced, and it has proven difficult to reliably induce flow in the laboratory (Moller, Meier & Wall, 2010).

One possible way in which flow could be facilitated is through mindfulness training. Interestingly, individual differences in mindfulness and flow proneness tend to be positively related (Kee & Wang, 2008; Moore, 2013), such that those who are more mindful tend to experience more flow. A study conducted by Moore (2013), found that dispositional mindfulness—as assessed by the Cognitive and Affective Mindfulness Scale-Revised (CAMS-R; Feldman, Hayes, Kimar, Greeson & Laurenceau, 2007)—was a good predictor of participants' propensity for experiencing flow. Similar results have been demonstrated in studies conducted with athletes; those who tend to be more mindful also tend to experience more flow (Bernier, Thienot, Codron & Fournier, 2009; Kaufman, Glass & Arnkoff, 2009; Kee & Wang, 2008). One recent study of undergraduate athletes found that several aspects of mindfulness, such as mindful awareness and the ability to refocus, were positively correlated with the experience of flow (Thienot et al., 2014). While these measures were focused on mindfulness and flow in the context of sports, the authors also reported a positive correlation between flow proneness and mindfulness in everyday life as assessed via the Mindful Awareness Attention Scale (MAAS; Brown & Ryan, 2003). Thus, across several populations and using several different measures, it has been shown that those individuals who are more mindful tend to experience flow more often.

There are several theoretical reasons why mindfulness training may be an effective way to increase flow states. For one, the constructs of flow and mindfulness training share similar qualities (Kaufman et al., 2009; Wright, Sadlo & Stew, 2006; Wright, Sadlo & Stew, 2007). For example, mindfulness can be defined as present moment awareness (Levison, Stoll, Kindy, Merry & Davidson, 2014) and flow is similarly characterized by the experience of deep, effortless concentration on a momentary task (DEC; Csikszentmihalyi & Nakamura, 2010; Marty-Dugas & Smilek, 2019; see also Schiefele, 2013). It could be the case that through practicing mindfulness, one is more readily able to translate this mental state to other situations which allows for greater focus and flow experiences to occur. In other words, by practicing focusing on the present moment with mindfulness meditation, one might be better able to stay focused on the present during flow. It has also been suggested that mindfulness may facilitate flow through the practice of acceptance and non-judgemental thinking (Kaufman, Glass & Pineau, 2018). That is, by accepting situations as they are and focusing on maintaining present moment awareness, mindfulness may help practitioners eliminate performance concerns and other distracting thoughts (Kaufman, Glass & Pineau, 2018), thus creating conditions thought to be conducive to flow.

Given the foregoing, it is perhaps unsurprising that many have begun to use mindfulness meditation as a means to increase flow. This approach has been particularly popular in the world of sports, where mindfulness interventions are often used by high level athletes, such as those in the NBA (Begley, 2014; Kutz, 2016; Joseph, 2018), the NFL (Mays, 2017; Christensen, 2017), and the MLB (Anderson, 2017; Wyllys, 2018). The popularity of mindfulness meditation is so great that the NBA recently partnered with the Headspace mindfulness app (NBA.com, 2018) to design meditation content featuring professional basketball players (Lee, 2019). One possibility is that mindfulness meditation may facilitate flow by allowing athletes to practice focusing outside of their chosen sport, a focus which they can then transfer into flow when playing the game. As the tennis phenom Bianca Andreescu recently put it, mindfulness meditation helped her with "…blocking everything and staying in the zone" during her victory at the 2019 US Open (Jaynes, 2019).

There is some empirical support for strategically using mindfulness meditation to facilitate flow and performance, with several studies suggesting that these efforts have been successful (Aherne, Moran & Lonsdale, 2011; Bernier et al., 2009; Chen, Tsai et al., 2019; Kaufman et al, 2009; Mistretta et al., 2017; Scott-Hamilton, Schutte & Brown, 2016). For example, mindfulness has been found to facilitate flow in baseball players (Chen, Tsai et al., 2019), collegiate athletes (Aherne et al., 2011; Mistretta et al., 2017), amateur golfers (Bernier et al., 2009; Kaufman et al., 2009), and cyclists (Scott-Hamilton et al., 2016). In one such study (Aherne et al., 2011) athletes were first asked to report on the experience of flow during a training session, which served as a baseline, pre-intervention flow score. Half of the athletes were subsequently assigned to practice mindfulness for a period of six weeks while the other half served as a waitlist control group. At the end of this six-week period, the athletes once again reported on flow after a training session, at which point flow scores were found to be significantly higher in the mindfulness group than the non-mindfulness control group. In addition, only the flow scores of the mindfulness group showed a significant increase from pre-intervention to post-intervention. A study of cyclists, using an 8-week mindfulness intervention, found similar results (Scott-Hamilton et al., 2016), whereby cyclists in the mindfulness group showed a significant increase in flow scores from baseline to post-mindfulness training, and those in the control group had no such increase (Scott-Hamilton et al., 2016).

However, there are reasons to believe that the relation between mindfulness and flow is not as clear as the preceding studies suggest. While most studies have found a positive relation between flow and mindfulness, there are others that have not. In a diary study of 162 participants (Sheldon, Prentice & Halusic, 2014, Study 1), the authors reported a negative correlation between mindfulness (as assessed by the Mindful Awareness of Attention States scale or MAAS; Brown & Ryan, 2003) and the absorption subscale of the Flow Short Scale (Rheinberg, Vollmeyer, & Engeser, 2003), as well as the Short Flow Scale (Jackson & Martin, 2008). An experience sampling study conducted by the same researchers (Sheldon, Prentice & Halusic, 2014, Study 2) found that flow and mindfulness (assessed using the same measures as above) were also negatively correlated at the state level. Most interestingly, an experimental study (Sheldon et al., 2014, Study 3) found that a brief mindfulness induction prior to playing Tetris reduced participant's reported flow (as measured by the absorption component of the Flow Short Scale) compared to a control group. This finding provides evidence that rather than facilitating flow, mindfulness may even interfere with or prevent flow experience.

Conceptual and Measurement Issues Relating to Mindfulness and Flow

While it may seem difficult to reconcile these disparate results, a potential explanation emerges when one considers the conceptual problems with the flow construct (as we described in Chapter 1; see also Schiefele, 2013). Most studies on mindfulness and flow have assumed a 'global flow' conceptualization and therefore have employed global flow measures. Under a global flow conceptualization, flow is considered to be a constellation of nine facets which combine in some unspecified way to produce global flow, an experience which is "more than the sum of its parts" (Csikszentmihalyi & Csikszentmihalyi, 1988; Jackson & Eklund, 2002; Nakamura & Csikszentmihalyi, 2002). Some of these facets, such as skill-challenge balance, unambiguous feedback, and clear goals, are thought to be precursor facets which make flow more likely (Jackson, 1996; Nakamura & Csikszentmihalyi, 2002; Swann, Keegan, Piggott & Crust, 2012; Scott-Hamilton et al., 2016), while others (such as time distortion, loss of self-consciousness & sense of control) may be considered consequences of flow (Hamari & Koivisto, 2014; Marty-Dugas & Smilek, 2019; see also Landhaüβer & Keller, 2012). However, despite the number of facets involved in flow, the global flow conceptualization seems to prioritize the experience of deep, effortless concentration, which has been called the "signature quality" of flow (Csikszentmihalyi & Nakamura, 2010, p. 182). Thus, an issue with the global flow conceptualization is that the defining feature of flow can be lost in a sea of extraneous facets. Typically, measures of global flow assess participant's experience of each of the nine facets before summing them together to create a global flow score (e.g. Aherne, Moran & Lonsdale, 2011; Steele & Fullagar, 2009; Ullén et al., 2012). This practice precipitates several problems: For example, the global flow approach conflates the putative causes of flow (i.e. skill-challenge balance) with the experience itself. Furthermore, and perhaps more critically, changes in global flow scores are sometimes driven by changes in extraneous facets, and not by a change in participants' experience of deep, effortless concentration—the defining quality of flow (Csikszentmihalyi & Nakamura, 2010; Marty-Dugas & Smilek, 2019; see also Dormashev, 2010).

These issues are exemplified in two studies which employed a mindfulness intervention to facilitate flow in athletes. For example, in Aherne et al (2011), changes in global flow (following the mindfulness intervention) were driven by a change in extraneous facets (e.g. clear goals, sense of control and time transformation[34]) and not by a change in the experience of deep, effortless concentration. In the study by Scott-Hamilton et al (2014), the same general problem occurred again; the change in global flow scores was driven by changes in scores on the precursor facets—those which are implied to precede the experience of flow (i.e. skill-challenge balance, clear goals, unambiguous feedback)—rather than the core of the experience (i.e., deep effortless concentration). These studies illustrate how the use of global flow scores can make the interpretation of findings involving those measures difficult—at first glance mindfulness appears to facilitate flow in each of these studies, but upon more detailed examination, it is clear that the mindfulness interventions did not lead to changes in deep, effortless concentration. These issues are not unique to intervention studies, as global flow has also been the conceptualization of choice for studies of individual differences in mindfulness and flow (Moore, 2013; Thienot et al., 2014). Thus, whether and how individual differences in mindfulness relate to deep effortless concentration—the essence of flow experience—remains unresolved and an important open question.

While issues surrounding the conceptualization of flow undoubtably make it difficult to assess whether mindfulness can facilitate flow, these difficulties are further compounded by

[34] Note the 'clear goals' is a precursor facet, and the time transformation facet was marginally significant $p = .05$

concerns about the definition and measurement of mindfulness. In many ways, 'mindfulness' appears to be an umbrella term containing many different elements. For example, mindfulness could refer to a personality trait (i.e. trait mindfulness), a state of present moment awareness, informal mindfulness practices (e.g., mindful dishwashing), or formal mediation (Vago, Gupta & Lazar, 2019). Even if one were to restrict their definition of mindfulness to 'meditation', there are still a variety of possibilities, such as focused attention meditations, open awareness meditations, and loving-kindness meditations all of which have different goals (Vago, Gupta & Lazar, 2019). Furthermore, meditation can be guided (Tang et al., 2007; Xu, Purdon, Seli & Smilek, 2017) or unguided (Flett, Hayne, Riordan, Thompson & Conner, 2019); presented in relatively short single sessions (Sheldon et al., 2014; Xu et al., 2017; Watier & Dubois, 2016), or incorporated into mindfulness programs lasting several days or weeks (Mackenzie, Poulin & Seidman-Carlson, 2006; McMillan, Robertson, Brock & Chorlton, 2002; Mrazek, Franklin, Phillips, Baird & Schooler, 2013; Tang et al., 2007; Kiken, Garland, Bluth, Palsson & Gaylord, 2015). Thus, it would seem that the diverse and varied set of criteria and characteristics which define mindfulness present a particular difficulty for assessing whether or not practicing mindfulness can facilitate the experience of flow.

Given the many different possible meanings and practices of mindfulness, perhaps the disparate results from the literature on mindfulness and flow should not be so surprising. Indeed, one study in particular illustrates how concepts that fall under the same mindful umbrella can even have the *opposite* pattern of relations with flow. In a regression predicting trait flow, Moore (2013) found that trait mindfulness (assessed via the CAMS-R; Feldman et al., 2007) was positively related to flow, while a history of mindfulness meditation was *negatively* associated with flow[35].

[35] Demographic variables and a measure of cognitive flexibility were also included in the regression. Of these, only cognitive flexibility had a significant (positive) relation with flow

Interestingly, trait mindfulness and a history of mindfulness meditation were also found to be uncorrelated in that particular study. Thus, the shifting criteria and definitions of mindfulness may partly explain various incongruent results in the flow literature—perhaps some states commonly grouped under the 'mindfulness' umbrella support flow, while others interfere with it (i.e. Sheldon et al, 2014). Careful consideration of how mindfulness is defined and measured should be taken into account when assessing whether mindfulness can facilitate flow.

Addressing conceptual issues in the constructs of Mindfulness and Flow

Conceptual and definitional issues associated with the constructs of mindfulness and flow present a major hurdle for evaluating whether mindfulness is an effective strategy to facilitating flow. Fortunately, two recent developments may allow the relation between these two constructs to be assessed with greater clarity. The first is the recent development of a task for inducing/assessing mindfulness, which seems to provide a clear path for assessing this construct. This newly developed task is based on the notion that a common component across many instantiations of mindfulness is a focus on the breath (Buddhaghosa, 2010; Levinson et al., 2014). Indeed, even meditations with very different goals (e.g. focused attention and open awareness mediations) share this feature (Lutz et al., 2008) and a focus on one's breathing (as a proxy for the present moment) is incorporated into typical mindfulness programs (Vago et al., 2019). As such, Levinson et al (2014), suggest that defining mindfulness as present moment awareness, and *operationally* defining mindfulness as a focus on one's own breathing can make studies of mindfulness more tractable. An interesting question that arises from this definition of mindfulness is whether focused attention on the breath (an internal stimulus) has a benefit above and beyond focused attention in general (such as on an external stimulus).

In addition, Levinson et al (2014) developed and validated a simple breath-counting task as a means for inducing mindfulness. In the task participants are simply asked to count their breaths from 1-9 by making keypresses. Breath-counting accuracy was associated with a number of mindfulness-related factors. For example, those who counted their breaths more accurately reported feeling more mindful, had more meta-awareness, and engaged in less mind-wandering while breath-counting. Further, increased breath-counting accuracy was associated with better mood, and greater non-attachment (specifically, less attention capture from distractors formerly paired with reward). Interestingly, breath-counting was found to be distinct from measures of sustained attention and working memory. Finally, it was also demonstrated that the breath-counting task distinguished between expert and novice meditators—such that expert meditators had both greater counting accuracy and less mind-wandering than novice meditators. Taken together, these results demonstrate that the breath-counting task is associated with a number of concepts that fall under the umbrella of mindfulness.

A second key development is the creation of more precise measures of flow, which specifically assess deep, effortless concentration (DEC). Critically, unlike global flow measures, DEC measures assess only the defining experience of flow—that is, deep, effortless concentration—without the obfuscating presence of other more extraneous facets. In prior studies, which have predominantly used global flow measures, the relationship between mindfulness and flow could have been driven by a correlation between mindfulness and precursor facets, such as skill-challenge balance or clear goals. Given that these facets are theorized to *precede* the experience of flow (Jackson, 1996; Nakamura & Csikszentmihalyi, 2002; Swann et al., 2012; Scott-Hamilton et al., 2016) such a correlation would not demonstrate a relation between mindfulness and flow experience itself (i.e. DEC). Because DEC measures more precisely capture the core experience of flow in a less contaminated way, they allow us to more readily assess pertinent questions regarding the relationship between mindfulness and flow, such as 1) whether individual differences in mindfulness are related to more frequent experiences of deep, effortless concentration, and 2) whether a brief mindfulness intervention (e.g. breath-counting as defined by Levinson et al., 2014) could facilitate the experience of flow in a subsequent task.

The Present Studies

In the present work we investigate the relation between mindfulness and flow across three studies. In Study 5.1, we explore the relation between mindfulness and flow at the level of individual differences. As we noted above, previous investigations of the relation between mindfulness and flow at the level of individual differences have produced somewhat mixed results; some studies have yielded positive relations between mindfulness and flow (Moore, 2013; Thienot et al., 2014), while others have yielded negative relations (Sheldon et al., 2014). To address this, in the present study we employ two measures of mindfulness and, critically, we assess the frequency of flow experience using more precise and specific measures of deep, effortless concentration (DEC) in two large samples (N > 1600).

In Studies 5.2 and 5.3, we build on the results of Levinson et al (2014) and examine whether breath-counting (i.e. a brief mindfulness induction) is an effective strategy for facilitating the state of deep effortless concentration. Across studies we vary the nature of the breath-counting instructions and the nature of the active control groups to assess the possible roles of task instructions, and the way interventions are named (as using the term ‘mindfulness’ might trigger expectations that influence flow). Furthermore, we examine whether breath-counting (relative to various active controls) leads to improved performance on a game-like cognitive task. Finally, we investigate whether trait mindfulness and/or trait flow predict the experience of state DEC during the experimental task and whether the experience of state DEC is related to task performance.

Study 5.1

Given the somewhat mixed evidence for the relation between mindfulness and flow at the trait level, in Study 5.1 our goal was to clarify this relation. We employed four surveys; two for assessing mindfulness, and two for assessing the frequency of flow experience. Mindfulness was assessed using the CAMS-R (Feldman et al., 2007), which primarily assesses acceptance and non-judgmental thinking, and the MAAS-LO (Brown & Ryan, 2003; Carriere, Cheyne & Smilek, 2008), which measures the frequency of mind*less* behaviours (i.e. acting without awareness or intention). Importantly, flow was assessed using measures of internal and external deep, effortless concentration (DECI and DECE, respectively). By using DEC measures to assess flow, in Study 5.1 we were able to clearly measure the defining feature of flow experience (i.e. deep, effortless concentration). Data for Study 5.1 was collected from a pre-term mass screening survey, which included measures used by other researchers. Each term, this survey is completed by students registered in psychology courses for partial course credit. There were two terms (Winter, 2018 and Fall, 2018) in which the CAMS-R, MAAS-LO, DECI and DECE were present in the survey, which allowed us to examine the relation between mindfulness and flow in two relatively large samples.

Method

Individual Differences Measures

Deep Effortless Concentration - Internal (DECI) and External (DECE). To assess individual differences in the propensity to experience flow in everyday life, we employed the Deep Effortless Concentration – Internal (DECI) and Deep Effortless Concentration – External (DECE). These two scales assess the frequency with which individuals experience deep, effortless concentration, which defines the experience of flow. The DECI assess the frequency of flow during internal contexts (such as thinking, remembering or imagining), while the DECE assess the frequency of flow during external contexts (such as playing instruments, sports, or during hobbies). Each scale consists of eight items and which are rated on a seven-point scale ranging from (1) - *Never* to (7) - *Always*.

Cognitive and Affective Mindfulness Scale – Revised (CAMS-R). The CAMS-R is designed to index participants' tendency towards behaving mindfully in their everyday lives. In particular the CAMS-R assesses four key dimensions of mindfulness: attention, awareness, present-focus, and acceptance/non-judgement (Feldman et al., 2007). The scale is 12-items in length and includes questions such as "I try to notice my thoughts without judging them" and "It's easy for me to keep track of my thoughts and feelings". Questions are rated on a 4-point scale ranging from *rarely/not at all* (1) to *almost always* (4). All questions were included in the survey, though two items ("It is easy for me to concentrate on what I am doing" and "I am able to pay close attention to one thing for a long period of time") were removed from analyses due to their similarity with items from the DEC questionnaires.

Mindful Awareness of Attention States scale – Lapses Only (MAAS-LO). The MAAS-LO (Brown & Ryan; Carriere, Cheyne & Smilek, 2008) is used to assess the frequency of an individual's mindless or absent-minded behaviours during their everyday lives. This 12-item scale includes questions such as "I find myself doing things without paying attention" and "I rush through activities without being really attentive to them", which are answered on a six-point scale ranging from (1) *almost never* to (7) *almost always*.

Procedure

To investigate the relation between mindfulness and flow we looked back at the mass screening survey for each of the semesters which included the DECI and DECE. Of these semesters, there were two that included both the CAMS-R and the MAAS-LO. When examining the CAMS-R we removed two items, which overlapped with items on the DEC measures[36]. This was to prevent the possibility that a correlation between the scales would be driven by item similarity, rather than a relation between the constructs. Below, we present the correlations between these measures from each semester, removing those participants which overlapped with the previous semester (i.e. we include the unique respondents from each semester).

Results

First, we examined the relations between the DECI, DECE, CAMS-R and MAAS-LO from the Winter 2018 semester (n = 2034). As can been seen in Figure 11, the CAMS-R had a moderate positive correlation with both the DECI and DECE, indicating that those higher in trait mindfulness also tend to experience flow more frequently in their everyday lives. When mindfulness was assessed by the MAAS-LO (on which higher scores indicate more mind*less* behaviour), it was found to have a small negative correlation with the DECI and DECE, indicating that those who are more mind*less* tend to experience flow less frequently (see Figure 11). We then examined the data from the Fall 2018 survey (n = 1629) in which a similar pattern emerged. The CAMS-R was again moderately positively related to both the DECI and DECE, while the MAAS-LO had a small negative relation with the DECI and DECE (see Figure 12). As expected, the CAMS-R, for which higher scores indicate more mindfulness, and the MAAS-LO, for which higher scores indicate

[36] Those items were “It is easy for me to concentrate on what I am doing” and “I am able to pay close attention to one thing for a long period of time”.

more mind*less*ness, were negatively correlated in both samples (Winter 2018: r(2032) = -.48, $p <$ .001; Fall 2018: r(1627) = -.47, $p < .001$.

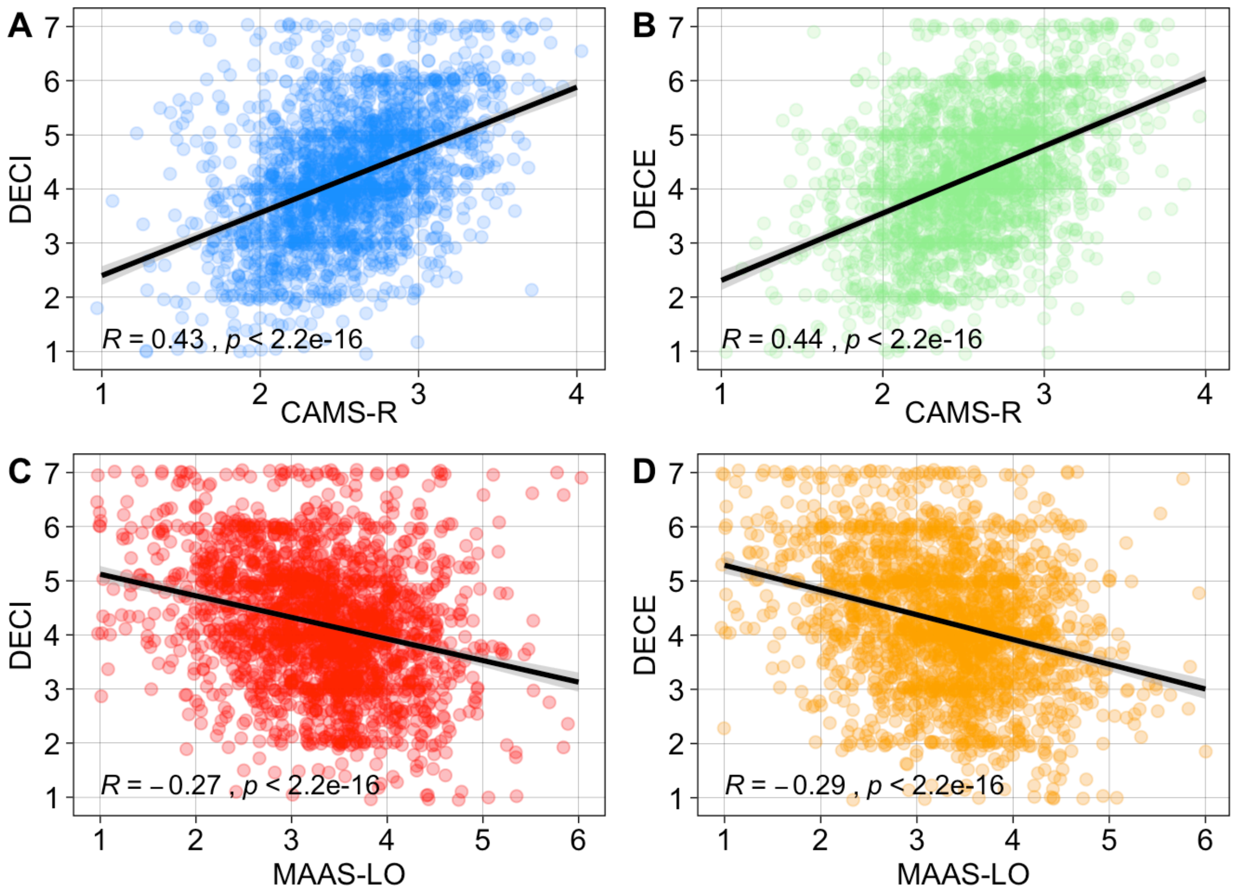

Figure 11. Relations between trait mindfulness and trait flow in Winter 2018 (n = 2034).

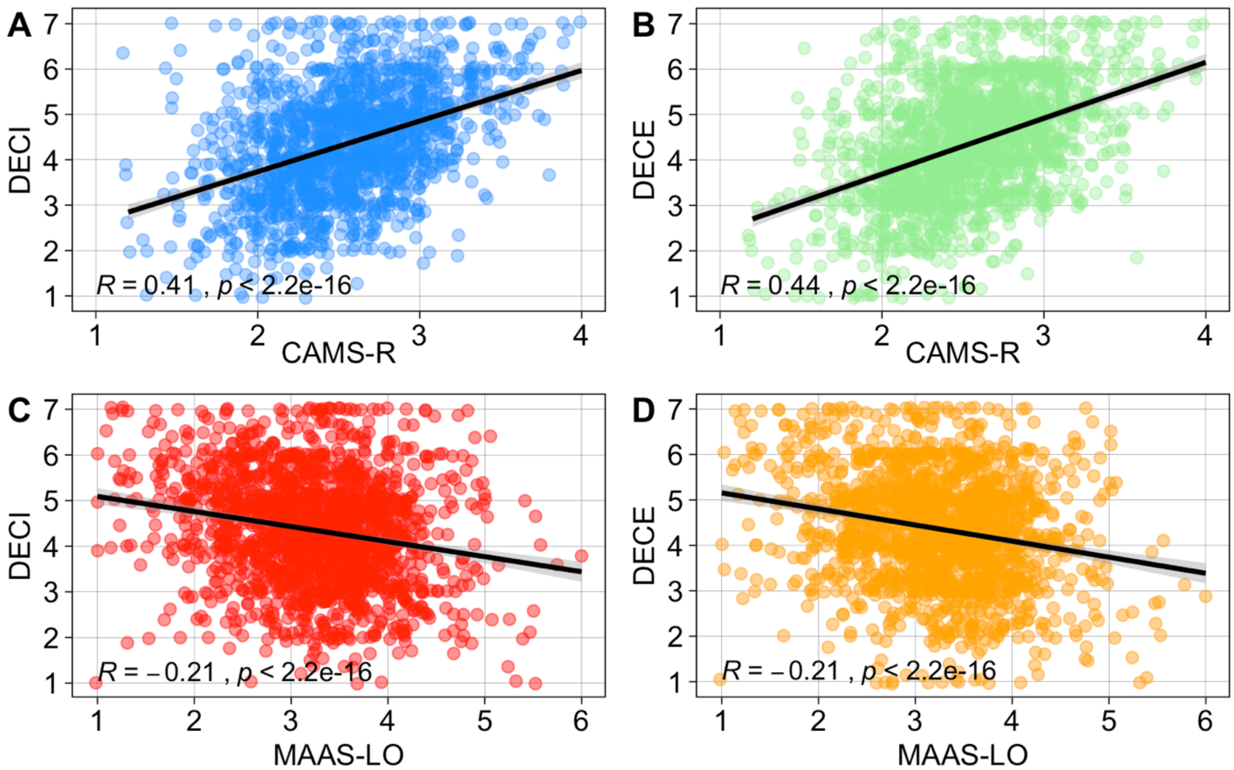

Figure 12. Relations between mindfulness and flow in Fall 2018 (n = 1629).

Discussion

Across two large samples we found that mindfulness and flow were positively related at the trait level, such that people who are more mindful tend to experience more frequent moments of flow. Importantly, flow was assessed using DEC measures, which clearly assess the core experience of flow in way that is uncontaminated by extraneous factors (e.g., skill challenge balance, clear goals, etc.) that are usually included in assessments of flow. Furthermore, the relation between mindfulness and flow was borne out using two different measures of mindfulness, the CAMS-R and MAAS-LO, which assess mindfulness in different ways. Given that these relations were consistent across two large samples, Study 5.1 provides evidence that there is a reliable relation between mindfulness and flow at the individual difference level.

Study 5.2

The consistent finding that people with higher levels of mindfulness tend to experience more flow is encouraging when it comes to the possibility that practicing mindfulness might be a useful way to facilitate flow experience. Along these lines, one promising result comes from Levison et al. (2014) who developed a task for assessing mindfulness behaviourally (i.e. the breath-counting task). Importantly, they operationally define mindfulness as a focus on the breath. A partial replication of the original findings indicated that counting accuracy during single session of breath-counting was related to better performance on a subsequent attention task (Wong, Massar, Chee & Lim, 2018). In Study 5.2, we employ the breath-counting task as a brief mindfulness meditation, and examine whether it can facilitate the experience of flow in a subsequent task.

As noted earlier, Levinson et al (2014) operationally defined mindfulness as present moment focus on the breath. This definition gives rise to an interesting question—is there a special benefit or quality to directing one's attention to the breath as opposed to another stimulus? There is some evidence which would support the notion that focused attention on one's breathing is beneficial, with some suggesting that focused attention on one's breathing may drive the beneficial effects of mindfulness (Jerath, Crawford, Barnes & Harden, 2015). Indeed, breathing exercises can have beneficial effects even when they are not paired with mindfulness per se (Ma et al., 2017).

Given the central role of breathing in mindfulness intervention and practice, Study 5.2 focused specifically on assessing whether practicing focused attention on one's breathing (i.e. mindfulness) would facilitate state flow and performance in the subsequent task—above and beyond practicing focused attention in general. Accordingly, we created the 'cross-counting' task to serve as an active control condition against which we assessed the efficacy of the breath-counting task (i.e. on flow experience and subsequent performance). The cross-counting task was matched to the breath-counting task in every way, except that it required participants to count the appearance of a rhythmically presented cross on a computer display (i.e. an external stimulus) rather than their own breaths.

Participants in Study 5.2 were randomly assigned to one of two conditions: breath-counting (i.e. the mindfulness induction) or cross-counting. In each condition, participants performed the assigned task for 15 minutes prior to the experimental task. For the experimental task participants were asked to play a "game" where they used the mouse to catch targets (i.e. the letter X) and avoid collisions with non-targets (i.e. the letter O). We refer to this game as the 'X's and O's task', which was based on the experimental task used by Kennedy, Metcalfe and Miele (2014). Performance on the X's and O's task was assessed by calculating the proportion of targets caught and the proportion of non-targets collisions during 30 minutes of gameplay. To assess flow, we employed measures of deep, effortless concentration (DEC) which were presented intermittently during the X's and O's game via thought probes.

Based on the results of Study 5.1 and prior work (Chen, Tsai et al., 2019; Levinson et al., 2014; Mistretta et al., 2017; Wong et al., 2018) we predicted that relative to the active control conditions, breath-counting (i.e. mindfulness) would lead to higher scores on DEC measures and better performance in the X's and O's task. However, we should also consider alternative possibilities; for example, Sheldon et al (2014) concluded that a brief (~10-minute) mindfulness meditation led to lower flow scores in a subsequent game of Tetris. When considering this finding, one might predict that breath-counting would lead to less flow during the X's and O's task. However, Sheldon et al's (2014) experiment did not include an active control condition, meaning that those in the mindfulness condition participated in the experiment for 10 minutes longer than controls. Thus, the inclusion of the cross-counting task is a strength of the present study, because it allows for breath-counting (i.e. the mindfulness exercise) to be compared to an active control condition. Nevertheless, the possibility remains that relative to our active control condition, breath-counting will lead to lower levels of DEC and poorer task performance.

Next, we considered the possibility that breath-counting may confer a benefit for only *part* of the X's and O's task, rather than over the full duration. If this were the case, benefits of breath-counting could be obscured by examining the aggregate data across the whole experiment. To account for this possibility, we examined whether the breath and cross-counting conditions differed in terms of DEC and performance at different time points of the task.

Building on the trait-level relations we observed in Study 5.1 (i.e. that trait mindfulness was positively related to trait flow), we explored various relations between trait-level measures of mindfulness and flow, and *state*-level experiences. Specifically, in Study 5.2 we examined 1) whether trait mindfulness predicts the experience of state flow during the task, and 2) whether trait flow predicts state flow during the experimental task.

Finally, we also examined the relation between state-level flow (DEC) and task performance. Much of the classic work on flow (i.e. typically using a global flow conceptualization) has reported a relation between peak experience (i.e. flow) and peak performance, such that the experience of flow is associated with better performance, whether performance is defined by athletic prowess or artistic output (Csikszentmihalyi, 1990; Jackson, 1995). In Chapter 4, we demonstrated that the frequency of DEC is also related to performance on sustained attention tasks and a previous study using the X's and O's task (where participants were asked to report their experience of flow every 20s during the task) has found that flow was related to superior performance (Kennedy, Miele & Metcalfe, 2014). In the present study, we examine how state-level DEC relates to both the proportion of targets caught, and the proportion of non-target collisions.

Methods

Participants

Data was collected from two hundred and six (206) participants (39 males, 1 non-binary[37]) from the University of Waterloo. Several participants were removed for non-compliance with experimental instructions (e.g. failing to silence or put away their phone) or if they stopped trying to succeed at the X's and O's task. Participants were required to have completed the Mass Testing survey prior to signing up to participate for the study via SONA. All participants provided informed consent prior to participation and the study was reviewed by and received ethics clearance from a University of Waterloo Research Ethics Committee.

Breath-counting (Mindfulness) Task

For the experimental condition, participants engaged in 15 minutes of mindful breath-counting (see Levinson et al., 2014). Participants were asked to silently count their breaths from 1-9 using the arrows keys. For their first eight breaths, participants were asked to press the 'down' arrow key. For their ninth breath, they pressed the 'right' arrow key. One full breath in and out was counted as one breath. If participants noticed that they had lost track of their count, they could press the 's' key to indicate they had lost track, and begin counting again at one on the next breath. In this task, focused attention is directed to the process of one's own breathing.

Cross-counting Task

In the cross-counting task, participants were asked to silently count a fixation cross which appeared on the screen every four seconds for a period of 15 minutes. Using the arrow keys,

[37] One participant indicated their gender as 'afab', which we believe was a typo

participants counted the crosses according to the same parameters of the breath-counting task—that is, for the appearance of the first eight crosses, they pressed the ‘down’ arrow and for the ninth cross they pressed the ‘right’ arrow before starting again at one. As in the breath-counting task, participants were asked to press the ‘s’ key if they noticed that they had lost count. As the cross task served as the control task, the tasks were nearly identical in terms of both the required behaviour (i.e. how to count) as well as the instructions explaining the task. The key difference between the two tasks was where participants were asked to focus their attention; either on their breath in the breath-counting task (the experimental condition) or on an external stimulus (i.e., the cross) in the control condition.

Experimental Task (X’s and O’s Task)

Following the manipulation (i.e., the breath or cross-counting task), all participants asked to complete a game-like computer task (adapted from Kennedy et al., 2014). In the task, participants used their mouse to horizontally move an on-screen bucket and attempt to catch targets (the letter ‘X’) and avoid non-targets (the letter ‘O’), which fell from the top of the screen at a rapid pace. A screenshot of the task is provided in Figure 13. The task was approximately 30 minutes in duration and was periodically interrupted by thought probes to collect measures of flow (see below). Performance on the X’s and O’s task is indicated by two metrics: 1) the proportion of targets caught (i.e. correctly caught X’s), where a higher proportion indicates better task performance and 2) by the proportion of non-target collisions (i.e. O’s the participant failed to avoid), where a higher proportion indicates worse performance on the task.

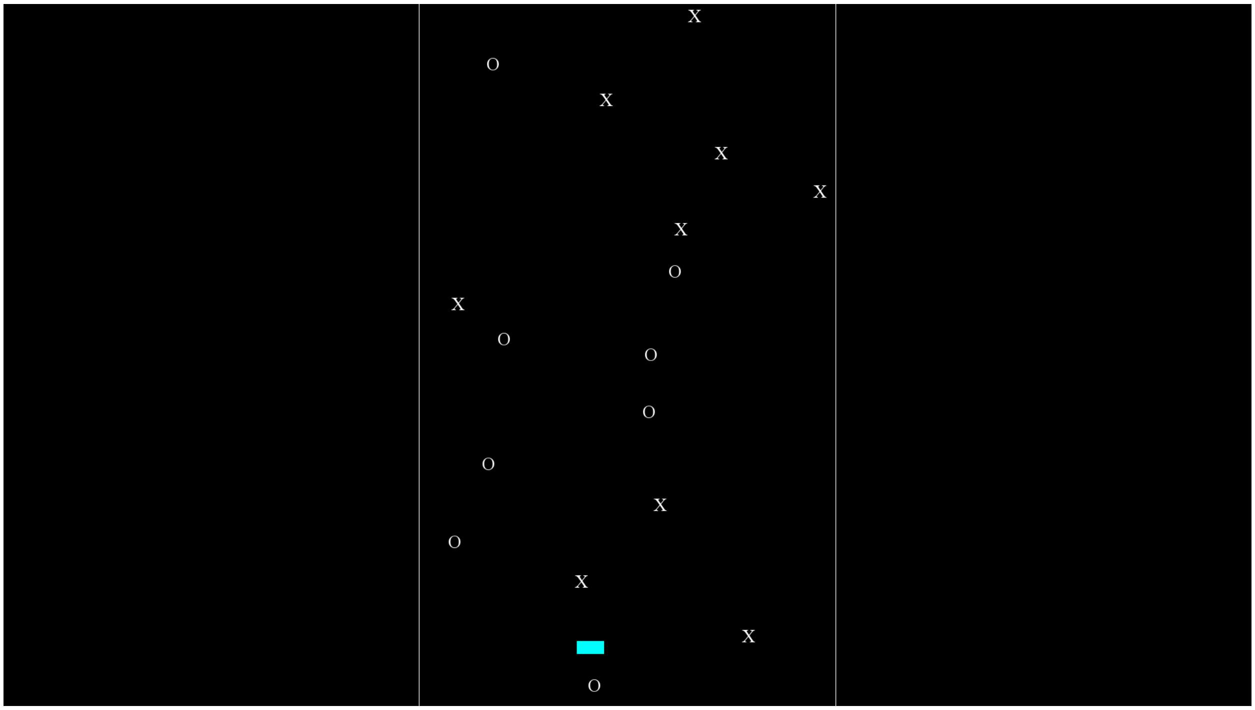

Figure 13. A screenshot of the X's and O's game (based on the task of Kennedy et al, 2014).

State Flow (State Deep Effortless Concentration; DEC)

At the state level, flow (i.e. deep, effortless concentration; DEC) was assessed via thought probes, which assessed the frequency with which participants experienced DEC during the experiment. The probes would briefly interrupt the task by popping up on the screen. Each probe consisted of four questions, which were answered on a seven-point scale ranging from (1) *Never* to (7) *Always*. The questions included in the probe were "I was able to completely focus on the task without straining to pay attention", "I seemed to reach a level of deep focus almost effortlessly", "I got in the zone and didn't have to force myself to concentrate on the task", and "I easily paid total attention to the task for extended periods of time". Participants answered these questions using the mouse before pressing a key to resume the task. Ten probes were presented pseudo-randomly throughout the 30 minutes of the X's and O's task[38].

[38] An 11th probe always occurred at the end of the task, immediately prior to the end of the experimental session, but was not included so as to avoid biasing the flow measure towards participants' end of task experience.

Results

Overall DEC and Performance

To assess whether the breath-counting condition facilitated the experience of flow, we compared DEC scores for the breath-counting and cross-counting condition using a t-test. The results of this test found that there were no significant differences between the two conditions, $t(204) = .656$, $p = .512$, indicating that focused attention on one's breathing did not influence flow relative to the active control of focusing attention on an external stimulus. Similar t-tests examining our metrics of task performance revealed that there was no difference between the two conditions in the proportion of targets caught $t(204) = 1.087$, $p = .278$, or in the proportion of non-targets collisions $t(204) = -.231$, $p = .818$. Together, these results suggest that overall, focusing attention on one's breath confers no special benefit (or cost) above and beyond focusing attention in general (i.e. on an external task) for either performance or the experience of flow.

Table 20. Study 5.2 Descriptives by Condition

		Flow (State DEC)		Targets Caught (%)		NTCs (%)	
Condition	n	M(SD)	Median	M(SD)	Median	M(SD)	Median
Cross-counting	105	4.32(1.47)	4.48	57.00(10.23)	57.10	5.24(2.84)	4.80
Breath-counting	101	4.19(1.38)	4.18	55.57(9.69)	54.70	5.33(2.35)	5.40

Note. NTCs stands for Non-Target Collisions

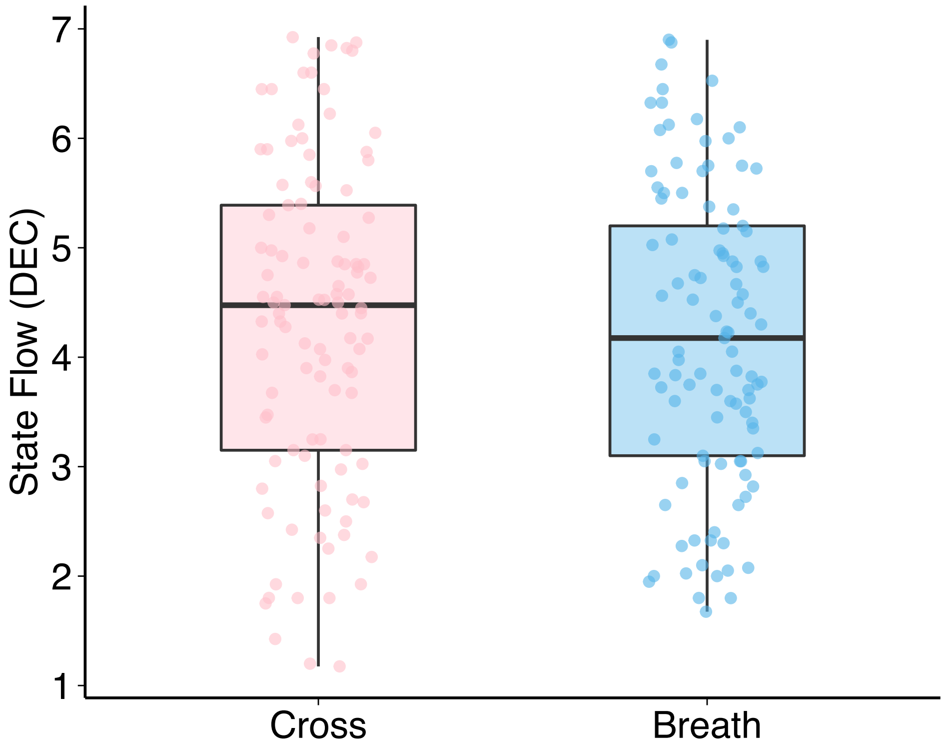

Figure 14. State flow (overall average) by condition in Study 5.2.

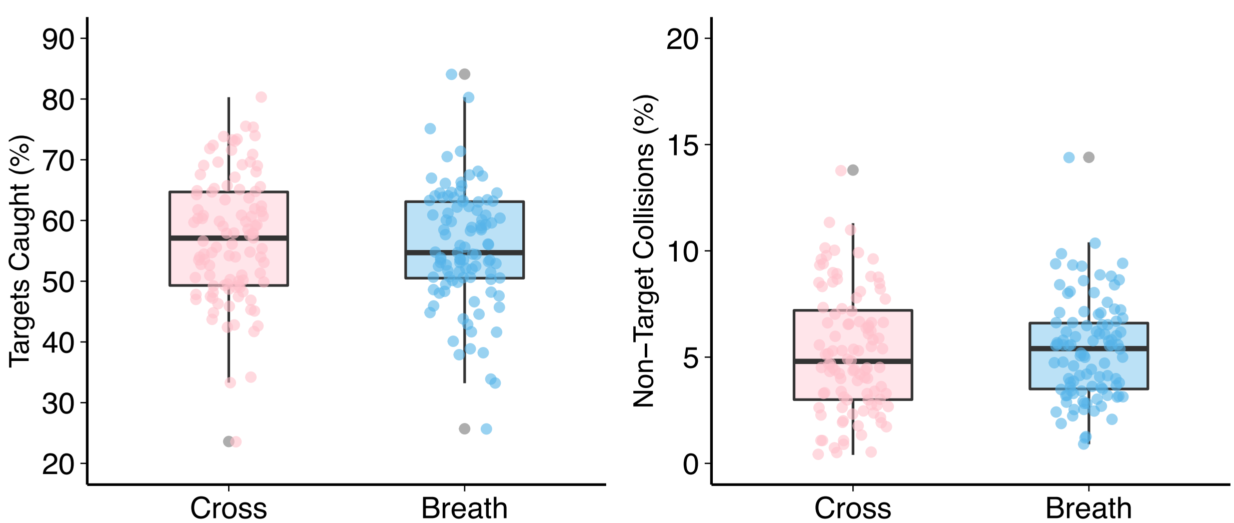

Figure 15. Performance on the X's and O's task by condition in Study 5.2.

DEC and Performance over Time

Next we examined the possibility that there might be a difference in performance or flow across the breath-counting and cross-counting conditions at some point during the experiment, perhaps in the early stages of the X's and O's task. If breath-counting were to produce a short benefit (e.g. 5 minutes), for instance, it may have been obscured by averaging the data across the entire experiment. Accordingly, the experiment was divided into 10 equal consecutive time windows (each of which was just under three minutes in length, i.e. 174000ms). Critically, this meant that each time window included one DEC thought probe. To calculate performance data (i.e. the proportion of targets caught, and percentage of non-target collisions), we aggregated performance on the 50 trials preceding each probe. Each of the measures (DEC, proportion of targets caught and proportion of non-target collisions) were submitted to a mixed ANOVA with Group (breath-counting vs. cross-counting) as a between-participant factor and Time (10 blocks) as a within-participants factor.

First, we conducted a 2x10 ANOVA on DEC with Condition (breath or cross-counting) as the between-subjects factor and Time (probe) as the within-subjects factor. Mauchly's test indicated that the assumption of sphericity had been violated W = .015, $p < .05$, so Greenhouse-Geisser corrected tests are reported ($\varepsilon = .44$). The omnibus ANOVA revealed a significant main effect of Time $F(3.96, 792) = 45.43$, $p < .001$, $\eta^2 = .072$, and a significant interaction between Condition and Time $F(3.96, 792) = 3.06$, $p < .001$, $\eta^2 = .005$. The main effect of Condition (breath vs cross-counting) was not significant $F(1, 200) = .57$, $p > .451$, $\eta^2 =.002$. We investigated the interaction using post-hoc t-tests and a Benjami-Hochberg correction for multiple comparisons. However, post-hoc tests found there was no significant difference between the conditions at any time point. This remained the case, even when there was no correction for multiple comparison.

Thus, while post-hoc tests found no differences between the conditions at any particular timepoint, the omnibus ANOVA nonetheless indicated a significant interaction between conditions.

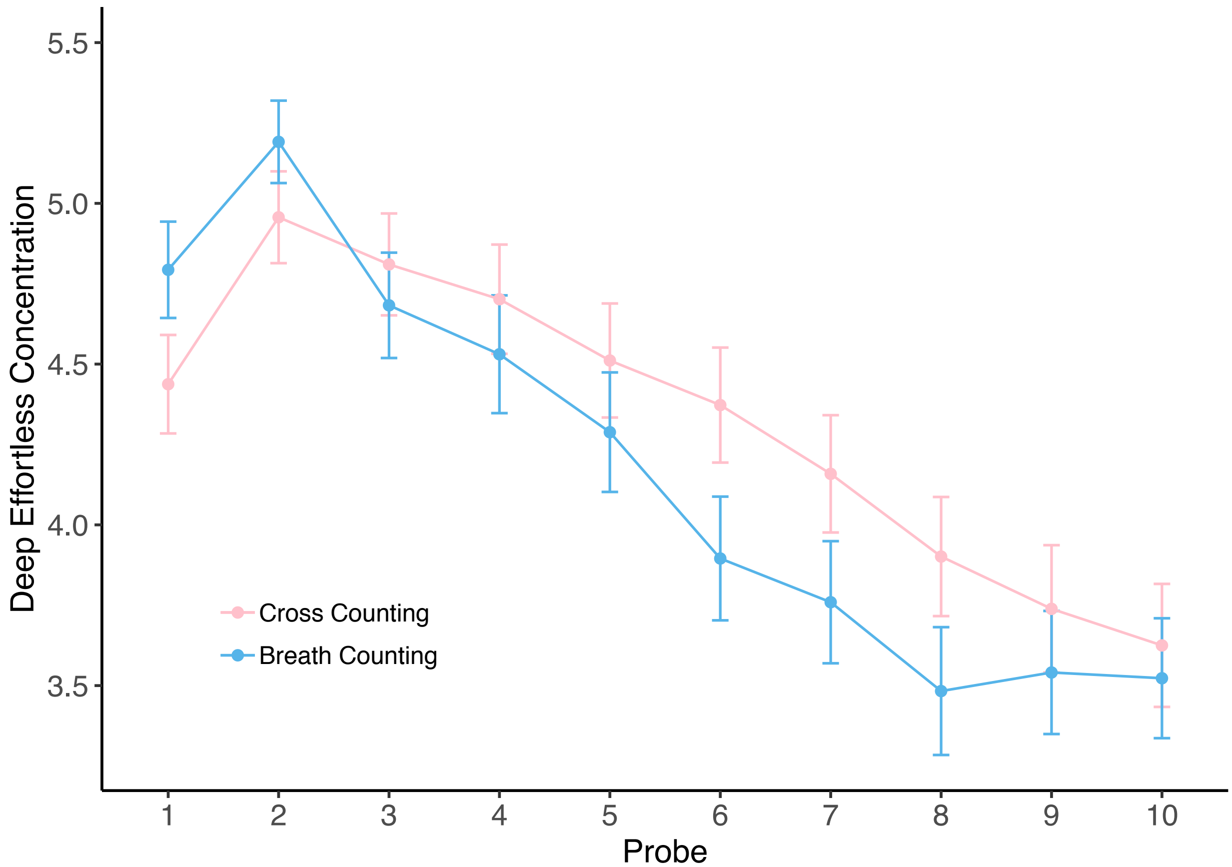

Figure 16. State flow over Time (probe) during the X's and O's task in Study 5.2.

Next, we conducted a 2x10 mixed ANOVA with Percentage of Targets caught as the dependent variable, and Condition (breath or cross-counting) as the between-subjects factor and Time as the within-subjects factor. Mauchly's test indicated the assumption of sphericity had been violated W = .64, p <.05 so Huynh-Feldt corrected tests are reported (ε = .95)[39]. The omnibus ANOVA found that there was no significant main effect of time (probe) $F(8.55, 1710) = 1.88$, p =

[39] Given that the value of ε was greater than .90 for both Greenhouse-Geisser and Huynh-Feldt corrections, we report Huynh-Feldt corrected tests (see Field, 2012)

.051, $\eta^2 = .005$, or condition (breath vs cross-counting) $F(1, 200) = .82$, $p = .365$, $\eta^2 =.002$. The interaction effect was also found to be non-significant $F(8.55, 1710) = .35$, $p =.958$, $\eta^2 = .001$.

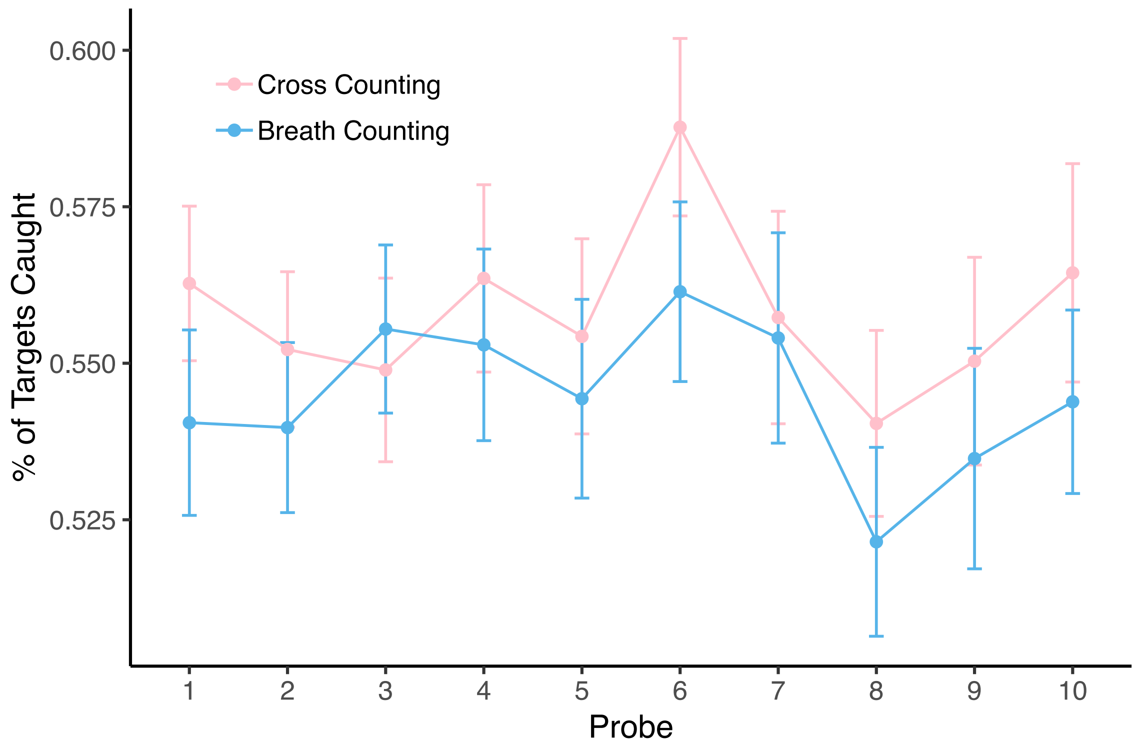

Figure 17. Percentage of targets caught over Time during the X's and O's task in Study 5.2.

Finally, we conducted a 2x10 mixed ANOVA with Percentage of Non-Target Collisions as the dependent variable, Condition (breath or cross-counting) as the between-subjects factor and Time as the within-subjects factor. Mauchly's test indicated the assumption of sphericity had been violated W = .66, $p < .05$ so Huynh-Feldt corrected tests are reported ($\varepsilon = .97$). The omnibus ANOVA found that there was a significant main effect of Time $F(8.73, 1746) = 5.67$, $p <.001$, $\eta^2 = .019$. However, neither the main effect of Condition (breath vs cross-counting) $F(1, 200) = .13$, $p = .907$, $\eta^2 =.000$ nor the interaction effect were found to be significant $F(8.73, 1746) = .77$, $p =$ .645 .05, $\eta^2 = .002$.

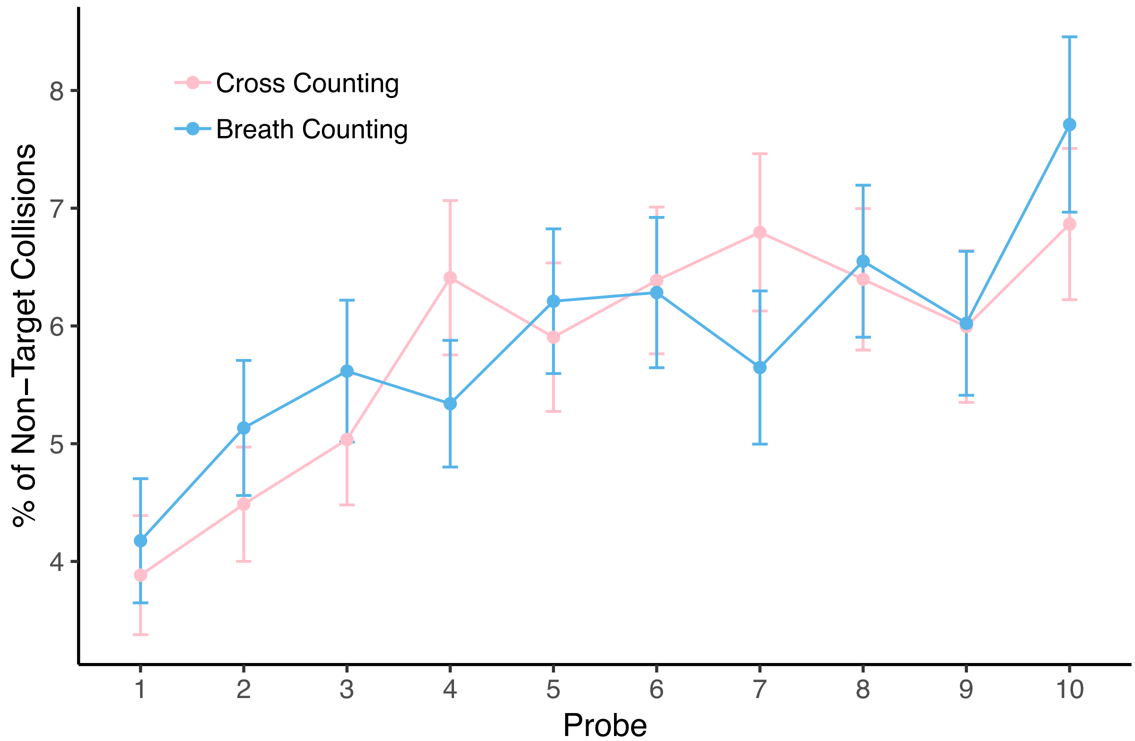

Figure 18. Percentage of non-target collisions over Time during the X's and O's task in Study 5.2.

Trait Mindfulness and state DEC

Given the relation between mindfulness and flow at the trait level, we examined whether trait mindfulness (measured during the mass testing survey) could predict the experience of DEC at the state level during the X's and O's task. To do so, we correlated scores on the CAMS-R[40] and the MAAS-LO with state DEC. Given that there were no differences between the breath-counting and cross-counting task on either flow or performance, we collapsed across conditions to examine state DEC[41]. The CAMS-R was found to be positively related to state DEC $r(189) = .27$, $p <.001$, indicating that those higher in trait mindfulness tended to experience more flow at the state level

40 Two questions from the CAMS-R ("It is easy for me to concentrate on what I am doing", "I am able to pay close attention to one thing for a long period of time") were removed due to similar wording with the items of the DEC thought probes.
41 When examining the data averaged across the entire experiment

during a laboratory task. On the other hand, our other measure of trait mindfulness, the MAAS-LO had no relation with state flow r(189) = -.04, p = .56.

Having examined the relation between trait mindfulness and state flow, we took the opportunity to examine whether trait flow could also predict DEC during the X's and O's task. Previous findings from our lab have indicated that individual differences in flow (as assessed by the DECI and DECE) were positively related to the experience of flow during a sustained attention task (see Chapter 4). To investigate whether this relation would conceptually replicate in the X's and O's task, we collapsed across conditions and examined the relation between the DECI/DECE and state DEC scores. Both the DECI r(189) = .24, p = .0011 and the DECE r(189) = .22, p = .002 were found to be positively related to state DEC during the X's and O's task, indicating that those who experience more flow in their everyday lives tended to experience more state flow during the experiment.

Relation between State DEC and Task Performance

Finally, given that there were no differences between the two conditions for either DEC or performance measures, we collapsed across conditions to examine the relation the relation between flow and task performance. Specifically, we examined the correlation between state flow and the percentage of correctly caught targets, as well as the relation between flow and the percentage of non-targets participants failed to avoid[42]. Those who reported more frequent DEC caught a greater percentage of targets r(204) = .259, p < .001 and successfully avoided more non-targets r(204) = -.179, p < .001. Thus, for both performance measures, higher DEC scores were related to superior task performance, providing evidence that state flow is positively related to performance.

[42] Using the data averaged across the whole experiment

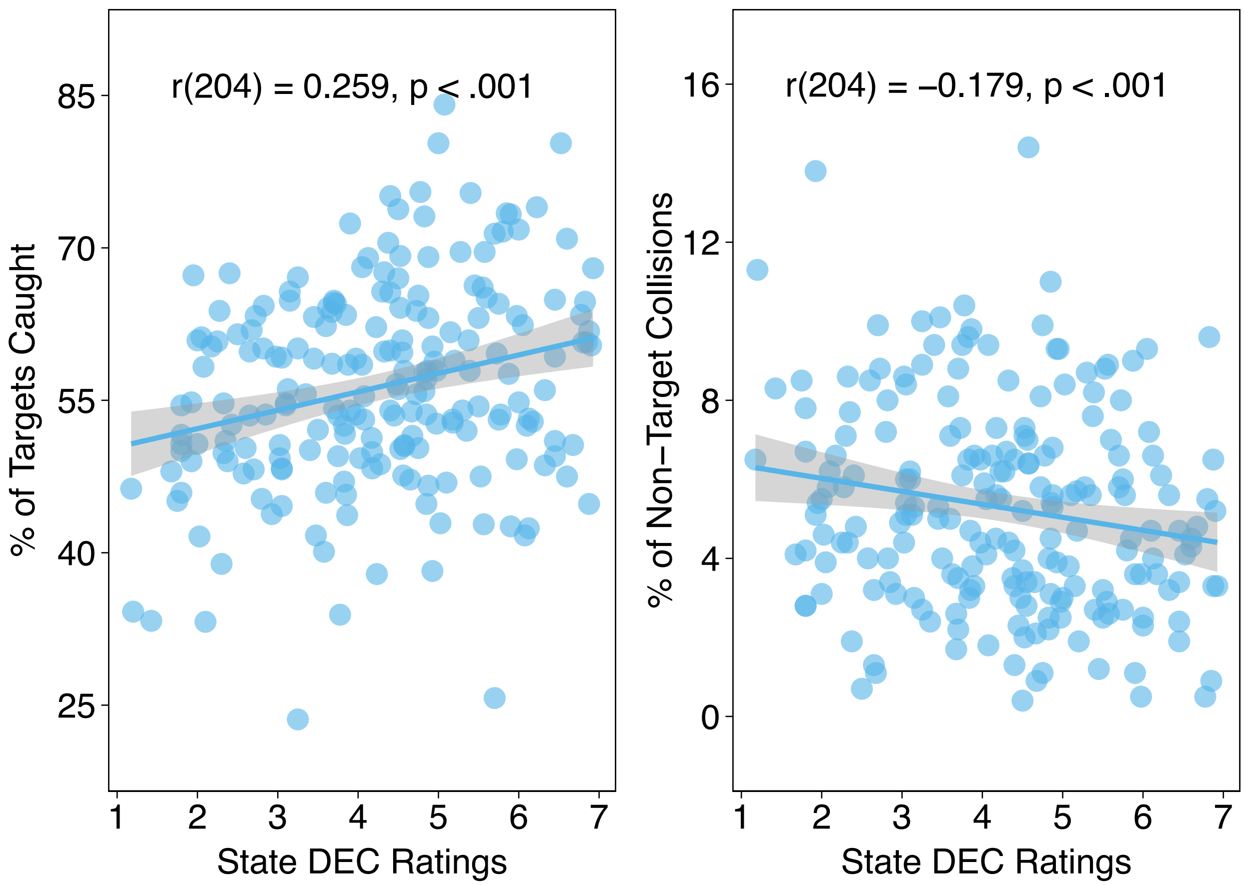

Figure 19. Relation between state flow and overall task performance in Study 5.2.

Study 5.2 Discussion

In Study 5.2, we investigated whether breath-counting (taken to be a mindfulness exercise, see Levinson et al., 2014) could facilitate the experience of deep, effortless concentration and performance on a game-like cognitive task. Participants were randomly assigned to either focus attention on counting their breath (i.e. the breath-counting condition), or on counting the occurrence of an external stimulus which appeared on the computer screen (i.e. a fixation cross), which served as an active control group. A key finding of Study 5.2 was that focused attention on one's breathing provided no benefit above and beyond focused attention in general. Specifically, there were no meaningful differences between the two conditions (breath-and cross-counting) in either flow experience (i.e. DEC) or task performance. Notably, this finding is inconsistent with prior work claiming that mindfulness meditation is incompatible with flow experience (Sheldon et al, 2014). When compared to an active control group (i.e. cross-counting), we found no evidence that mindfulness had a detrimental effect on flow.

In addition, we also examined whether breath-counting facilitated flow at any time in the experiment. That is, we tested for the possibility that breath-counting would confer a benefit to flow *somewhere* during the 30 minutes of the X's and O's task. The results of a mixed ANOVA indicated that there were no significant overall differences in flow scores between the two groups across time (i.e. probe) either. While post-hoc t-tests revealed no significant differences between the groups at any timepoint (even when multiple comparisons were uncorrected) the omnibus ANOVA did indicate a marginally significant interaction between group and time. This suggests that there was at least some influence of the conditions on flow experience. At this point, we remain cautious about over-interpreting this interaction.

The lack of a robust overall difference between conditions could be interpreted in two ways: It could be interpreted 1) as evidence that mindfulness does not effectively facilitate the experience of flow/task performance, or 2) as evidence that there is no special benefit to focusing on the breath. While the former interpretation is alluring, we must proceed with caution because of a nuanced feature of our task instructions. Specifically, to ensure that the cross-counting task was as closely matched a control condition as possible, the instructions for the task only differed from the breath-counting task in terms of where participants were asked to direct their focus (i.e. on their breath or on the cross). The similarity of the instructions can be seen in Appendix B, which contains the full task instructions. Examining these instructions, one is struck by the possibility that participants could have potentially interpreted the cross-counting task as a mindfulness task. Like the breath-counting (i.e. mindfulness) instructions, the cross-counting instructions require people to maintain a singular point of focus. Indeed, some researchers have noted the importance of mindfulness instructions for the effectives of mindfulness interventions. For example, Tang et al (2007), note that they worded their instructions with the express goal of creating a particular (i.e. mindful) mental state. Notably, the instructions used by Tang et al (2007) appear to have had similar phrasing to the instructions we employed in both the breath and cross-counting tasks (i.e. to be 'aware of' rather than trying to control breathing or thoughts). Accordingly, it could be that the reason there was no effect of our 'mindfulness' condition (i.e. singular focus on the breath) was because it was being compared to *another* mindfulness condition (i.e., singular focus on the cross). However, it is important to note that even if one subscribes to this view, the results of Study 5.2 still demonstrate that there is no special benefit to focusing on the breath.

Given the relation between trait measures of mindfulness (i.e. CAMS-R & MAAS-LO) and trait flow (i.e. DECI & DECE) observed in Study 5.1, in the current study we followed up on this finding to examine the relation between trait mindfulness and *state* flow (i.e. mean scores of state DEC probes). Interestingly, we found evidence of a positive relationship between mindfulness and state flow during the X's and O's task. In particular, we found that those who scored more higher on the CAMS-R tended to experience more frequent DEC during the experiment, indicating that those who were more mindful tended to experience more state flow. However, when assessing mindfulness using the MAAS-LO (where higher scores indicate great mind*less*ness) there was no discernable relation with state flow.

In addition to the above analyses, we also conducted correlational analyses to assess questions of interest to the flow literature. First, we examined the relation between trait flow and state flow to investigate whether trait flow is predictive of flow during a particular event. We observed a positive relation between each of the two trait flow measures (DECI & DECE) and state DEC during the experimental task, indicating that those who tend to experience flow more frequently during their everyday lives also tended to experience more flow during the X's and O's task. This finding provides a conceptual replication of prior work, in which we found that trait flow predicted state flow during an attention task (see Chapter 4). In addition, the current finding indicates that the relation between trait and state flow has generalized to a different experimental task.

Secondly, we examined the relation between state flow and performance during the X's and O's task. While previous work has demonstrated that DEC during a sustained attention task is related to better performance on that task, we were curious to see whether this relation would generalize to a new (and likely more interesting) task (i.e. the X's and O's task). Study 5.2 indicated that this is indeed the case, as state flow was associated with superior performance on the X's and O's task. In particular, more frequent DEC was related to a greater proportion of targets caught, and to a smaller proportion of non-target collisions.

Study 5.3

The primary goal of Study 5.3 was to assess whether the breath-counting task (i.e. the mindfulness inducing task) would confer a benefit to DEC and/or task performance compared to the cross-counting task with instructions that were less mindful than those used in Study 5.2. To address this goal in Study 5.3 we included the same breath-counting condition that we used in Study 5.2, as well as a cross-counting condition similar to that of Study 5.2 but with simplified instructions that were stripped of their mindfulness-related content (i.e., the simplified cross-counting condition). The cross-counting task itself was unchanged. As such, if it was the similarity of the instructions that led to the null effect found in Study 5.2, then we may be able to detect a difference in DEC and/or task performance between breath-counting and the simplified cross-counting condition.

A secondary goal of Study 5.3 we to examine whether *labelling* an intervention as a "mindfulness" intervention would influence DEC and/or task performance. The secondary goal was based on a recognition of the fact that in many prominent popular publications, such as Time magazine (January 2014; August 2016), mindfulness has been depicted as a positive force in the world—one which can reduce pain, interpersonal conflict, anxiety, depression and stress and promote positive outcomes such as calmness, happiness and better focus (Barker, 2016; Pickert, 2014; Harris, 2018). Empirical research has also found participants expect mindfulness to be associated with positive outcomes such as relaxation, enhanced attention, and better performance (Pratzlich, Kossowsky, Gaab & Krummenacher, 2016; Mistretta et al., 2017). Thus, it is conceivable that participants may come into a study of mindfulness with the expectation that mindfulness will confer some benefit, and may then report experiencing benefits consistent with their expectations. To address this issue, in Study 5.3 we also included an additional condition that was identical to the breath-counting condition used in Study 5.2 (and in this study), except that the instructions referred to the task as a 'mindfulness exercise' (i.e. the mindfulness label condition). If labelling an intervention as a 'mindfulness' exercise matters, then we might find a difference in DEC and/or performance between the breath-counting condition, and the mindfulness label condition.

The design of the study also allowed us to assess the possibility that a mindfulness effect requires *both* the mindful instructions *and* the mindfulness label. Specifically, to address this possibility we can compare the simplified cross-counting condition and the mindfulness label condition. For each of these comparisons, we examined whether the groups differed in either participants' experience of DEC and/or task performance.

Methods

Participants

Data was collected from two hundred and sixty-eight (268) participants (52 males, 216 females) from the University of Waterloo during the Fall 2019 and Winter 2020 Semesters. Several participants were removed for non-compliance with experimental instructions (e.g. failing to silence or put away their phone) or anomalous events that interrupted the experiment (e.g. when construction outside caused the psychology building to smell like gasoline). A full list of the excluded participants is included with the associated data https://osf.io/2zu9h/. Participants were required to have completed the Mass Testing survey prior to signing up to participate for the study via SONA. All participants provided informed consent prior to participation. We decided a priori to collect 100 participants per condition (consistent with Study 5.2), but fell short of this goal when we had to halt data collection due to the novel coronavirus. The study was reviewed by and received ethics clearance from a University of Waterloo Research Ethics Committee.

Breath-counting Condition

In Study 5.3, the breath-counting condition was unchanged. Both the instructions and the task itself were identical to the implementation in Study 5.2 (see Appendix B for complete instructions used in the experiment).

Simplified Cross-counting Task

The cross-counting task in Study 5.3 was identical to the cross-counting task in Study 5.2. However, in Study 5.3, the instructions for the cross-counting task were simplified to remove the mindful qualities they had in Study 5.2 (see Appendix B for the complete instructions).

Mindfulness Label Condition

The mindfulness label condition asked participants to perform a 'mindfulness exercise' for 15 minutes prior to completing the X's and O's task. In fact, the mindfulness exercise was the same breath-counting task employed in the breath-counting condition. Both the instructions and the mindfulness exercise itself were identical to the breath-counting task, except for referring to the task as a "mindfulness exercise" (see Appendix B for complete instructions).

Experimental Task (X's and O's Task)

As in Study 5.2, participants were asked to perform 30 minutes of the X's and O's task after experiencing the experimental manipulation (i.e., the breath-counting task, simplified cross-counting task, or the 'mindfulness exercise'). The X's and O's task was exactly the same as in Study 5.2. As before the X's and O's task was periodically interrupted by thought probes to collect measures of DEC (i.e. flow).

State Flow (State Deep Effortless Concentration; DEC)

Participants' state DEC (i.e. flow) was once again measured via 10 intermittent thought probes, which were presented pseudo-randomly throughout the 30 minutes of the X's and O's task[43]. The probes in Study 5.3 were presented in an identical manner to those Study 5.2.

Results

Overall DEC and Performance

First, to assess whether breath-counting (i.e. mindfulness) could facilitate DEC when compared to a simplified cross-counting condition, we compared state DEC scores from these two conditions. As the distribution of the breath condition appeared slightly bimodal, we conducted an

[43] An 11^{th} probe always occurred at the end of the task, immediately prior to the end of the experimental session, but was not included so as to avoid biasing the flow measure towards participants' end of task experience.

independent samples Mann-Whitney U test, rather than a t-test as planned. The results of this test found that there were no significant differences between the two conditions $W = 4067$, $p = .961$,

Table 21. Study 5.3 Descriptives by Conditions

		Flow (State DEC)		Targets Caught (%)		NTCs (%)	
Condition	n	M(SD)	Median	M(SD)	Median	M(SD)	Median
Simplified Cross-counting	89	4.45(1.03)	4.53	56.20(9.19)	56.30	5.27(2.72)	4.90%
Breath-counting	91	4.45(1.09)	4.38	53.79(10.69)	53.90	5.94(3.91)	5.20%
Mindfulness Label	88	4.33(1.09)	4.24	56.90(11.12)	56.50	5.01(2.87)	4.75%

Note. NTCs stands for Non-Target Collisions

indicating that breath-counting (i.e. mindfulness) did not facilitate the experience of flow—even when compared to the simplified cross-counting conditions, without mindfully worded instructions. When examining task performance, we found similar results. There were no significant differences between the breath-counting condition and the simplified cross-counting condition either in terms of the proportion of targets caught[44] $t(178)=1.62$, $p = .107$, nor in the proportion of non-target collisions $W = 3744$, $p = .383$.

Next, we examined whether the use of the term 'mindfulness' could facilitate DEC by comparing the mindfulness label condition to the breath-counting condition. A Mann-Whitney U test revealed that there were no significant differences between these two conditions $W = 4186.50$, $p = .599$ indicating that participants did not experience any additional DEC when they were expecting to complete a mindfulness task (i.e. when they saw a task labelled as mindfulness in the instructions). The mindfulness label (condition) also does not appear to facilitate task performance, as there were no significant differences between the mindfulness label condition and the breath-

[44] Proportion of targets caught was normally distributed, so we conducted a t-test as planned.

counting condition on either the proportion of targets caught $t(177) = 1.90$, $p = .059$ or non-target collisions $W = 4655.50$, $p = .06$.

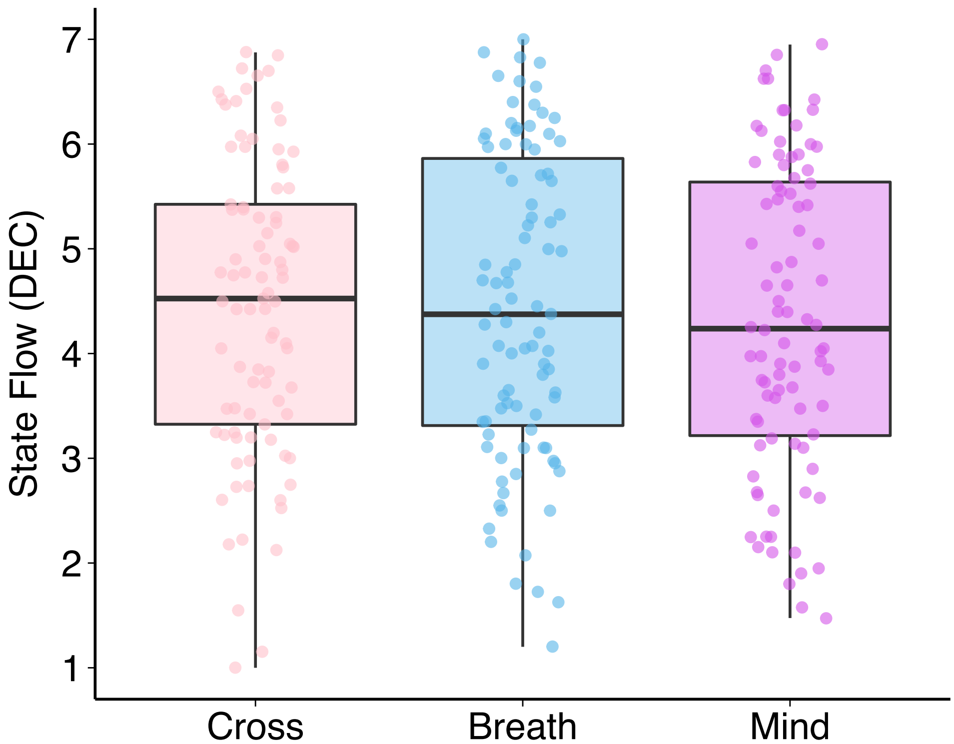

Figure 20. State flow (overall average) by condition in Study 5.3.

Finally, we examined whether both the mindful instructions and the mindfulness label were necessary to observe a mindfulness effect by comparing the mindfulness label condition to the simplified cross-counting condition. A Mann-Whitney U test indicated no significant differences in DEC between the mindfulness label and cross-counting conditions $W = 4102$, $p = .586$. In terms of task performance, an independent samples t-test found there were no significant differences between the mindfulness label and the simplified cross-counting task in the percentage of targets caught $t(175) = 0.46$, $p = .650$, and a Mann-Whitney U test indicated there were no significant differences in the percentage of non-target collisions $W = 4217$, $p = .377$. Taken together, these results suggest that even with the mindfulness label and the mindful instructions, focused attention on one's breathing (i.e. mindfulness) did not facilitate the experience of flow (or task performance) compared to a basic focused attention task.

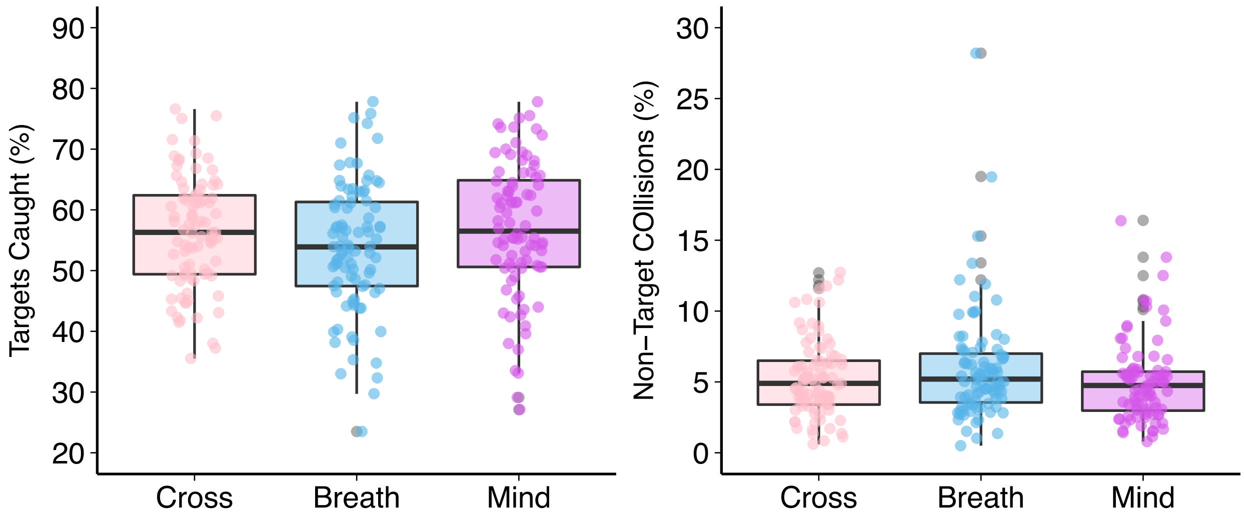

Figure 21. Performance on the X's and O's task by condition in Study 5.3.

DEC and Performance over Time

As in Study 5.2, we conducted three mixed ANOVAs to examine whether the conditions differed at any point over the time-course of the experiment. First, we conducted a 3x10 ANOVA on DEC with Condition (i.e. simplified cross-counting, breath-counting, or mindfulness label) as the between-subject factor and Time (probe) as the within-subjects factor. Mauchly's test indicated that the assumption of sphericity had been violated W = .025, $p < .05$, so Greenhouse-Geisser corrected tests are reported ($\varepsilon = .44$). The omnibus ANOVA revealed that the main effect of Condition was not significant $F(2, 258) = 0.17$, $p = .846$, $\eta^2 = .0009$, though there was a significant main effect of Time $F(3.96, 1021.68) = 79.44$, $p < .001$, $\eta^2 = .088$, and a significant interaction between Condition and Time $F(7.92, 1021.68) = 2.59$, $p <.001$, $\eta^2 = .006$. To investigate the interaction, we conducted post-hoc t-tests.

There was a significant difference between the breath-counting condition ($M = 5.25$, $SD = 1.36$) and the simplified cross-counting condition ($M = 4.44$, $SD = 1.48$) at the first probe $t(173) = 3.79$, $p < .001$, such that those in the breath-counting condition experienced more DEC than those in the simplified cross-counting condition. There was also a significant difference between the mindfulness label condition ($M = 5.16$, $SD = 1.28$) and the simplified cross-counting condition ($M = 4.44$, $SD = 1.48$) at the first probe $t(172) = 3.45$, $p < .001$, indicating those in the mindfulness-

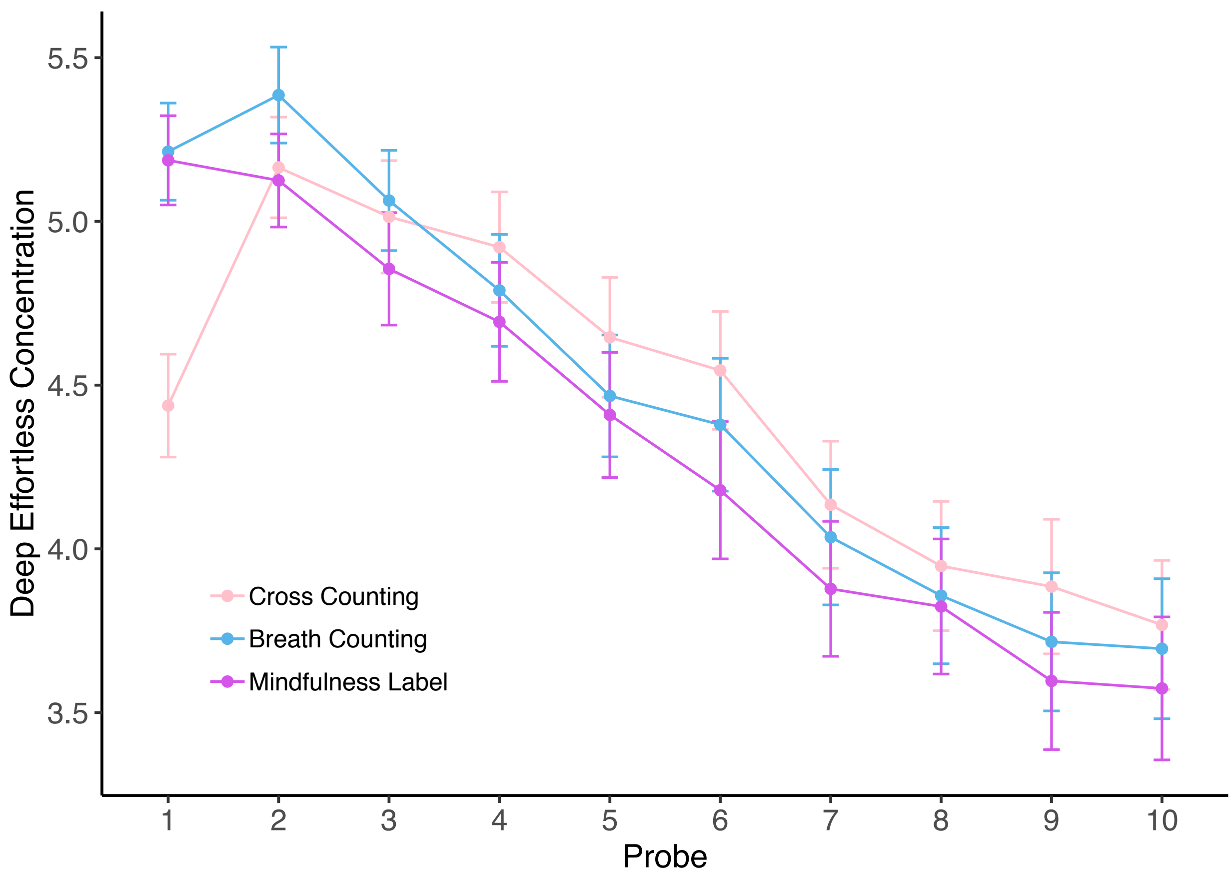

Figure 22. State flow over Time (probe) during the X’s and O’s task in Study 5.3.

label condition experienced significantly more DEC than those in the simplified cross-counting condition. However, there was no significant difference between the breath-counting (M = 5.25 SD = 1.36) and mindfulness label (M = 5.16, SD = 1.28) conditions, $t(171)$ = .46, p = .663, suggesting that the presence of the mindfulness label did not significantly impact participants' experience of DEC. There were no significant differences between the conditions at any other time-point.

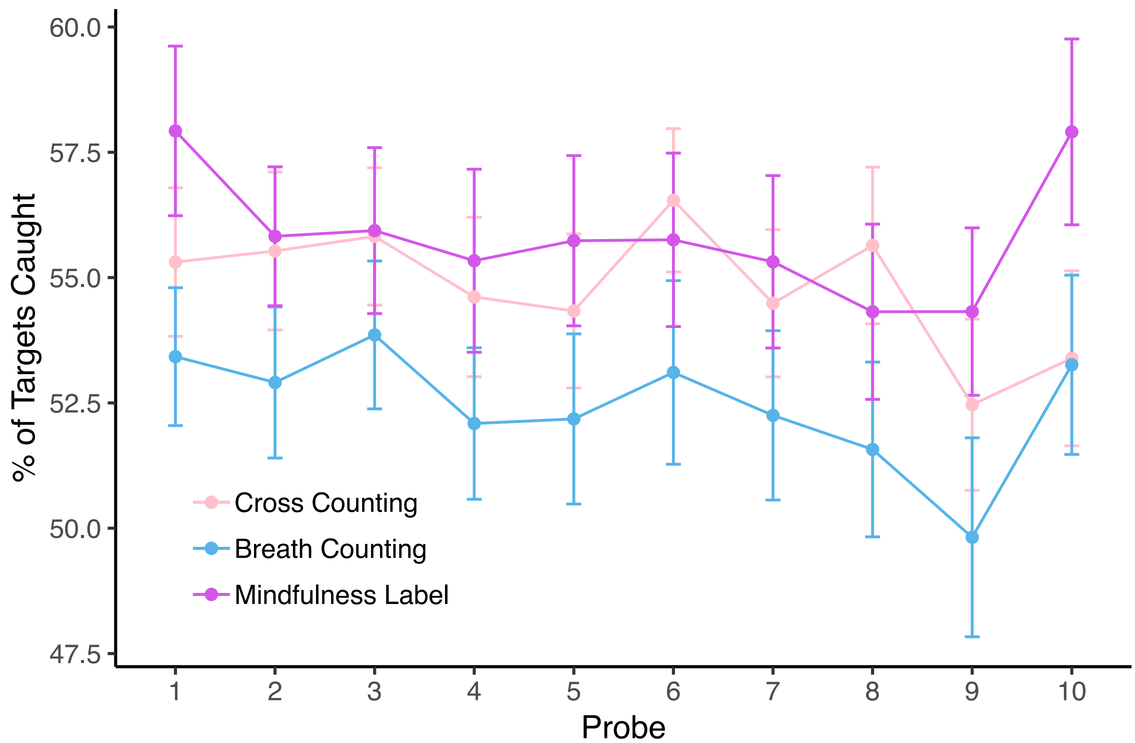

Figure 23. Percentage of targets caught over Time during the X's and O's task in Study 5.3.

Next, we examined the whether there were any differences between the conditions as a function of time by conducting a 3X10 mixed ANOVA on the proportion of targets caught. For this ANOVA, Condition (simplified cross vs breath-counting vs mindfulness label) was the between-subjects factor and Time (probe) was the within-subjects factor. Mauchly's test indicated that the assumption of sphericity had been violated W = .80, $p < .05$, so Huynh-Feldt corrected tests are reported ($\varepsilon = .98$). The results of the omnibus ANOVA indicated that there was no significant main effect of Condition $F(2, 265) = 2.19$, $p = .114$, $\eta^2 = .008$. There was a significant main effect of Time $F(8.82, 2337.30) = 1.93$, $p = .044$, $\eta^2 = .004$, but no significant interaction $F(17.64, 2337.30) = 0.54$, $p = .940$, $\eta^2 = .002$.

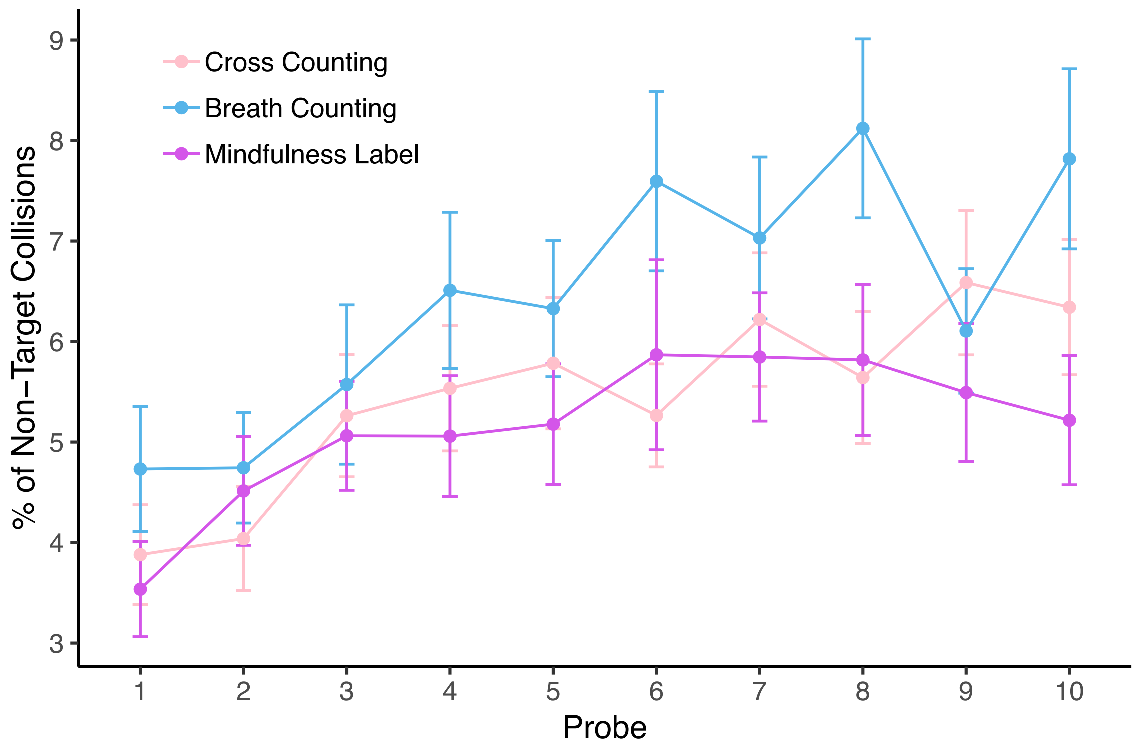

Figure 24. Percentage of non-target collisions over Time during the X's and O's task in Study 5.3.

Finally, we examined whether there were any differences in the proportion of non-target collisions between the conditions as a function of time by conducting a 3X10 mixed ANOVA. For this ANOVA, Condition (simplified cross vs breath-counting vs mindfulness label) was the between-subjects factor and Time (probe) was the within-subjects factor. Mauchly's test indicated that the assumption of sphericity had been violated W = .68, $p < .05$, so Huynh-Feldt corrected tests are reported ($\varepsilon = .96$). The omnibus ANOVA indicated that there was no significant main effect of Condition $F(2, 265) = 2.72$, $p = .068$, $\eta^2 = .008$. There was a significant main effect of Time $F(8.64, 2289.60) = 6.81$, $p < .001$, $\eta^2 = .016$, indicating the proportion of non-target collisions increased over the course of the experiment. The interaction between Condition and Time was not significant $F(17.28, 2289.60) = 0.88$, $p = .600$, $\eta^2 = .004$.

Trait Measures and State DEC

In Study 5.3, trait mindfulness was assessed via the MAAS-LO which was included in the mass testing survey in the Winter 2020 term. The MAAS-LO was found to have a significant negative correlation with state DEC r(153) = -.18, $p = .022$ indicating that those who are more mindless tended to experience DEC less frequently during the experimental task.

In addition, we once again examined the relation between trait and state DEC. Consistent with the results of Study 5.2, both the DECI $r(252) = .29$, $p < .001$ and DECE $r(253) = .27$, $p < .001$ were found to have significant positive correlation with State DEC. These results indicate that the frequency with which one experiences flow in everyday life predicted the experience of flow during the X's and O's task.

Relation between State DEC and Task Performance

As in Study 5.2, we once again examined the correlation between State DEC and task performance on the X's and O's task in Study 5.3. State DEC was found to have a significant relation with both performance metrics. Specifically, those who reported more frequent DEC during the task caught a greater percentage of targets r(266) = .32, $p < .001$ and successfully avoided more non-targets r(266) = -.25, $p < .001$. Thus, for both performance measures, higher

DEC scores were related to superior task performance, providing evidence that flow is positively related to performance.

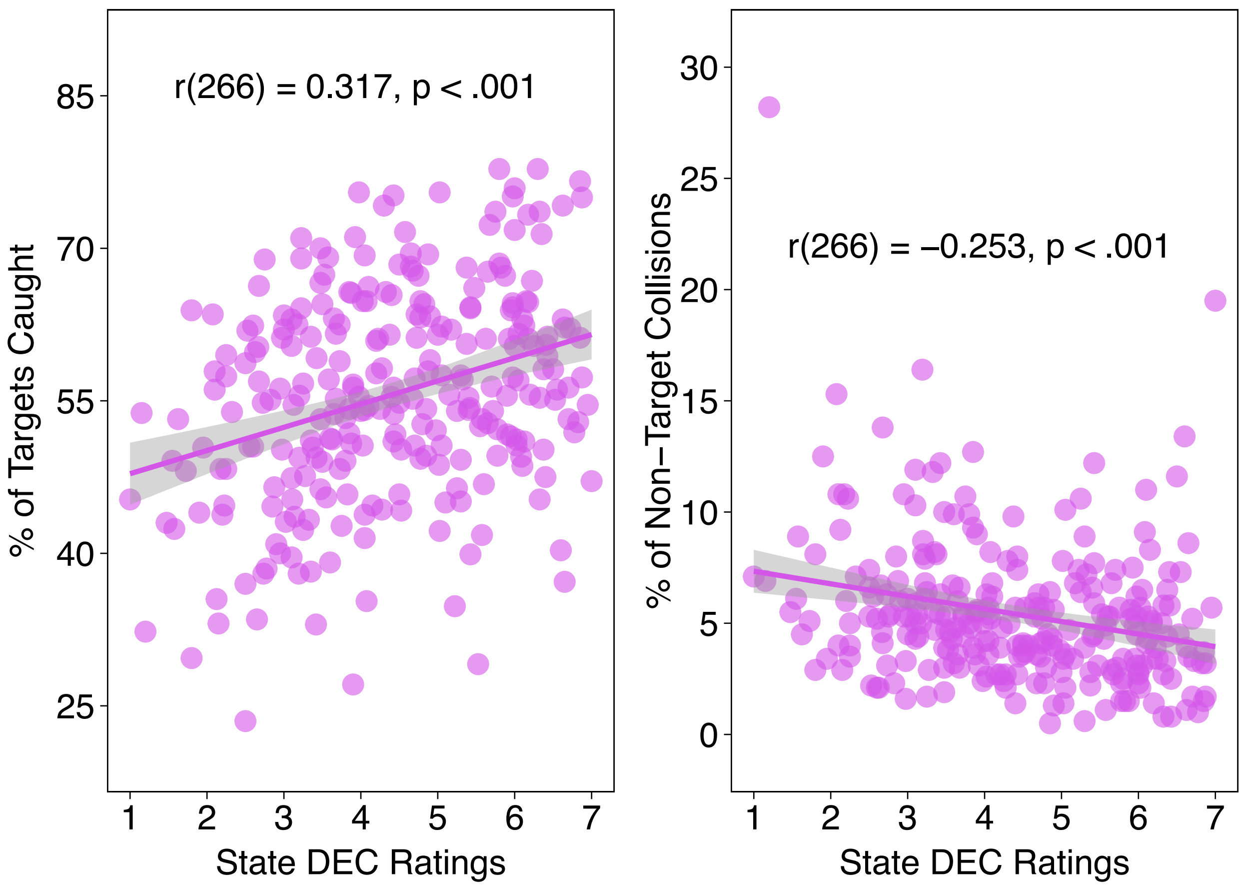

Figure 25. Relation between state flow and overall task performance in Study 5.3.

Study 5.3 Discussion

When examining the data averaged across the entire duration of the experiment, the results of Study 5.3 suggest that a brief mindfulness intervention (whether labelled as breath-counting or mindfulness) does not facilitate either the experience of deep, effortless concentration or improved performance on the experimental task. Specifically, neither the breath-counting condition nor the mindfulness label condition were significantly different from the simplified cross-counting condition in terms of either DEC, proportion of targets caught, or proportion of non-target collisions. Notably, the mindfulness label condition did not differ from either the breath-counting condition or the simplified cross-counting condition in terms of overall average DEC or task performance. This suggests that the presence of the term mindfulness in the task instructions did not significantly impact the effectiveness of the mindfulness induction.

However, when the data were analyzed across time, the results suggest that mindfulness is able to *briefly* facilitate the experience of deep, effortless concentration. In particular, the results indicated that participants in the breath-counting condition and mindfulness label condition experienced significantly more flow (i.e. DEC) than participants in the simplified cross-counting condition—but only at the first probe (i.e. within the first time window). Thus, the benefit appeared to wear off after the first three minutes of the task, as the three conditions did not significantly differ from one another at any of the other timepoints. However, when examining performance, the results indicated that there was no significant interaction effect between condition and time for either the Proportion of Targets Caught or the Proportion of Non-Target Collisions. Thus, the faciliatory effect of the two mindfulness conditions appears to be restricted to participant experience.

While the CAMS-R was not included in the Mass Testing survey during data collection for Study 5.3, the MAAS-LO was included in the Winter 2020 term. Thus, we were able to examine the relation between trait mindfulness (as measured by the MAAS-LO) and state DEC in a subset of the participants in Study 5.3. After collapsing across conditions, the MAAS-LO was found to have a significant negative relation with state flow, indicating that those who are more mindless (i.e. less mindful) tended to experience less flow during the X's and O's task. However, this finding is inconsistent with the results of Study 5.2, where it was found that there was no significant relation between the MAAS-LO and State DEC in a slightly larger sample (n=189). This inconsistency suggests that while there may be a relation between the MAAS-LO and State DEC, it would seem to be both small and highly variable.

In addition, we examined the relationship between trait flow (e.g. DECI & DECE) and state flow (i.e. DEC) during the X's and O's task. The DECI and DECE were found to be significant, positive predictors of the experience of state DEC during the task—a finding consistent with both the results of Study 5.2, and previous work examining the relation between trait and state flow assessed as DEC (Marty-Dugas, Howes & Smilek, submitted).

Finally, when collapsing across all three conditions, state DEC was again found to have a significant positive relation with performance on the X's and O's task, consistent with the results of Study 5.2. Specifically, those who experienced DEC more frequently during the task also caught a greater proportion of the targets, and were more successful at avoiding collisions with non-targets.

Chapter 5 Discussion

The present studies yielded the following main conclusions: First, at the level of individual differences, we observed that individuals who report being more mindful also report experiencing flow more frequently in their everyday lives (Study 5.1). Second, people who reported more trait-level mindfulness also experienced more flow during the experimental task (Studies 5.2 and 5.3). Third, and most importantly, we found that a brief mindfulness-based exercise can increase—though in a limited manner and for a very brief duration—state-level flow during a game-like task (Studies 5.2 and 5.3).

One of the unique contributions of the present studies concerned the way we assessed flow. This was done using measures that specifically define flow as deep, effortless concentration, and the combination of this assessment of flow with an assessment of mindfulness, which was assessed using multiple measures that effectively capture different aspects of the mindfulness construct. With regard to our measure of flow (i.e., DEC), we were able to assess the core aspect of flow without the potentially contaminating effects of various extraneous factors (i.e. causes and consequences of flow), such as time distortion and skill-challenge balance. With regard to mindfulness, we included two measures (CAMS-R and MAAS-LO) that conceive trait mindfulness in slightly different ways: The MAAS-LO assesses mind*lessness*, or the *inverse* of mindfulness; while the CAMS-R seems to consider mindfulness in terms of acceptance and non-judgmental thinking[45]. Despite the differing conceptualizations, these measures lead to similar conclusions. Assessing the DEC and mindfulness measures together, we found that at the level of individual differences, higher levels of mindfulness are associated with more frequent flow experiences.

Our experimental results also add important nuance to the possibility that a brief mindfulness intervention (in the form of a brief induction) can facilitate the experience of flow. Importantly, we found that the conclusion drawn regarding the effectiveness of a mindfulness intervention on flow critically depends on the level of analysis; specifically, it depends on whether the DEC data are aggregated across the entire task, or whether they are examined in terms of specific probes indexed at different time points in the task. When we examined mean flow aggregated across all DEC probes there were no differences between any of our mindfulness intervention conditions (Studies 5.2 and 5.3). In contrast, when we examined the data as a function of distinct probes that unfolded over time in the studies, we consistently found an interaction

[45] Importantly, the relations between DEC measures and CAMS-R were calculated having removed two items of the CAMS-R which shared similarities to DEC. That is, two of the items in the CAMS-R assess the ability to sustain attention over time. Since we removed these two items, the relations between CAMS-R and DEC measures could not have been driven by surface similarities in the items of the scales.

between mindfulness intervention condition and the individual probes. When examining the associated graphs it appears the interaction is driven by a cross-over interaction, whereby compared to the cross-counting conditions, participants in a mindfulness condition (i.e., the breath-counting or mindfulness label conditions) began with higher flow scores in the early part of the task and end up with lower flow scores by the end of the task. Note that while there were seldom any significant differences between the conditions for any given probe, the omnibus ANOVA consistently suggested that there was a significant interaction, and the differences between conditions appeared to be (nominally) more pronounced for earlier probes. This suggests that a brief mindfulness intervention may benefit flow for a brief period of time.

The present findings are promising, and they suggest that it may be fruitful to examine whether multiple sessions of mindful breath-counting might lead to a larger or more consistent benefit to the experience of flow. That is, if a brief mindfulness intervention can lead to a small benefit and facilitate flow for a short period of time, longer mindfulness interventions may lead to larger or longer lasting benefits. Potential experiments could examine the efficacy of breath-counting sessions that are longer in duration, take place over multiple sessions, and interventions lasting several weeks. Previous anecdotal work (Aherne et al., 2011; Bernier et al., 2009; Chen, Tsai et al., 2019; Kaufman et al, 2009; Scott-Hamilton, 2016) has indicated that mindfulness interventions over a period of weeks can facilitate flow, which lends some support to this idea. Further support comes from findings that mindful breath-counting over a period of 20 days can facilitate better attention, as assessed by mind-wandering during breath-counting[46]. Moreover, some work has found that practicing state mindfulness (e.g., mindfulness meditation) over multiple sessions can lead to changes in trait mindfulness (Kiken et al., 2015), such that individuals become

[46] In this instantiation, breath counting was also supported by calming ambient sounds, contemplative music, and a soothing mindful voice which may have had an influence.

more mindful at the trait level. Similar results have been demonstrated with breath-counting (Levinson et al., 2014), but only in a small sample (n = 22). Given the reliable findings between trait mindfulness and flow in the current study, it would be interesting to see whether multiple sessions of breath-counting would facilitate flow through increases in trait mindfulness.

Of particular importance was our inclusion of an active control group in the form of the cross-counting task (and simplified cross-counting task) when we assessed the influence of mindful breath-counting on flow experience. While prior work has indicated that mindfulness meditation *reduces* flow in a subsequent task (Sheldon et al., 2014) the study did not have an active control condition and, in fact, the comparison group spent less time in the experimental session. As such, in Sheldon et al.'s study, flow may have been reduced in the mindfulness meditation condition relative to the control condition simply because the experiment was longer for participants in that condition. By including an active control, the present studies were able to demonstrate that mindfulness did not lead to significantly lower flow scores when compared to an active control condition. In fact, as we noted earlier, a mindfulness intervention even appears to briefly *facilitate* flow in the subsequent task[47]. This being said, it is important to note that there were other differences (in addition to the presence of an active control) between the present study and the study reported by Sheldon et al. (2014)—such as the nature of the flow measure, the task being performed and the details of the mindfulness intervention.

Interestingly, while those in the cross-counting group had lower DEC scores on the first probe, their DEC scores rose from probe one to probe two in both Study 5.2 and 5.3. Thus, while

[47] It may be interesting for a future research to compare breath counting to other active control tasks. For example, like the breath-counting task, the cross-counting task is rhythmic in nature (i.e. crosses are presented with a consistent timing or 'beat'). If breathing becomes entrained with the presentation of the cross, then participants in the cross-counting conditions may have had a similar breath rate to those in the breath-counting condition (even though they were not explicitly focusing on the breath). Thus, it is possible that the difference between these two conditions would be greater if the cross-counting task was presented with a variable inter-stimulus interval (ISI), rather than with a consistent ISI as was the case in the present study.

DEC tended to decrease over time (i.e. probe) in all conditions, in the cross-counting condition DEC scores rose from probe one to probe two. One possibility is that entering a flow state is not immediate upon starting a task—rather, that it may take some time to reach a flow state. This could explain the jump in DEC from probe one to probe two in the cross-counting group. If this is the case, it could be that breath-counting helps one enter a flow state more quickly, thus leading to the higher DEC scores at probe one (in the breath-counting and mindfulness conditions). Another possible interpretation, however, is that cross-counting may interfere with the flow state (but only briefly) resulting in lower DEC scores in the cross-counting group, relative to the other two groups, at probe one. Teasing these possibilities apart could be addressed in future research with additional active control groups—such as 15 minutes of doing nothing, or 15 minutes of scrolling through one's smartphone. However, it is important to keep in mind that in this situation it is unclear what a truly 'neutral' condition would be (for more on the issue of selecting neutral conditions, see Jonides & Mack, 1984).

Focusing for a moment on the concept of flow, we note that our studies revealed several interesting findings relevant to the flow literature. For one, we found that flow during the task was consistently related to better performance. In both Study 5.2 and Study 5.3, both of which included large samples, we consistently found that those who reported more frequent DEC also tended to have a higher percentage of targets caught and a lower percentage of non-target collisions. This finding is consistent with prior work examining flow and task performance (Kennedy et al., 2014; Chapter 4), and with qualitative and descriptive studies which also indicate a relation between flow and better performance (Csikszentmihalyi, 1990; Jackson, 1995). In addition, we found that trait level flow was related to state-levels of flow indexed with probes as participants completed a task in the laboratory. Importantly, these trait measures were measured well prior to the experimental session, and in a different context (i.e. as part of a much larger survey). As such, this degree of convergence between trait and state measures is encouraging, and suggests that flow experienced induced in the laboratory relate to people's general tendencies to experience flow in everyday life. Importantly, this finding is consistent with prior work (see Chapter 4) indicating that trait measures of flow predict the experience of state flow in two different laboratory tasks (i.e. The X's and O's task and a sustained attention task.

In conclusion, we note there is a rapidly growing interest in the potential of mindfulness practices and other self-transcendent experiences both to alleviate negative experiences, such as depression (Kuyken et al., 2015) and anxiety (Hofmann, Sawyer, Witt & Oh, 2010), as well as to increase attentional engagement in everyday tasks, such as learning in the classroom (Meiklejohn et al., 2012; Napoli, Krech & Holley, 2005) or performance at work (Good et al., 2016). In the present study, we documented a link between mindfulness and flow, and the possibility that flow may be facilitated through mindfulness training. Future studies should focus on the potential impact of regular mindfulness mediation practices on flow experience to understand the impact this of practice on our experience deep, effortless concentration.

General Discussion and Conclusion

General Summary of Findings

Broadly, the work in the present dissertation has contributed to the over-arching goal of understanding and encapsulating the experience of flow. By working towards this goal, there have been four key contributions of the present work: 1) Theoretical contributions via the re-conceptualization of the flow construct, 2) The development of metrics for assessing the experience of flow as deep, effortless concentration, 3) Elucidating the precise relations between the defining characteristic of flow (i.e. DEC) and conceptually relevant variables (such as sustained attention and well-being), and 4) Identifying a promising avenue for future research on how the experience of DEC might be facilitated (i.e. mindfulness).

In accordance with the reconceptualization of flow that outlined in Chapter 1, we developed two measures for assessing the frequency of deep, effortless concentration in both internal (DECI) and external (DECE) activities. The scales were found to have high internal consistency (see Study 2.1, 3.1 & 2.3), and to be reasonably stable when measured across time (Study 3.3). The results of a confirmatory factor analysis indicated that these two measures tapped two related, but nonetheless distinct, latent factors therefore indicating that internal and external flow are separate constructs.

Having developed two reasonable measures, we began examining how the experience of deep, effortless concentration related to several variables of interest. Generally, we found that those who tended to experience flow more frequently also tended to have better sustained attention, both in everyday life (as assessed via subjective reports; Study 2.1 and 3.2) and during a behavioural sustained attention task (Study 4.1). Deep effortless concentration was also found to be associated with greater well-being in several independent samples, such that those who experienced flow more often tended to have higher well-being.

Finally, in Chapter 5, we explored a potential strategy for facilitating the experience of DEC. Specifically, we found evidence that, at the level of individual differences, mindfulness is positively related to the experience of DEC, such that those who are more mindful tend to experience flow more frequently (Study 5.1). Trait mindfulness was found to predict the experience of DEC during a laboratory task (Study 5.2). In addition, we found that those who practice 15 minutes of mindful breath-counting experienced more DEC in the first few minutes of a subsequent task than those in an active control group (5.2 & 5.3). Taken together, these findings suggest that mindfulness meditation is a promising strategy for facilitating flow as well as for future research.

In addition, over the course of this dissertation we examined both trait and state flow, in several studies. In each, we found a positive relation between trait and state flow in (see Study 4.1, 5.2 and 5.3), indicating that our DECI and DECE are able to predict the experience of flow in laboratory tasks.

Theoretical contributions

In order to better understand the experience of flow, it was first necessary to establish a clear theoretical basis through which to understand the flow experience. Under the multi-faceted global view of flow, researcher degrees of freedom *at the conceptual level* have made flow into a highly elastic and inconsistent concept. That is, the conceptualization and measure of flow continuously shift across different studies (and when examining flow in different contexts), as researchers pick and choose different facets to include in their measures (see Hoffman & Novak, 2009). Some have noted that "It is an understatement to suggest that there is some lack of consistency in operational definitions of flow" (Hoffman & Novak 2009, p. 26), while others have (more bluntly) noted that "the construct of flow is, however, too broad and ill-defined". By defining flow as the experience of deep, effortless concentration—and developing measures through which to assess this experience—the present work may prove most valuable through helping bring greater conceptual clarity and consistency to the flow literature, both in terms of conceptualization and measurement. Specifically, this contribution comes from reducing the elasticity of the flow concept by way of the DEC re-conceptualization, such that the nature flow experience is now more refined.

Further, with a DEC definition flow can now be studied in a broader range of circumstances. While one might expect refining the flow definition to restrict the number of circumstances it can apply to, the DEC conceptualization actually presents more to study flow in new scenarios which may have previously been ignored. For example, as we noted in Chapter 1 flow research has typically focused on the experience of flow in external circumstances—perhaps in part, because the measurement of flow developed with a focus on sports (e.g. Jackson, 1995; Jackson & Marsh, 1996)—which may have caused a reference to external tasks to become integral to the concept of flow. As such, previous conceptualizations of flow may have biased the literature towards excluding certain contexts, such as flow in internal thought (Nakamura & Csikszentmihalyi, 2002). However, as we noted earlier, DEC can apply equally to multiple contexts both external and internal. Thus, while DEC makes the definition of flow more specific, this specific definition reflects *a more general process* (i.e. DEC) that applies to more situations/activities (whereas facets such as action-awareness merging may only apply to certain activities). Importantly, this means that the experience of flow (i.e. DEC) can be more studied more broadly while keeping the conceptualization and measurement of flow consistent across situations—an advantage over previous conceptualizations where the definition and/or measurement of flow often shifted depending on the activity in which flow was being examined.

In addition, the DEC conceptualization helps to avoid a common conceptual error in the measurement of flow—specifically the confusion that can occur when the putative causes of flow are conflated with the characteristics of the flow experience itself. As we outlined in Chapter 1, under the global flow conceptualization, a common practice is summing participant responses from multiple facets of flow to create global flow scores—thus combining the precursors and consequences of flow into a single measure. This is conceptually problematic, as several facets considered to be the antecedents to flow (i.e. skill-challenge balance, clear goals, unambiguous feedback; Hamari & Koivisto, 2014; Jackson et al 1995; Nakamura & Csikszentmihalyi, 2002) are included in the assessment of the flow experience itself. By conflating the preconditions of flow with the experience itself, the global flow approach can lead to misleading inflations in the size of correlations. For example, in a meta-analysis examining the relation between skill-challenge balance and flow, Fong et al (2014) found that the correlation between skill-challenge balance and flow was significantly higher when skill-challenge balance and flow were assessed with global flow measures ($r = .75$) as opposed to separate measures ($r = .30$). In other words, the measurement issues associated with the global flow conceptualization can lead to huge overestimation of the relation between skill-challenge balance (thought to be a key precursor of flow) and flow experience by including skill-challenge balance in the correlation twice. Under a DEC conceptualization, where skill-challenge balance is clearly indicated as a precursor and flow experience is defined as DEC, this issue is perhaps more apparent and might be avoided.

Going forward, the DEC conceptualization might also prove useful in investigating some of the tenets of flow theory. One example, is the central tenet that optimal skill-challenge balance engenders the experience of flow (Hamari & Koivisto, 2014; Jackson, 1995; Nakamura & Csikszentmihalyi, 2002), and that the relationship between flow and skill-challenge balance has an inverted-U shape curve. Notably, despite the primacy of this claim, hardly any of the studies investigating the relation between skill-challenge balance and flow have experimentally manipulated different levels of skill-challenge balance (Fong et al., 2014). Further, of those studies which are experimental, it has been suggested that the level of difficulty employed when examining the relation between skill-challenge balance and flow is too extreme (Schiefele & Raabe, 2011). That is, in the underload condition, task difficulty is often so low that success is all but guaranteed, whereas in the overload condition the task is so difficult that success is next to impossible. Compared to these two conditions, it may be unsurprising that 'optimal' skill-challenge balance produces the most flow—it is the condition with a reasonable level of difficulty. Thus, examining the relation between DEC and different levels of task difficulty may be an important first step.

Flow and Sustained Attention

One theme throughout the present work has been to examine the relation between flow and sustained attention, both behaviourally and through self-report. While flow has sometimes been described in terms of attention, the relation between sustained attention and flow is not trivial. In considering this relation, we identify three critical components which are all related, but nonetheless distinct, and which can be dissociated from one another. The first component is *performance* on sustained attention tasks such as the SART. The second component is the *cognitive process* of attending to the task, or how well one is paying attention (for example, whether one is mind-wandering, media multitasking, or pay close attention to the task). The third component is the *subjective experience* during a task, specifically with regard to the extent to which one's engagement feels, deep, effortless and fluent (i.e., flow).

Let us now consider how these various components are distinct from one another. First, we note that task performance (the first component) is distinct from the cognitive process of attending to the task (the second component). Typically, in sustained attention tasks, participants must respond to infrequent critical targets (or non-respond to the them in the case of the SART). In these tasks, one may be attending to a task very closely but performing poorly (as in a difficult task), or one may be attending very little, but still performing very well (e.g. in an easy task). As pointed out by Thomson et al (2015), many tasks do not require one's full attention to maintain performance, and as such, mind-wandering (which can be taken as an index that participants are not attending to the task) can occur without causing performance cost. Research on mind-wandering during vigilance tasks provides several examples of this[48]; for example, mind-wandering rates are lowest in the most difficult condition of a word reading task, and yet it is in this condition that task performance is lowest (Thomson, Besner & Smilek, 2013. In another study using a visual search paradigm, mind-wandering rates were higher in the easier (low perceptual load) condition, but performance in this condition was higher than in the more difficult (high perceptual load) condition, which had lower mind-wandering rates (Forster & Lavie, 2009). As another example, Ralph (2017) compared the performance of two groups on a low demand task (i.e. the 0-back), where one group was given the option to watch a task-irrelevant video during the task. Despite completing the majority of trials with the video on, participants in this group were able to maintain a high level of performance (above 90% hits, and less than 5% false alarms)—further, their performance did not significantly differ from those in the control group. As these

[48] Where mind-wandering is assumed to index the cognitive process of attending to the task.

examples clearly demonstrate, task performance can clearly be dissociated from the cognitive process of attending to the task.

Similarly, the degree to which one is actually attending to the task (the second component) can be dissociated from DEC/flow (the third component). Firstly, one could be attending to task well (i.e. monitoring the task diligently with minimal inattentiveness), *without* feeling that one is in the zone (i.e. *not* experiencing deep, effortless concentration). Second, it is also possible that one could be experiencing DEC and *not* actually attending very well to the task. This is because DEC, by definition, refers to an individual's subjective perception of the quality of his or her engagement—and though one might perceive that they are deeply attending to something, and their engagement feels smooth and fluid, their perception may be wrong. That is, it is possible that despite having a feeling of fluency or effortlessness, one may not be actually engaging attentional processes in an effective way. We can find a useful analogy in the context of classroom learning. Students may often feel as though they comprehend a topic well (e.g. it felt fluent while listening), but misjudge their level of understanding. As a result, they may be shocked or disappointed in their performance on the test, or their inability to recall the construct and explain it to someone else.[49] Similarly, because flow/DEC is a perception of the quality of one's engagement, it can be dissociated from the cognitive process of actually attending to the task.

Furthermore, DEC is also distinct from attention performance. Importantly, DEC is not just an absence of attention errors, and in some cases, one might even make attention errors or perform a task poorly while experiencing DEC. As can occasionally occur during the writing process, one may experience flow while writing a draft (of an article, a class assignment, or a dissertation

[49] For example, there is a wide body of research Judgements of Learning (JOLs) which examines the relationship between one's confidence in their future memory performance, and their actual performance at recall. Perceptual fluency is one factor which seems to play an important role in JOLs (for more on JOLs, see Dunlosky, Mueller & Tauber, 2015; Rhodes, 2016; and Fiaconni, Mitten, Laursen, & Skinner, 2020)

chapter), but find the same draft to be incomprehensible upon a second look. This is because DEC is the subjective experience of deep, effortless concentration—it is the perception of high quality, fluent engagement with a task—and is not equivalent with task performance or sustained attention in everyday life.

From the current data, it is not clear whether improved performance on sustained attention tasks result from the experience of flow, or whether DEC emerges alongside good attentional performance. As neither the experience of DEC, nor performance can be manipulated *directly*, determining one causal direction may be difficult. Indeed, it could be the case that more flow leads to better performance and/or that better performance leads to more flow. Using structural equation modelling to examine the contributions of DEC to explaining subsequent performance (and performance to explain subsequent DEC) may prove to be a more fruitful approach. (For example, this approach has been used to address similar problems in the study of hypnosis, see Benham, Woody, Wilson & Nash, 2006).

One interesting possibility is that DEC may cause people to return to particular tasks in the future. For example, experiencing DEC during an activity might cause one to pursue that activity more often in the future—in order to experience DEC again. Lending some support to this notion is recent work which found that deep, effortless concentration is positively related to grit—a concept defined as consistency of interest and commitment to long term goals—such that those who experience flow more often are higher in grit as well (Smith et al., 2020). Further, previous work has reported that the experience of flow during high school science was predictive of student's major in college—those who experienced flow more frequently tended to major in science (Shernoff & Hoogstra, 2001). However, given the shortcomings of previous flow conceptualizations, it would be beneficial to employ similar designs with a DEC perspective to better characterize the effect on flow on subsequent behaviour. Of course, it is also possible that DEC is epiphenomenal. Indeed, as with *any* conscious state there is no strong way to clearly rule out this possibility. Nonetheless, examining how DEC relates to subsequent behaviours is likely to be a fruitful avenue for future research.

DEC as an Integrative Framework for Flow and Flow-like experiences

At the end of Chapter 1, we discussed the relation between our trait measures of DEC (i.e. DECI/DECE) with both the TAS, the gold standard measure of individual differences in absorption, and the SFPQ, a trait measure of global flow. Flow and absorption seem to be highly overlapping constructs; flow is characterized by the experience of deep, effortless concentration, while absorbed has been described as a propensity for experiencing episodes of ‘total attention’ (Tellegen & Atkinson, 1974). Furthermore, absorption has also been used as a way to define flow experience in many studies (Crust & Swann, 2013; Csikszentmihalyi, 1990; Csikszentmihalyi & Nakamura, 2002; Harari, 2008; Jackson, 1995; Jackson & Marsh, 1996; Jackson et al., 2001 Jackson et al, 2008; Martin & Jackson, 2008; Peifer, Schulz, Schächinger, Baumann, & Antoni, 2014; Schiefele & Raabe, 2011; Schiefele, 2013; Ullén et al., 2010, Wright, Sadlo & Stew, 2006; Wright, Sadlo & Stew, 2007). Given this overlap, one might even assume that flow and absorption are the same construct. However, the literature on absorption and flow seem to have developed with relatively little reference to one another—and as such, examining the correlations between these various measures was a key contribution of Study 1. Nonetheless, despite the high degree of *conceptual* overlap between DEC and absorption, we found in Study 1 that there was only a modest degree of overlap between their respective *measures* (e.g. DECI/DECE and the TAS), and notably there was no correlation between the TAS and SFPQ. In addition, the DECI/DECE and SFPQ were found to have a strong positive correlation. This pattern of findings might be considered somewhat surprising, given the conceptual overlap between flow, absorption and DEC.

As a potential explanation for this pattern of results, we proposed that the various measures of flow and absorption (DECI/DECE, SFPQ, TAS) may be assessing different aspects of a more general flow/absorption experience through the use of the different measurement strategies. Recall that the TAS measures absorption indirectly, and many of the items have a dissociative quality; in contrast the SFPQ measures flow by indexing multiple facets, such as enjoyment and feeling in control[50]. In other words, the TAS seems to focus on more negative absorptive states, while the SFPQ seems to be focused on more positive absorptive states. On the other hand, the DECI/DECE directly measure flow by assessing the experience of deep, effortless concentration without any explicit references to positive or negative qualities of this deep engagement. One possibility is that the DECI/DECE tap the general construct of deep, effortless concentration, while the TAS taps some of the general construct, but also a variety of negative states, and the SFPQ taps the general construct as well as other mostly positive experiences[51]. These considerations could explain why both the TAS and the SFPQ have positive correlations with the DECI/DECE, but no relation to one another; the specific areas of focus of the TAS and SFPQ are quite different from one another, and as a result they have virtually no correlation with one another, and yet both significant

[50] Interestingly, the differences between the TAS and SFPQ also seem to reflect the difference in the literatures on absorption and global flow in the literature. That is, the literature on "flow" is mostly focused on positive experiences, while the literature on absorption seems to be more negatively focused. This difference in valence may be one reason why these two literatures have developed largely independently of one another despite the core similarity which they share—a focus on episodes/the subjective experience of deep, effortless concentration.

[51] Though it should be noted that the problems with global flow measures outlined in Chapter 1 (and with the SFPQ in particular in Study 1) continue to apply. It may be more accurate to say that the SFPQ (and global flow measures in general) tap positive precursors and consequences of positive engagement states.

correlations with DECI/DECE, reflecting the fact that they both tap aspects of deep, effortless concentration.

Building on these ideas, here we propose a preliminary (DEC) framework which might prove useful for organizing various ‘flow-like’ experiences—such as ‘dark’ flow (Dixon, Stange et al., 2018), hyperfocus (Hupfeld, Abagis & Shah, 2018), absorption (Tellegen & Atkinson, 1974; Roche & McConkey, 1990), involvement (Reed, Hagen, Wicker & Schallert, 1996) and others—around a common principle. In our proposed framework, DEC is considered to be at the core of all such related experiences and thus serves as a ‘hub’ construct through which they can be understood in relation to one another. The addition of different facets, antecedents, and consequences determines whether the experience is, for example, considered to be an episode of flow (in the traditional positive sense), hyperfocus, or dark flow. For example, in this framework, absorption (as measured by the TAS) is defined by the experience of deep, effortless concentration, plus the inclusion of negative affect or feelings of dissociation. Below, we explore in more detail how this framework might be used to understand how concepts such as dark flow and hyperfocus and traditional “flow” may relate to one another.

Traditional (Positive) Flow

To begin, we examine how one might view the traditional flow literature through the lens of the DEC framework. We refer to this area as ‘traditional’ or ‘positive’ flow to reflect the fact that much of flow research has focused on the experience of DEC as it relates to positive outcomes such as flourishing or happiness (Csikszentmihalyi, 1999; Csikszentmihalyi, 2014). Typically, positive flow has been studied under a global flow conceptualization, where (it is important to note) flow is characterized by the experience of deep, effortless concentration, but includes a number of other facets (which, as previously mentioned, are often all summed together to create ‘global’ flow scores). Importantly, traditional flow is associated with enjoyment, and tend to be associated with positive outcomes, such as well-being (Asakawa, 2010; Bassi et al, 2014; Catley & Duda, 1997; Collins et al., Clarke & Haworth, 1994; Eisenberger et al., 2005; Fritz & Avsec, 2007; Haworth & Evans, 1995; Rankin et al., 2018; Rogatko, 2007). Typically, it has been studied in the context of human flourishing, and the performance of desirable or productive activities (e.g. such as sports, rock climbing, and academic achievement)—activities in which the experience of DEC is also associated with desirable outcomes, such as better performance or higher achievement (Jackson & Eklund, 2002; Jackson, Thomas, Marsh & Smethurst, 2001; Schmidt, 2010). In other words, facilitating flow in these domains is seen as desirable, and associated with personal growth, commitment to goals (Smith, Marty-Dugas, Ralph & Smilek, 2020), and productivity.

Thus, in the DEC framework, positive flow can be thought of as the experience of deep, effortless concentration with the added presence of several other factors. For example, “flow” would refer to DEC when it takes place in a productive activity, which is personally meaningful to individual performing the activity, and which is facilitated by particular precursors (e.g. skill-challenge balance, clear goals and unambiguous feedback). In these scenarios, DEC is accompanied by positive affect, and perhaps other facets such as a sense of control. Following the activity, individuals will tend to feel accomplished, autonomous, or otherwise ‘good’ about themselves as a result of experiencing DEC.

Dark Flow

In the gambling literature, several studies have documented a relation between problem gambling and the experience of dark flow during multi-line slot machines (Dixon, Stange, et al., 2017; Dixon et al., 2019a; 2019b). Dixon et al., (2019b) describe dark flow as “a pleasurable, but maladaptive state where players become completely engrossed in slots play”. For problem gamblers, dark flow during slot machine play seems to offer a respite from their everyday lives, where they frequently experience depressive states and tend to have difficulty staying on task (Dixon, Graydon, et al., 2014; Dixon, Stange, et al 2017; Dixon et al 2019a). Specifically, those who experience (dark) flow during slot machine play tend to experience less mind-wandering and more positive affect (Dixon et al, 2019a). Thus, for those with mindfulness problems and higher depressive symptoms, dark flow by way of slot machine gambling provides a means for escaping their negative everyday experience (Dixon et al., 2019a). Notably, while dark flow may lead to negative consequences (such as financial problems, potentially increased depressive symptoms, and gambling disorder; Schluter & Hodgins, 2019), the flow experience itself remains highly enjoyable during gameplay (Dixon et al., 2019a; 2019b).

Under the DEC framework, dark flow, in the moment, is assumed to be characterized by the experience of DEC, and differentiated from other forms of DEC by its precursors and consequences. For example, unlike more positive forms of flow, dark flow seems to be brought about by escape motivation, and associated with negative consequences following the flow experience. Interestingly, however, the experience of DEC during slot machine gambling (dark flow) and DEC during sports (traditional flow) seem to have little difference in the moment (i.e. during the activity). That is, the difference between DEC and dark flow while gambling, does not appear to be in the subjective experience during the task itself. Instead dark flow differs from other forms of flow/DEC in terms the motivation for engaging in the activity, how DEC is initiated, and the consequences that occur as a result of experiencing DEC in that particular task.

When considering dark flow in the DEC framework it is also interesting to note the relationship of the typical flow precursors with the experience of dark flow. For some flow researchers, it seems that flow only occurs when there is optimal skill-challenge balance (e.g.

Schiefele & Raabe, 2011; Bowers, Na, Elkins, 2018). However, this apparently key facet is noticeably absent from descriptions of dark flow. In games of chance, such as multi-line slot machines, there is no true skill that participants can enact on the game—they have no influence on their success/performance—and thus, the notion that skill-challenge balance enables flow cannot apply in this situation. Yet, clearly, even without this critical precursor, participants nonetheless experience "the slot machine zone" (Schull, 2012). By focusing on the experience of deep, effortless concentration in particular (which clearly occurs during slot machine play), the DEC framework is more inclusive. Thus, "dark" flow can be understood as the experience of DEC when it is preceded by an escape motivation, and negative consequences follow as a result.

Hyperfocus

Hyperfocus is sometimes considered to be a characteristic of ADHD and is described as a state of heightened or focused attention (Hupfeld, Abagis & Shah, 2018). Hyperfocus is characterised by the experience of deep, effortless concentration, together with the additional component of attention errors. Hyperfocus seems to be an exogenous process whereby attention is captured by a stimulus that is extraneous to one's over-arching goals. Indeed, this framing is apparent in the measurement of hyperfocus when assessed using the Adult Hyperfocus Questionnaire (AHQ; Hupfeld et al., 2018). For example, consider the following item from the AHQ: "Generally, when I am very focused on something or doing something I find especially rewarding, I might accidentally miss meals, stay up all night, or keep doing the activity until I absolutely must get up to go to the bathroom". Interestingly, many of these items seem to have two components; for some, one component describes the feeling of DEC, and the second component describes a consequence of that DEC (consequences which tend to be similar to attention errors as described by the MAAS-LO or ARCES, such as missing meals or obligations without noticing). Thus, the difference between DEC and hyperfocus appears to be consequential; the experience in the moment is the same, but hyperfocus results in attention errors, while DEC makes no assumptions about the consequences of the DEC experience.

Hyperfocus can also be characterized as *perseveration,* which has a distinctly negative affective component. Characterized in this way, hyperfocus is akin to being on a runaway train (Ayers-Glassey, 2020). This characterization of hyperfocus/perseveration can also be understood using the DEC framework. In particular, perseverative hyperfocus is the experience of DEC, but it is coupled with the feeling of being out of control and negative affective experience. Notably, in the case of perseverative hyperfocus the experience of DEC is unpleasant in the moment (as well as leading to consequences such as missed appointments). Thus, unlike traditional forms of flow where "consciousness is aligned" (Jackson & Marsh, 1996; Wright et al., 2007), in perseverative hyperfocus one's consciousness and actions are in opposition—it could be characterized as DEC during activity, but combined with the cognition of "I would like this to stop, but I can't stop it". This sense of a lack of autonomy or control over the DEC/hyperfocus episode is captured in some of the items of the AHQ, for example "Generally, when I am very focused on something or doing something that I find especially rewarding, I feel like I can't stop doing the activity, even if I have other more important responsibilities" and "Generally, when I am very focused on something or doing something that I find especially rewarding, I can get "stuck" on little details that keep me from finishing other important parts of the task" (Hupfeld et al., 2018).

The DEC framework can also be used to understand how this form of unpleasant flow is contrasted with the dark flow of slot machine gambling. Interestingly, the hyperfocus form of DEC is also distinct from dark flow because perseveration/hyperfocus feels unpleasant *during* the experience itself. While in the case of slot machine gambling, negative affect seems to follow the flow experience when one realizes that they have lost large sums of money, those individuals experiencing DEC as perseverative hyperfocus are likely to feel non-agentive, or a loss of autonomy and negative affect, during the activity. That is, dark flow seems to be highly alluring because it provides an escape from mindfulness problems and feelings of depression (Dixon et al., 2019a; 2019b) by providing a pleasant experience of DEC. On the other hand, in hyperfocus/perseveration, the subjective experience is an unpleasant one characterized by DEC, negative affect, and a lack of control. While negative affect and a perceived lack of control may also be associated with slot machine gambling, these experiences seem to take place either before or after gambling (and experiencing DEC), rather than during. In sum, while slot machine flow is characterized by DEC and positive affect during the activity (and followed by 'dark' consequences), perseverative hyperfocus is characterised by DEC and negative affect during the activity.

Concluding Remarks

As we have noted, Flow is a subjective experience, and thus the phenomenological approach taken by early research on flow is certainly justifiable. However, an unfortunate side effect is that theoretical/methodological concerns have limited the ability to consistently and systematically study flow, as such limiting our understanding of the phenomenon as well. Over the course of this dissertation, we have moved the understand of flow forward by making both theoretical and empirical contributions. Re-conceptualizing flow as DEC means that flow can be defined consistently, applied to more situations, and measured with greater consistency. By applying these theoretical contributions to address question regarding the relationship of flow concepts such as sustained attention and well-being, we have provided evidence that DEC in particular—the defining characteristic of flow—is related to: 1) greater sustained attention ability (assessed both behaviourally and via self-report), 2) greater well-being and more positive affect, and 3) provided evidence that mindfulness meditation can facilitate flow. Moving forward, DEC provides the opportunity for future research to make headway in understanding the flow concept with greater conceptual rigour.

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Appendices

Appendix A – DEC scales (Internal and External)

The Deep Effortless Concentration Scale - Internal

Please indicate how often you have each of the following experiences during an internal task (e.g. while thinking, remembering, or imagining) on the 1-7 Scale:

I can achieve a level of deep concentration on my thoughts quickly and automatically

1 Never 7 Always

I am able to completely focus on my thoughts without straining to pay attention

1 Never 7 Always

I feel like I don’t have to force myself to keep fully engaged with my thoughts

1 Never 7 Always

I seem to reach a deep level of focus almost effortlessly

1 Never 7 Always

When thinking, I get completely engaged without having to work at it

1 Never 7 Always

I get in the zone and don’t have to force myself to concentrate on my thoughts

1 Never 7 Always

I can naturally and effortlessly sustain my full attention on my thoughts

1 Never 7 Always

I can easily pay total attention to my thoughts for extended periods of time

|————————————————————|

1 Never 7 Always

The Deep Effortless Concentration Scale - External

Please indicate how often you have each of the following experiences during an external task (e.g. practicing a musical instrument, playing a sport, engaging in a hobby) on the 1-7 scale:

I can achieve a level of deep concentration on a task quickly and automatically

|————————————————————|

1 Never 7 Always

I am able to completely focus on my task without straining to pay attention

|————————————————————|

1 Never 7 Always

I feel like I don’t have to force myself to keep fully engaged with an external task

|————————————————————|

1 Never 7 Always

I seem to reach a deep level of focus almost effortlessly

|————————————————————|

1 Never 7 Always

When performing an external task, I become completely engaged without having to work at it

|————————————————————|

1 Never 7 Always

I get in the zone and don’t have to force myself to concentrate on the task I am doing

|————————————————————|

1 Never 7 Always

I can naturally and effortlessly sustain my full attention on a task

|————————————————————|

1 Never 7 Always

I can easily pay total attention to an external task for extended periods of time

|———————————————————————|
1 Never 7 Always

Appendix B – Mindfulness Instructions for Chapter 5

Here we list the full instructions for participants in each of the four different conditions used in Studies 2 and 3. Note that the 'Breath Counting' condition was identical in both studies.

Full Task Instructions for Study 2 and 3
Four sets of instructions were used across two experiments. In Study 2, participants were assigned to either 1a) the Cross-Counting Condition or 2) the Breath-Counting Condition. In Study 3, participants were assigned to one of three conditions: 1b) the Simplified Cross-Counting Condition, 2) the Breath-Counting Condition, or 3) the Mindfulness-Label Condition. Below we present the instructions for each manipulation.

1a) Cross-Counting Condition (Used in Study 2)
In Study 2, the instructions for the cross-counting task were matched as closely as possible to those of the breath counting condition. The mindfully worded are italic and underlined.

The below instructions appeared prior to the practice session:
Before you begin the game, we'd like you to complete a short counting task. *In this task, we would like you to be aware of a cross that will be presented on the screen.* The cross will appear in the center of the screen.

At some point, you may notice your attention has wandered from the task. That's okay. Just gently place it back on the task.

While doing the task, you'll use a small part of your attention to silently count the number of times the cross appears from 1 to 9, again and again. Each time the cross appears, you'll make one count

For the first 8 crosses, press the down arrow key to count the cross. On cross 9, press the right arrow key to count the cross. Then begin your count again at number 1.

For example:
The Cross appears -----> 1 (Press DOWN ARROW)
The Cross appears -----> 2 (Press DOWN ARROW)
The Cross appears -----> 3 (Press DOWN ARROW)
And so on, until Cross 9...
The Cross appears -----> 9 (Press RIGHT ARROW)
The Cross appears -----> 1 (Press DOWN ARROW)

If you lose count, press the 's' key and re-start your count.
There will now be a brief practice. Press the spacebar to begin the practice.

The following instructions appeared on screen during the practice sessions:
Begin counting the crosses now. *Simply concentrate on the cross*
Each time the cross appears makes 1 count.

For crosses 1-8 press the 'down' arrow key. For cross 9 press the 'right' arrow.
If you lose track of your count, press the 's' key to re-start the count at 1.

The below instructions appeared after completion of the practice session:
The practice is over and the counting task will now begin. _*During the task, please be aware of the appearance of the cross in the middle of your screen.*_ The counting task will be 15 minutes in length.

During the task you will not receive on-screen feedback, but your response is being recorded. Please continue to count using the arrow keys until the task ends.

Press the spacebar when you are ready to begin. The task will begin immediately after you press the spacebar.

1b) Simplified Cross-Counting Condition (used in Study 3)
In Study 3, the instructions of the cross-counting task were altered to remove the mindful wording. The task itself remained the same. We refer to this condition as the 'simplified' cross-counting condition because of the simplified instructions.

The below instructions appeared prior to the practice session:
Before you begin the game, we'd like you to complete a short counting task. The cross will appear in the center of the screen.

Your task is to silently count the number of times the cross appears from 1 to 9, again and again. Each time the cross appears, you'll make one count.

For the first 8 crosses, press the down arrow key to count the cross. On cross 9, press the right arrow key to count the cross. Then begin your count again at number 1.

For example:
The Cross appears -----> 1 (Press DOWN ARROW)
The Cross appears -----> 2 (Press DOWN ARROW)
The Cross appears -----> 3 (Press DOWN ARROW)
And so on, until Cross 9...
The Cross appears -----> 9 (Press RIGHT ARROW)
The Cross appears -----> 1 (Press DOWN ARROW)

If you lose count, press the 's' key and re-start your count.
There will now be a brief practice. Press the spacebar to begin the practice.

The following instructions were present on the screen during the practice session:
Begin counting the crosses now. Each time the cross appears makes 1 count.

For crosses 1-8 press the 'down' arrow key. For cross 9 press the 'right' arrow.
If you lose track of your count, press the 's' key to re-start the count at 1.

The below instructions appeared after completion of the practice session:
The practice is over and the counting task will now begin. During the task, the cross will appear in the middle of your screen. The counting task will be 15 minutes in length. During the task you will not receive on-screen feedback, but your response is being recorded. Please continue to count using the arrow keys until the task ends.

Press the spacebar when you are ready to begin. The task will begin immediately after you press the spacebar.

2) Breath-Counting Condition (Used in Study 2 and Study 3)
Note, these instructions are unchanged from Study 2. The breath counting condition was identical in Study 2 and Study 3.

The below instructions appeared prior to the practice session:
Before you begin the game, we'd like you to complete a short counting task. In this task, we would like you to be aware of your breath. Please be aware of the movement of your breath in and out in the space below your nose and above your upper lip.

There's no need to control the breath. Just breathe normally.

At some point, you may notice your attention has wandered from the breath. That's okay. Just gently place it back on the breath.

While doing the task, you'll use a small part of your attention to silently count breaths from 1 to 9, again and again. Together, one 'in' breath and one 'out' breath make 1 count.

For the first 8 breaths, press the down arrow key to count your breath. On breath 9, press the right arrow key to count your breath. Then begin your count again at number 1.

For example:
Breathe in, Breathe out -----> 1 (Press DOWN ARROW)
Breathe in, Breathe out -----> 2 (Press DOWN ARROW)
Breathe in, Breathe out -----> 3 (Press DOWN ARROW)
And so on, until Breath 9...
Breathe in, Breathe out -----> 9 (Press RIGHT ARROW)
Breathe in, Breathe out -----> 1 (Press DOWN ARROW)

If you lose count, press the 's' key and re-start your count.
There will now be a brief practice. Press the spacebar to begin the practice.

The following instructions appeared on screen during the practice session:
Begin counting your breath now. Simply concentrate on your breathing. Together, one 'in' breath and one 'out' breath make 1 count.

For breaths 1-8 press the 'down' arrow key. For breath 9 press the 'right' arrow

If you lose track of your count, press the 's' key to re-start the count at 1.

The below instructions appeared after completion of the practice session:
The practice is over and the counting task will now begin. During the task, please be aware of the movement of your breath in and out in the space below your nose and above your upper lip. The counting task will be 15 minutes in length.

During the task you will not receive on-screen feedback, but your response is being recorded. Please continue to count using the arrow keys until the task ends.

Press the spacebar when you are ready to begin. The task will begin immediately after you press the spacebar.

3) Mindfulness-Label Condition (Used in Study 3)
Note, except for referring to the task as 'mindfulness' or a 'mindfulness exercise' in the instructions, the mindfulness label condition is identical to the breath-counting condition

The below instructions appeared prior to the practice session:
Before you begin the game, we'd like you to complete a short *mindfulness exercise*. In this task, we would like you to be aware of your breath. Please be aware of the movement of your breath in and out in the space below your nose and above your upper lip.

There's no need to control the breath. Just breathe normally.

At some point, you may notice your attention has wandered from the breath. That's okay. Just gently place it back on the breath.

While doing the task, you'll use a small part of your attention to silently count breaths from 1 to 9, again and again. Together, one 'in' breath and one 'out' breath make 1 count.

For the first 8 breaths, press the down arrow key to count your breath. On breath 9, press the right arrow key to count your breath. Then begin your count again at number 1.

The following instructions appeared on screen during the practice session:
Begin counting your breath now. Simply concentrate on your breathing. Together, one 'in' breath and one 'out' breath make 1 count.

For breaths 1-8 press the 'down' arrow key. For breath 9 press the 'right' arrow
If you lose track of your count, press the 's' key to re-start the count at 1.

The below instructions appeared after completion of the practice session:
The practice is over and the *mindfulness exercise* will now begin. During the *mindfulness exercise*, please be aware of the movement of your breath in and out in the space below your nose and above your upper lip. The *mindfulness exercise* will be 15 minutes in length.

During the *mindfulness exercise* you will not receive on-screen feedback, but your response is being recorded. Please continue to count using the arrow keys until the *exercise* ends.

Press the spacebar when you are ready to begin. The *mindfulness exercise* will begin immediately after you press the spacebar.

Appendix C – Tercile Analysis

In Chapter 4, we observed that the correlation between DEC and commission errors during the SART was significantly stronger in the second half of the task. We speculated that this pattern may arise because those experiencing high levels of DEC are better able to maintain performance over time. That is, everyone may perform relative well at the beginning of the task (regardless of their level of flow), but those with high levels of flow are better at maintaining their performance in the second half of the task, relative to those experiencing lower levels of DEC.

As a preliminary exploration of the relation between flow and sustained attention over time (and of this particular speculation), here we conduct a tercile analysis. In particular, we split participants into thirds according to their DEC scores during the experiment, and compared the number of commission errors for those in the highest third ('high flow') and lowest third ('low flow') for both Sample 1 and Sample 2 (see Chapter 4). However, the results must be interpreted cautiously, as the study was not designed to address this question, and by its nature, tercile analysis substantially cuts down the sample size[52], which could lead to a loss of power.

In Sample 1, we conducted a 2x2 ANOVA with Tercile as the Between-Subjects Factor (high flow tercile, low flow tercile) and Time (first half, second half) as the Within-Subjects Factor. The omnibus ANOVA indicated there was no significant main effect of Tercile $F(1, 49) = 1.99$, $p = .164$, $\eta^2 = .035$, suggesting that commission errors across the two tercile groups were not substantially different from one another. The main effect of Time was found to be significant $F(1, 49) = 13.07$, $p < .001$, $\eta^2 = .028$. The interaction between Tercile and Time approached, but did not reach significance $F(1, 49) = 3.09$, $p = .085$, $\eta^2 = .007$.

[52] Sample 1 falls from 76 to 52, and Sample 2 falls from 97 to 65

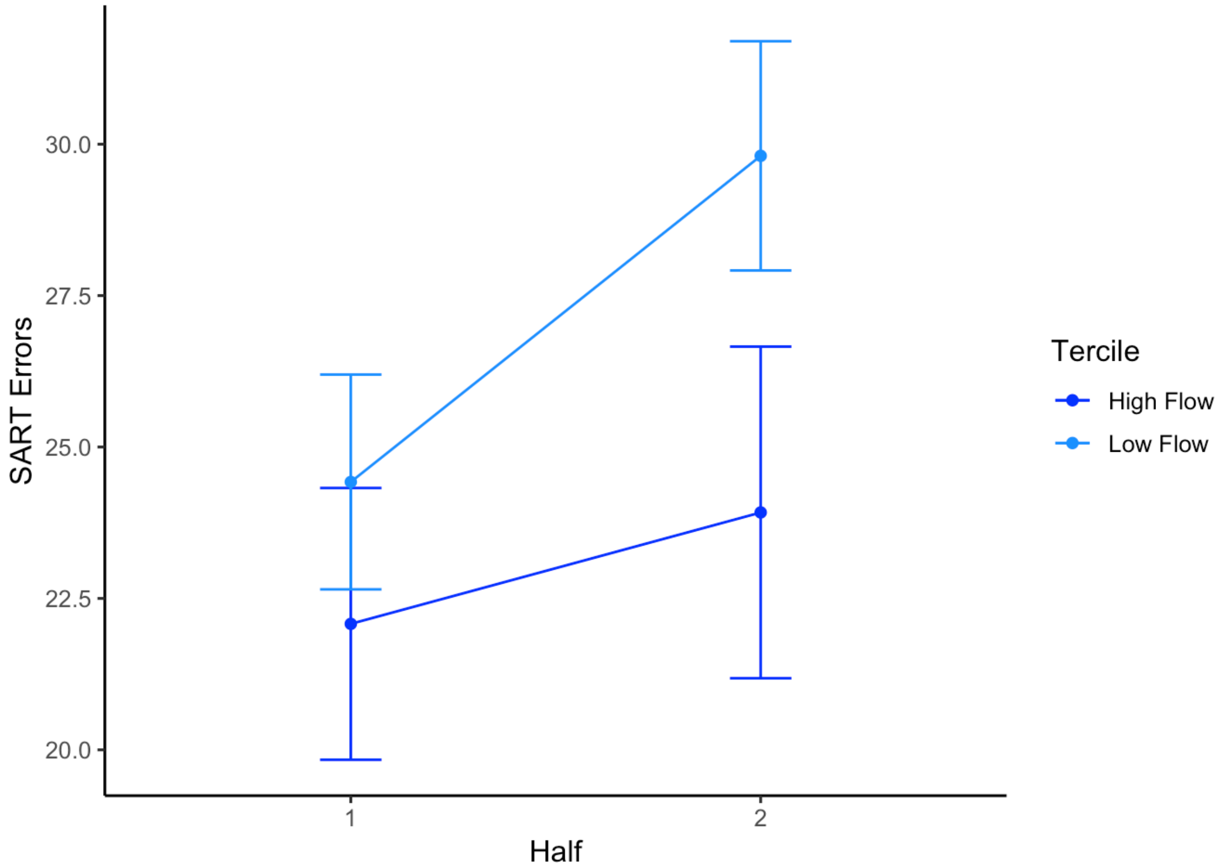

Figure C-1. SART commission errors by Tercile and Half in Sample 1 (n = 52)

In Sample 2, we again conducted a 2x2 ANOVA with Tercile as the Between-Subjects Factor (high flow tercile, low flow tercile) and Time (first half, second half) as the Within-Subjects Factor. The omnibus ANOVA indicated there was a significant main effect of Tercile $F(1, 63) = 18.75$, $p < .001$, $\eta^2 = .219$, such that those in the high flow tercile had fewer commission errors than those in the low flow tercile. There was also a significant main effect of Time, $F(1, 63) = 28.66$, $p < .001$, $\eta^2 = .026$, suggesting that there were more commission errors during the second half of the experiment. However, once again, the interaction between Tercile and Time was not significant $F(1, 63) = .701$, $p = .403$, $\eta^2 = .001$.

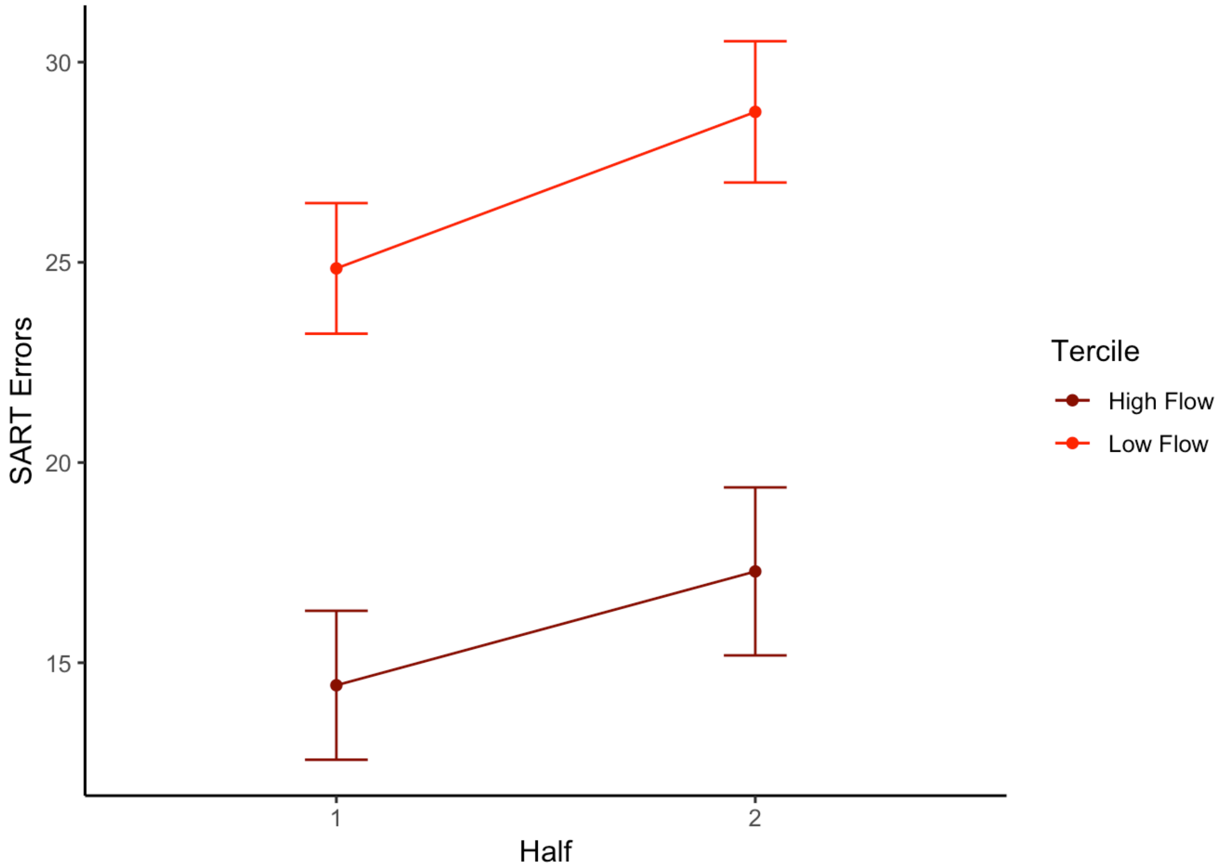

Figure C-2. SART commission errors by Tercile and Half in Sample 2 (n = 65)