A SERIES OF QUERIES ON THE WANDERING MIND

ON THE EBB AND FLOW OF CONSCIOUS THOUGHT: A SERIES OF QUERIES ON THE WANDERING MIND

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DECLARATION OF ACADEMIC ACHIEVEMENT

Chapter 2

Dr. Lynn Hasher, primary researcher for the Aging and Cognition Laboratory at the University of Toronto, provided guidance on the theoretical development of this project. Along with designing the project, I was responsible for programming the experiment, the analysis and interpretation of the data, as well as the writing of the manuscript. Dr. Scott Watter, my primary supervisor, provided invaluable advice on the statistical methodology and composition of the paper. Tim Li and Claire Howard, both members of the Cognitive Science Laboratory, completed the data collection.

Chapter 3

Under the supervision of Dr. Scott Watter, I was responsible for the design of the experiments as well as the data analysis and interpretation, and write-up of the findings. Alex Gough, a friend and colleague within the Psychology, Neuroscience and Behaviour department at McMaster University, programmed Experiment 2. Kaian Unwalla, Aadil Barwahni, and Esther Manoian, all members of the Cognitive Science Laboratory, completed the data collection and coding for this project.

Chapter 4

Jonathan Smallwood, a primary researcher at the Max Planck Institute of Human Brain and Cognitive Sciences in Germany, provided insight on the theoretical development of this project. I was responsible for the experimental design, programming, data collection and analysis, and the interpretation and write-up of the findings. Dr. Scott Watter provided guidance on statistical methodology and writing of the paper.

Chapter 5

Mitchell LaPointe, a friend and colleague within the Psychology, Neuroscience and Behaviour department at McMaster University, partnered with me in the design of the experiment. I was responsible for the programming, data analysis and interpretation, and write-up of the findings. Dr. Scott Watter provided guidance on the experimental design, statistical methodology and composition of the paper. Esther Manoian and Fei Fei Li, both members of the Cognitive Science Laboratory, completed the data collection and coding for this project.

Chapter 6

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ABSTRACT

The study of the wandering mind offers a unique window into how, why and for whom the dominant control mechanisms within our brain tend to fail (or not to fail). Smallwood (2013) argues that understanding the answers to these particular questions remain the most important in mind wandering research. In the current dissertation, I explored the degree to which the emotional quality of the internal and external world shapes our conscious experience, and the control mechanisms that give us stability in focus in our daily lives.

I argue that the vacillation between internal and external processing operates at the nexus of two primary theories: the resource control theory (Thomson et al., in press) and the current concerns theory (Klinger, 1971; 1999; 2009). While the former offers a framework for understanding *how* the mind may wander, the latter provides a framework to understand *why* and *for whom*. The result is the conceptualization of an executive control system that operates to coordinate the activation between various neural networks, which when activated, operate to distribute cognitive resources toward the information most relevant at that moment in time. Driven by the emotional quality of our internal state and contextual cues in our external environment, relevance is determined by our current concerns and most personal of goals. The experiments presented in the current dissertation provide some granularity to this theoretical integration.

ACKNOWLEDGEMENTS

Thank you, to all of those who tolerate the aberrant nature of my wandering mind.

And Scott, thank *you*.

For everything.

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"YEAH, IT'S STILL SQUIRMING A LITTLE"
MIND UNDER MICROSCOPE

CHAPTER 1: AN INTRODUCTION TO THE INTERNAL WORLD

> Consciousness does not appear to itself chopped up into bits. It is nothing jointed; it flows. A 'river' or a 'stream' are the metaphors by which it is most naturally described. In talking of it hereafter, let us call it the stream of thought, of consciousness, or of subjective life. – William James, 1890

The ebb and flow of thought is the most definitive feature of our private life. When tuned toward the internal world, the physical becomes distant and we are able to entertain fantasies (Klinger, 1971, 2009), revisit experiences of the past (Smallwood, Nind, & O'Connor, 2009), contemplate the future (Baird, Smallwood, & Schooler, 2011; Schacter, Addis, & Buckner, 2007), or sing the tune of a particularly catchy song (Beaman & Williams, 2010). It is during these mental detours that we are able to solve problems (Baird et al., 2012), and with some contemplative effort, engage in meditative practice to reduce the stress of daily life (Sood & Jones, 2013). The content of our conscious experience vacillates between the external world and our personal thoughts, enabling us to allocate our energy and attention to focus on what is most personally relevant at that point in time (Klinger, 1971, 2009).

Focusing our energy internally allows us to travel mentally through time and aids problem solving efforts. With these qualities providing a distinct advantage in the complex social environment in which we humans exist (Baars, 2010; Frith & Frith, 2007; Smallwood & Andrews-Hanna, 2013), it is not entirely surprising that we are estimated to spend between 30% (Kane et al., 2007) and 50% (Killingsworth & Gilbert, 2010) of our daily lives engaged with the internal world. Typically coined as "mind wandering episodes", these mental aberrations are defined in cognitive science as spontaneous, stimulus-independent thoughts that transcend the current environmental context (Smallwood, 2013; Smallwood & Schooler, 2006). A mind wandering episode is therefore often unrelated to direct perceptual input (see Smallwood et al., 2013), with the majority of the content of the episode arising from the episodic memory system (Schacter & Addis, 2007a). The current dissertation explores this definition of mind wandering behaviour through a series of experiments, with a particular focus on the interaction between the internal and external environment.

Sometimes our attention wanders to the detriment of performance on an external task. These performance deficits typically occur when we are required to maintain a focused state of attention on a specific set of stimuli for an extended period of time (Cunningham, Scerbo, & Freeman, 2000; Teasdale et al., 1995; and for a review, see Thomson, Smilek, & Besner, in press), which can lead to costly errors in daily life (He, Becic, Lee, & McCarley, 2011). One of the earliest pioneers to study the effects of declining vigilance was Norman Mackworth, a

British cognitive scientist, who noticed a general increase in the rate at which Royal Air Force radar operators would fail to detect critical enemy combatants (Mackworth, 1948). Mackworth's insights sparked the interest of both cognitive psychologists and neuroscientists alike, spawning an empirical movement to investigate the boundaries of sustained attention and the impact of vigilance decrement on performance (see See, Howe, Warm, & Dember, 1995b). The empirical paradigms designed to study sustained attention have been useful for modelling attentional control systems and understanding the nature of attentional deficits (Broadbent, 1971; Manly, Robertson, Galloway & Hawkins, 1999; Robertson, Manly, Andrade, Baddeley & Yiend, 1997). With the assumption of an absolute inverse relationship between task-oriented focus and task-irrelevant thought (see Thomson et al., in press), these paradigms have also proven useful for exploring the antithesis of sustained attention: the cognitive phenomenon of mind wandering.

There are two types of tasks used to measure sustained attention. The first task is the Traditional Vigilance Task (TVT), which involves a go/no-go method requirng participants to withhold their response on frequent non-target trials and respond on infrequent target trials (Temple et al., 2000). Vigilance is inferred by the proportion of times participants respond on target trials, with a low proportion (or high error rate) indicative of a vigilance decrement. The second task is the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997), which is the most prominent paradigm used in mind wandering research. As the direct inverse paradigm to the TVT, the SART requires participants to make a response on frequent non-target trials and withhold their response on infrequent target trials. To perform well on the task, participants must maintain a focused state of attention and inhibit inappropriate response behaviours on the rare critical trials. The inability to withhold their response, called "error rate" in the current dissertation, represents a failure in critical signal detection and is presumed to reflect failures in sustained attention (Cheyne, Solman, Carriere, & Smilek, 2009; McVay & Kane, 2009; Robertson et al., 1997; Seli, Cheyne, & Smilek, 2012; Smallwood & Schooler, 2006). Response time variability on non-target trials provides an additional measure of attentional focus, with a variable response pattern presumed to reflect transient shifts between on-task and off-task focus (for a review, see Cheyne et al., 2009). In line with the assumption that mind wandering is the default attentional state (Thomson et al., in press), error rate and response time variability are typically used in conjunction as measures of mind wandering behaviour (for a review, see Cheyne et al., 2009; Smallwood & Schooler, 2006). When the SART was initially commandeered as a measurement tool for mind wandering, self-report measures were included to support the behavioural measures of off-task focus. Probe trials intermittently interrupt task performance and require that participants indicate whether their attention was focused on the task (for a review, see Smallwood & Schooler, 2006), and when relevant, to report the content of their mind wandering episodes (Baird et al., 2011; Smallwood, Nind, et al., 2009; Vinski & Watter, 2013).

Why does mind wandering impair task performance?

The decoupling hypothesis of mind wandering (Smallwood, Brown, Baird, & Schooler, 2012; Smallwood & Schooler, 2006) proposes that the mental faculties that serve to maintain internally oriented thought overlap with the faculties that serve externally oriented focus. These two faculties are reliant on the same pool of limited resources (for a review, see Smallwood, 2010; Smallwood, 2013) and therefore, entertaining an internal stream of thought necessarily degrades perceptual processing. In replication of Mackworth's initial observations in the late 1940's (Mackworth, 1948), this perceptual deficit translates into a decline in task performance, a finding consistently reported in the mind wandering literature (Barron, Riby, Greer, & Smallwood, 2011; Kam et al., 2011; Smallwood, Baracaia, Lowe, & Obonsawin, 2003; Smallwood, Beach, Schooler, & Handy, 2008). Deficits in performance associated with mind wandering extend beyond traditional vigilance tasks to everyday activities such as reading (Reichle, Reineberg, & Schooler, 2010; Schooler, Reichle, & Halpern, 2004), driving (He et al., 2011) and comprehension of course material presented during a lecture (Risko et al., 2012). The same logic applies to the degree to which task performance is reliant on attentional resources, with an increase in task demand systematically diminishing the rate at which the mind wanders (for example, Forster & Lavie, 2009; Thomson, Besner, & Smilek, 2013).

Recent findings within the field of cognitive neuroscience support the battle for resources proposed by the decoupling hypothesis. In one of the first imaging-based explorations of the neural correlates of mind wandering, Christoff, Gordon, Smallwood, Smith, and Schooler (2009) found that mind wandering episodes are supported by the co-activation of two typically anti-correlated networks – the executive network, which is actively involved in effortful attention (Posner & Rothbart, 1998), and the default mode network, which is typically active during periods of rest (Raichle et al., 2001) or self-referential (Mason et al., 2007), stimulus-independent cognition (Buckner, Andrews-Hanna, & Schacter, 2008). The co-activation between these two networks supports the intriguing idea that mind wandering episodes are not an unproductive and transient type of cognition but rather, a focused and effortful attentional state (see Smallwood & Andrews-Hanna, 2013; Smallwood et al., 2012).

Smallwood, Brown, Baird and Schooler (2012) provided a global workspace account to conceptualize the division of resources between internal and external focus. Global workspace theory (Baars, 1988; Baars, Ramsoy, & Laureys, 2003) proposes that the content held online within our "mental workspace" of consciousness is represented by a set of competing sub-modules that share a limited, but global resource. Each sub module reflects a neural constellation that represents a distinct cognitive process (such as perception, memory or language) (Dehaene, Kerszberg, & Changeux, 1998). The sub module responsible for external focus would therefore be the architecture active during perceptual processing (i.e. the dorsal attention network, Spreng, Stevens, Chamberlain, Gilmore, & Schacter, 2010; Vincent, Kahn, Snyder, Raichle, &

Buckner, 2008), while the sub-module responsible for internal focus would be the architecture active during stimulus independent cognition (i.e. the default mode network, Buckner et al., 2008; Raichle et al., 2001). Our conscious experience therefore represents the "winner" of the competition between sub modules for access to the workspace, which is declared by a top-down control system (i.e. the fronto-parietal network, Corbetta, Patel, & Shulman, 2008; Posner & Dehaene, 1994; and see Smallwood et al., 2012, for a conceptual review). A graphic representation of the global workspace account of internal and externally-oriented cognition is shown in Figure 1 (pg. 39).

How do we achieve mental stability?

The stability of content within the mental workspace is ensured by both a biased processing of the current online information and a suppression of irrelevant information competing for access to the workspace (Baars et al., 2003; Smallwood et al., 2012). The resource control account of mind wandering, recently proposed by Thomson and colleagues (in press) builds on the decoupling hypothesis to provide an appropriate framework for understanding the stability of content within the mental workspace and in what circumstances the mind will wander. The theory proposes that mind wandering consumes attentional resources (as per the decoupling hypothesis, Smallwood, 2010; Smallwood et al., 2012; Smallwood & Schooler, 2006), but that mind wandering arises due to failures of executive control (McVay & Kane, 2010; McVay & Kane, 2009). Generally, executive control encapsulates a set of cognitive processes associated with the planning, initiation, sequencing and monitoring of complex behaviour to ensure goal achievement in the face of distraction (Baddeley, Logie, Bressi, Della Sala, & Spinnler, 1986). Thomson and colleagues (in press) argue that in situations where executive control is depleted, such as when we are completing a task over a long period of time (e.g. Teasdale et al., 1995), when we are in a stressful situation (Vinski & Watter, 2013), or when we are under the influence of alcohol (Sayette, Reichle, & Schooler, 2009), we are more likely to engage in our default mode of thinking (i.e. engage in mind wandering behaviour).

The “winner” of the resource competition between sub modules, chosen and reinforced by the top-down executive control system (Thomson et al., 2013; Thomson et al., in press), is therefore dependent on our ability to distribute resources efficiency. For example, when attempting to focus on a task such as writing a doctoral thesis, stability of focus is dependent on the suppression of task-irrelevant distraction, such as the contemplation of what to cook for dinner or what to pack for an upcoming trip. Keeping in mind the decoupling hypothesis and what we know about the neural architecture of internally-oriented cognition, the processes engaged in maintaining a task-relevant focus are analogous to the processes that maintain an internal stream of thought. An individual with a stable mental workspace is therefore likely to have an efficient executive control system and can therefore effectively inhibit distractors to maintain a coherent focus (whether that focus is toward the external or the internal world). An individual with an unstable workspace on the other hand, will fail to inhibit distractors, resulting in a diffuse distribution of resources and a distracted attentional state. In Chapter 2, I integrate mechanisms of inhibitory regulation (Hasher & Zacks, 1988) within the global workspace account of mind wandering to explore whether individual differences in inhibitory control predict mind wandering during periods of reduced executive control. I found that some inhibitory mechanisms protect against a rise in mind wandering behaviour, while others do not.

The allocation of resources is guided by our current goals and concerns (see Thomson et al., in press). The "winner" of the resource competition is therefore maintained by a consistent comparison between the mental costs associated with the current task and the opportunity cost associated with pursing alternative tasks (or thoughts) (Thomson et al., in press), with effective distribution achieving maximal focus as a function of personal saliency (e.g. Smallwood, Riby, Heim, & Davies, 2006). In other words, we pay attention to information that is most important to us at that given time. This salience-driven theory of attentional allocation aligns with the "current concerns theory" proposed by Eric Klinger in the early mind wandering literature (1971). This motivational theory, used extensively in the current literature as a tool to predict and interpret mind wandering behaviour in a variety of situations (for example, Baird et al., 2011; Christoff et al., 2009; Kane et al., 2007; McVay & Kane, 2010; McVay & Kane, 2009; Stawarczyk, Majerus, Maj, Van der Linden, & D'Argembeau, 2011), proposes that our mind will wander to our most pertinent concerns in the service of resolving said concerns. The predictive power holds true in direct empirical tests, too. Antrobus, Singer, and Greenberg (1966) found that activating personally salient concerns in their participants lead to a boost in mind wandering rates on a subsequent vigilance task. McVay and Kane (2013) observed a similar increase in global mind wandering rates when personally relevant cues were embedded within a task. Stawarczyk, Majerus, and D'Argembeau (2013) also observed an increase in mind wandering rates after informing participants that they would have to partake in a stressful event post-experiment (thus activating a current concern). Additionally, Stawarczyk and colleagues (2011) found that priming participants to think about their personal goals facilitated future-oriented thought during mind wandering episodes. Within the context of the computational process proposed by Thomson et al. (in press), the greater the discrepancy between the goal of the current task and the goal of resolving current concerns, the more likely it is that the stability of an externally-oriented task focus will wax and wane, and the more likely we are to engage in internally-oriented cognition.

Let’s reconsider the example of a doctoral candidate writing her dissertation. If the hopeful student is especially eager to complete the writing task, she will maintain a distribution of resources that favours a thesis-oriented focus of attention. As long as the thesis is maintained as the primary goal, attentional resources are likely to be distributed accordingly to achieve that goal. The “winner” of the battle for resources, the online content represented within the mental workspace of consciousness, therefore should reflect the cognitive processes required to write the thesis. However, if a concern emerges that is especially demanding (for example, her stomach begins to rumble with hunger or she must make amends for a recent disagreement with her significant other), then the mental cost of the writing task becomes too high relative to said concerns. In this circumstance, her mind will be more likely to wander (and in the former example, she is more likely to wander to the kitchen). For a graphic representation of the mentioned relationship between executive control and personal relevance of the task, see Figure 2 (pg. 40).

Are we all equally susceptible to mind wandering?

The more we perceive our lives to be impeded by current concerns, the more likely we are to engage with our internal world. There is one subset of the general population in which the distribution of cognitive resources is particularly biased toward internally-oriented thought. In this population, the exertion of executive control required to maintain an on-task focus is especially arduous. This population represents those diagnosed with a clinical mood disorder or more specifically, depressed individuals. An extensive literature supports the idea of an impaired executive control system in depressive populations (for reviews, see Burt, Zembar, & Niederehe, 1995; Hartlage, Alloy, Vazquez, & Dykman, 1993), with this impairment included as a central component to a number of theoretical models mapping the cognitive architecture of the disorder (Barrett, Tugade, & Engle, 2004; Ellis & Ashbrook, 1988; Hasher & Zacks, 1979; Hertel & Rude, 1991). However, this tendency is not exclusive to those with a clinical diagnosis. Generally, a positive association exists between the frequency with which an individual engages in mind wandering and the degree to which they are in a negative mood (Poerio, Totterdell, & Miles, 2013; Smallwood, O'Connor, & Heim, 2006; Smallwood, O'Connor, Sudbery, & Obonsawin, 2007; Smallwood, Obonsawin, Baracaia, et al., 2003), with the relationship maintained even when the negative mood is induced by an experimental procedure (Smallwood, Fitzgerald, Miles, & Phillips, 2009; Smallwood & O'Connor, 2011). In the pursuit of understanding how the mind wanders, it is reasonable to study a population where the distribution of resources is driven by a compromised executive control system. In Chapter 3, 4 and 5, I explore mind wandering behaviours in those that report a high degree of negative mood. Specifically, I look at how the external environment influences the rate at which this population mind wanders and their thinking patterns during episodes of off task thought. The data suggests that both prominent and subtle cues in the external environment can bias the way people mind wander and the content of the off task thoughts, with those in a negative mood more vulnerable to these effects.

How malleable is the content of a mind wandering episode?

Our understanding of how attention shifts between objects in the external environment has been developed through fine-tuned theoretical frameworks (for example, Corbetta & Shulman, 2002; Posner & Petersen, 1990), and our understanding of how attention shifts between the external and the internal environment is becoming increasingly clear (see Smallwood, 2013; Smallwood et al., 2013). Our understanding of how attention shifts within the internal environment however, is in its empirical infancy (Kanwisher & Wojciulik, 2000; Sabine & Underleider, 2000).

As stated in the introductory paragraph, Schacter and Addis (2007a) suggest that the content of mind wandering episodes is primarily derived from the episodic memory system. It is at this point where the process of understanding the flow and content of mind wandering episodes is especially intriguing, and permits a point of view from the nexus of mind wandering and memory retrieval theory. Studies within the memory literature have shown that researchers can systematically cue the retrieval of autobiographical memories with particular cues or phrases, with this process especially effective when the cues are personally relevant to the participant (e.g. Bernsten & Hall, 2004; Klinger, 1971, 2009; Kvavilashvili & Mandler, 2004). The effects persist even when the cues are imbedded as visual distractors (Kvavilashvili & Schlagman, 2011; Schlagman & Kvavilashvili, 2008). These findings provide a context for which we are able to understand the previous current concern-based experiments described above, where personally-salient cues were found to boost mind wandering rates (Antrobus et al., 1966; McVay & Kane, 2013; Stawarczyk et al., 2013). These mind wandering experiments do not however, give any insight into the types of memories retrieved in response to the cues. In Chapters 4 and 5, we explore how cues can bias the retrieval of specific autobiographical memories.

Finally, to tackle some of the inconsistent data reported in the chapters previous, Chapter 6 aims to explore the degree to which self-report methods reflect true instances of off-task thought. The final discussion occurs in Chapter 7. It is in this Chapter that I aim to discuss what the following series of queries tell us about the wandering mind.

Indeed, the ebb and flow of thought is the most definitive feature of our conscious experience. In the current dissertation, I explore the degree to which the emotional quality of the internal and external world shapes this flow of thought, and the inhibitory control mechanisms that give us stability of focus in our daily lives.

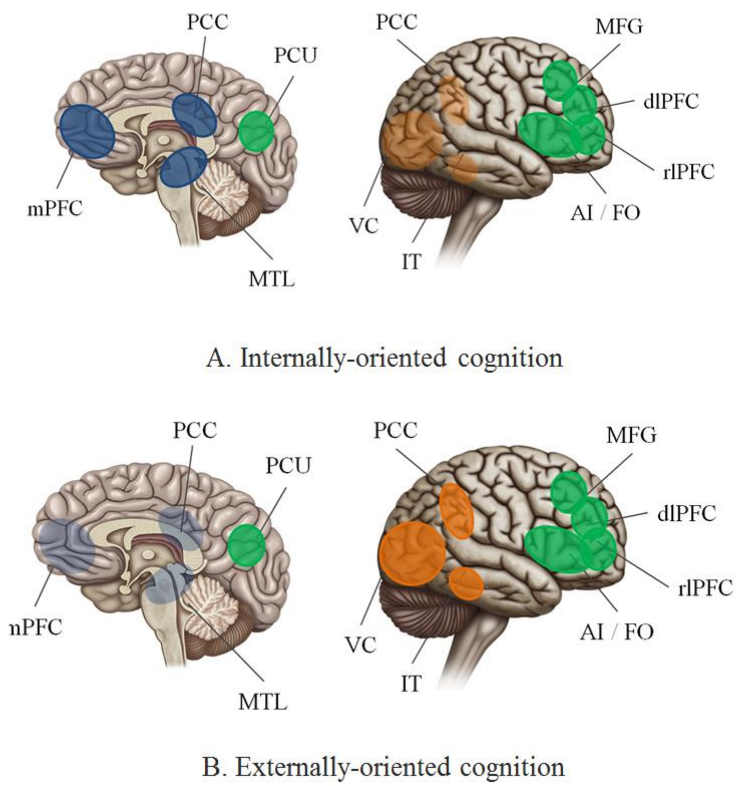

Figure 1 | A contrived architecture of activation patterns involved in the focus on an internal train of thought (A) and an external train of thought (B). The fronto-parietal control network is represented in green, the default mode network is represented in blue, and the dorsal attention network in orange. An index of regions: anterior insula/frontal operculum (AI/FO), anterior cingulate (aCC), Dorso-lateral pre-frontal cortex (dlPFC), medial Frontal Gyrus (MFG), medial Prefronal Cortex (mpFC), medial Temporal Lobe (mTL), posterior cingulate cortex (PCC), PCU Precuneus, rostro-lateral prefrontal cortex (rlPFC), Posterior Parietal Cortex (PPC) and Visual Cortex (VC). This figure was adapted from Smallwood, Brown, Baird & Schooler (2012).

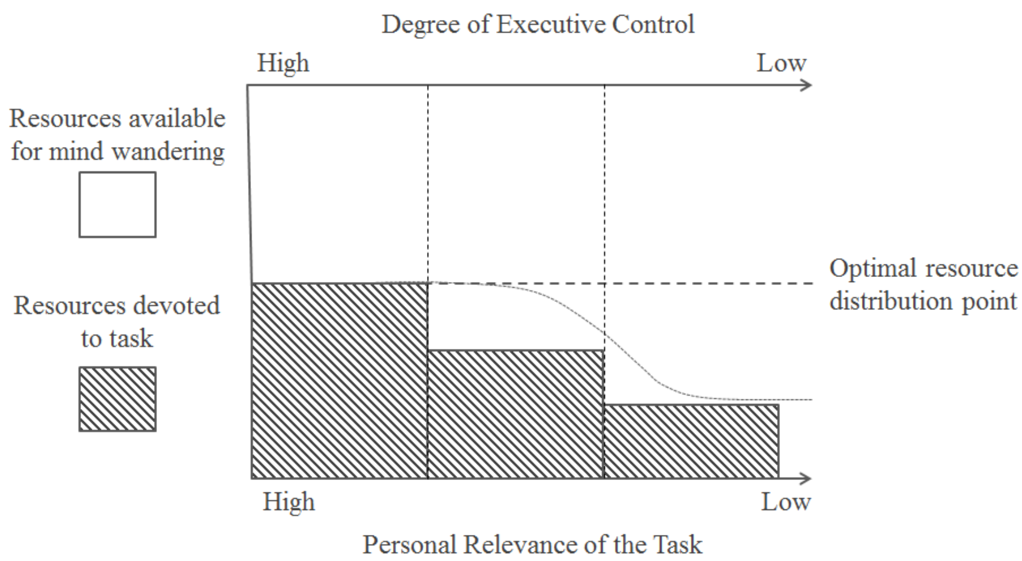

Figure 2 | A graphic representation of the how the optimal distribution of resources changes depending on the personal relevance of the task, and the degree of executive control required to maintain an on-task focus. This figure was adapted from Thomson et al. (in press).

CHAPTER 2: THE INFLUENCE OF INHIBITION ON MIND WANDERING RATES OVER TIME

> Vinski, M. T., Watter, S. & Hasher, L. (in review). Nipping the bud of spontaneous thought: The role of inhibitory control in mind wandering behaviour across task duration. *Psychonomic Bulletin and Review*.

Executive control processes operate to distribute a limited pool of resources between internal and external cognition (Thomson et al., in press). However, the executive control system is responsible for a set of processes that include updating of current goals, flexible switching between strategies, and the inhibition of irrelevant information (Miyake et al., 2000). Which of these processes is most important for stability of focus, or the stable distribution of resources toward either the internal or external world? In Chapter 2, I attempt to tackle this problem by exploring whether one of the proposed executive functions, inhibitory control, predicts individual differences in mind wandering rates. I framed this research question within a context where cognitive resources tend to be distributed toward the internal world: during the second half of a long and monotonous task (Smallwood, Obonsawin, & Reid, 2003). I predicted that efficient inhibitory control would be associated with an optimal distribution of resources.

The work in this chapter has been revised and resubmitted at the journal Psychonomic Bulletin & Review.

Chapter 2: The influence of inhibition on mind wandering rates over time

Our mind sometimes wanders away from the present. During these mental detours our cognitive presence in the external world becomes distant, allowing us to ponder our goals and concerns in life (Klinger, 1971, 2009). Mind wandering episodes are self-generated thoughts that arise independent of the external environment (Smallwood & Schooler, 2006). The decoupling hypothesis of mind wandering (see Smallwood, 2013) proposes that externally and internally-oriented cognition share (and compete) for a limited pool of global resources. So, what determines whether our attention will be tuned toward the internal or the external world? Thomson, Besner and Smilek (in press) argue for a resource-control account of mind wandering propensity, where the distribution of attentional resources between internal and external focus is reliant on an individuals' executive control capacity. This theory partially stems from a series of experiments conducted by Kane and McVay (2012) which show that working memory capacity, a direct measure of executive control, is negatively correlated with mind wandering.

Smallwood (2013) argues that determining the mechanisms that insulate the generation and maintenance of internal thought is one of the largest theoretical hurdles in mind wandering research. Thomson and colleagues (2012) argue that these operations are determined by the executive control system. While a useful theory to predict mind wandering rates, it lacks granularity. The executive system is comprised of a number of processes that operate to update current goals, to permit the flexible shift between strategies and inhibit the processing of irrelevant information (e.g. Friedman & Miyake, 2004). One way to tackle the hurdle proposed by Smallwood (2013) is to investigate one particular aspect of executive control. In the current study, we explore whether two prominent inhibitory mechanisms, access and deletion inhibition, account for individual variability in mind wandering frequency. We were particularly interested in exploring this relationship in situations when people are more susceptible to succumb to mind wandering episodes. One such circumstance is the duration that an individual spends on a task (Smallwood, Obonsawin, & Reid, 2003), which Thomson and colleagues (in press) argue, is due to diminished executive control capacity. We therefore wanted to ask, do individual differences in inhibitory control account for this incremental increase in mind wandering over a task?

Inhibition Theory (Hasher & Zacks, 1988) proposes two active, goal-directed processes that operate to maintain a stable focus of attention (Hasher & Zacks, 1988). The first process, called access inhibition, operates to prevent irrelevant information from entering the mental workspace (e.g. Campbell, Grady, Ng, & Hasher, 2012), with an inefficient access filter predicting a high level of distraction on both current tasks (May, Hasher, & Kane, 1999) as well as on subsequent tasks (Rowe, Valderrama, Hasher, & Lenartowicz, 2006). The second process is called deletion inhibition, which operates to down-regulate task-irrelevant information from the mental workspace that can arise from either an inefficient access filter or a change in goal states (Scullin, Bugg, McDaniel, &

Einstein, 2011). Individuals with inefficient deletion inhibition are more vulnerable to interference from irrelevant information (May, Zacks, Hasher, & Multhaup, 1999), which leads to high switch costs and poor performance on working memory tasks (May, Hasher, et al., 1999).

Inefficient inhibitory control appears to bolster a distracted focus of attention. We therefore predict that individuals with efficient inhibitory control will be better able to maintain an optimal distribution of resources toward the task, and therefore less likely to engage in mind wandering behaviour over the duration of the task. We measured mind wandering using both behavioural and subjective indicators of task inattention during performance on the Sustained Attention to Response Task (Robertson et al., 1997), a paradigm typically used in mind wandering research (see Smallwood & Schooler, 2006 for a review). We measured access regulation using the Reading With Distraction Task (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008) and deletion regulation using the Directed Forgetting Task (Zacks, Radvansky, & Hasher, 1996).

METHOD

Participants

Participants (n = 85, 51 female) were undergraduate students from McMaster University. Participants were recruited using the University's online recruitment program and received partial course credit in exchange for their participation.

Procedure

After providing informed consent, participants were required to complete the Reading with Distraction Task, the Directed Forgetting task, and a Sustained Attention to Response Task.

Reading With Distraction (RWD) Task. The RWD task is a typical measure of access inhibition (Darowski et al., 2008). Participants were presented with two high distraction passages and two low distraction passages. In the low distraction condition, a series of "XXXXX"s were randomly embedded within the text and the high distraction condition was embedded with a series of non-relevant but meaningfully related words. Distractors were written in normal font while the remainder of the passage was written in italic font. Conditions were presented in an ABBA format, with the high distraction condition occurring during the A blocks and low distraction condition during the B blocks. Each passage was approximately 125 words in length with approximately 60 imbedded distractors. Each passage followed by 6-item multiple choice questions to assess comprehension. Access regulation was computed by subtracting the average reading time on the low-distraction passages from the average reading time on the high-distraction passages. A high difference score is proposed to reflect the inability to resolve conflict and inhibit irrelevant information and is used as an indicator of poor access regulation.

Directed Forgetting (DF) Task. The DF task is commonly used as a measure of deletion inhibition (Zacks et al., 1996). Participants were shown a total of 250 words in either blue or red font. On 48 of the trials, the colour of the words presented would change (for example, from the presentation of a red word to the presentation of a blue word). Upon the change, participants were instructed to forget the words that were presented in the old colour (red), and remember the words presented in the new colour (blue). Words were presented serially for 1300ms, followed by a blank screen with a fixation cross for 1000ms. After the presentation of 2, 4, 6, or 8 words, participants were shown a blank screen for 3 seconds, followed by the presentation of a word in black font. Participants were asked to indicate whether they remember having seen the black word during the experiment. The more to-be-forgotten words participants remember, the less efficient their deletion inhibition.

Sustained Attention to Response Task (SART). The SART is a go/no-go paradigm typically used to measure mind wandering behaviour (Robertson et al., 1997; Smallwood & Schooler, 2006). Participants were required to respond quickly and accurately to non-target stimuli (single-digit numbers) and withhold their response to infrequent target stimuli (the number 3). Participants were shown two blocks of 250 non-target stimuli with 10 target stimuli pseudorandomly distributed throughout per block. Stimuli were shown for 500ms with an inter-stimulus interval of 2000ms (Smallwood, Riby, et al., 2006). Mind wandering is inferred from the proportion of times participants failed to withhold their response on target trials (error rate; Smallwood & Schooler, 2006), the response time coefficient of variability on non-target trials (RTCV; calculated as SD/Mean), and the proportion of response latencies on non-target trials quicker than 100ms, also known as the anticipation rate (see Cheyne et al., 2009).

Immediately following the target trials, participants completed a two-part probe trial to provide an in-the-moment measure of mind wandering. The first probe was presented as “Where was your attention just focused?” with participants given a choice between (1) “My attention was focused on the task” and (2) “My attention was not focused on the task” (Vinski & Watter, 2012), and the second probe presented as “Were you aware of where your attention was just focused?”, with participants given a choice between (1) “I was aware of where my attention was focused” to (7) “I was unaware of where my attention was focused”. Response values between 1 and 3 were classified as participants being aware of their attentional focus, while responses between 5 and 7 were classified their being unaware of their attentional focus (Christoff et al., 2009). All stimuli and questionnaires were presented using E-Prime software (Schneider, Eschmann, & Zuccolotto, 2002).

RESULTS

The following analyses aim to test the assumption that mind wandering rates increase across task duration, and quantify the degree to which individual differences in inhibitory control account for the rise in mind wandering behaviour.

To complete the latter of the two aims, correlations were initially computed between all dependent measures on the SART and both access and deletion inhibition. For all significant correlations, we then computed a mixed Analysis of Variance (ANOVA) to permit an inferential interpretation of the relation between inhibitory control and the rise in mind wandering frequency over task duration.

Mind Wandering Rates Across Task Duration

To test the assumption that mind wandering rates increase across task blocks, we computed a paired t-test between the first and second block for each dependent measure on the SART. The paired t-tests revealed that response variability, anticipation rate, report of off task thought, and unawareness of attentional focus reliably increased from the first to the second block of trials [all p's < 0.05]. With error rates failing to increase across task blocks and occurring on approximately 50% of target trials, we reasoned that error rates may not reflect task inattention in the current study (see Seli et al., 2012) and did not consider it a credible dependent measure. Descriptive statistics are shown in Table 1 (pg. 58).

Access Inhibition

Access inhibition is calculated using the difference score on the RWD task (RT on high distraction condition – RT on low distraction condition) (M =32.35, SE = 14.74 in seconds), with a low RWD score proposed to reflect efficient access regulation. Three participants failed to complete the RWD task and were therefore removed from the analyses. A bivariate correlational matrix was computed between participants' difference score and the dependent measures of the SART for the first block, second block, and change score. The correlations were not reliable [all p's > 0.05] (see Table 2, pg. 59). We also computed correlations between the proportion of times participants chose an answer in the high distraction condition that corresponded to the "distractor" items embedded within the paragraphs, and the SART dependent measures. This type of error suggests that participants processed the distractor information (i.e. an intrusion error) and could serve as an additional measure of access inhibition. Again, the correlations were not reliable [all p's > 0.05] (see Table 2, pg. 59).

Deletion Inhibition

Deletion inhibition is calculated as the proportion of times participants recognized a word they were instructed to forget on the DF task (M = 0.14, SE = 0.15). A low proportion of recognized to-be-forgotten words are proposed to reflect efficient deletion regulation. Two participants failed to complete the DF task and were therefore removed from the analyses. As per access inhibition, a bivariate correlational matrix was computed between deletion regulation and the dependent measures of the SART for the first block, second block, and change score. Positive correlations were observed between deletion inhibition and three measures of mind wandering behaviour: response variability, anticipation rate, and unawareness of attentional focus [all p's < 0.05]. Correlations are shown in Table 2 (pg. 59).

We then computed a mixed ANOVA with the within subjects factor *Block* (first block, second block) and the between subjects factor *Inhibition* (low, high) on response variability, anticipation rate, and unawareness of attentional focus.

Response Variability (RTCV)

As expected, a main effect of block was observed, $F(1,59) = 4.36$, $p < 0.05$, with participants more likely to engage in variable response behaviour during the second block relative to the first (See Table 1, pg. 58). While the main effect of deletion inhibition failed to reach significance, $F(1,59) = 0.79$, $p = 0.38$, the interaction term was reliable, $F(1,59) = 4.03$, $p < 0.05$, with simple main effects revealing a significant increase in response variability for the low deletion group (Block 1: $M = 0.18$, $SE = 0.04$; Block 2: $M = 0.22$, $SE = 0.02$), $F(30) = -2.50$, $p < 0.05$, but not for the high deletion group (Block 1: $M = 0.18$, $SE = 0.02$; Block 2: $M = 0.18$, $SE = 0.01$), $F(29) = -0.07$, $p = 0.95$.

Anticipation Rate

As expected, a main effect of block was observed, $F(1,59) = 10.56$, $p < 0.05$, with participants more likely to engage in a variable response behaviour during the second block relative to the first. As with response variability, the main effect of deletion inhibition failed to reach significance, $F(1,59) = 3.44$, $p = 0.07$, while the interaction term was reliable, $F(1,59) = 9.17$, $p < 0.05$. Simple main effects revealed a significant increase in anticipation rate across blocks for the low deletion group (Block 1: $M = 0.02$, $SE = 0.01$; Block 2: $M = 0.05$, $SE = 0.01$), *F*(30) = - 3.42, $p < 0.05$, but not for the high deletion group (Block 1: *M* = 0.02, *SE* = 0.01; Block 2: *M* = 0.02, *SE* = 0.00), *F*(29) = - 0.31, $p = 0.76$.

Unawareness of Attentional Focus

As expected, a main effect of block was observed, $F(1,59) = 29.16$, $p < 0.05$, with participants more likely to engage in a variable response behaviour during the second block relative to the first. As with the behavioural measures, the main effect of deletion inhibition failed to reach significance, $F(1,59) = 0.50$, $p = 0.48$, while the interaction term was reliable, $F(1,59) = 4.69$, $p < 0.05$. Unlike the behavioural measures however, simple main effects revealed a significant increase in unawareness across blocks for the low deletion group (Block 1: *M* = 0.16, *SE* = 0.03; Block 2: *M* = 0.49, *SE* = 0.06), *F*(30) = - 4.62, $p < 0.05$, and the high deletion group (Block 1: *M* = 0.21, *SE* = 0.04; Block 2: *M* = 0.35, *SE* = 0.06), *F*(29) = - 2.88, $p < 0.05$.

DISCUSSION

The investigation of how the mind wanders is an especially intriguing one. The current paper aims to integrate inhibition theory (Hasher & Zacks, 1988) within a resource control account of mind wandering (Kane & McVay, 2012; Thomson et al., in press) in an attempt to explore whether inhibitory control accounts for individual variability in mind wandering. We were particularly interested in scenarios where executive control capacity tends to diminish or deplete, resulting in a boost in mind wandering rates. One such scenario is the amount of time an individual spends on a task (Thomson et al., in press).

Inhibitory control operates to inhibit the activation of competing, task-irrelevant information (Hasher & Zacks, 1988; Hasher et al., 1999) or by down regulating information that is active within the mental workspace, but not relevant to the current task (May, Zacks, Hasher, & Multhaup, 1999; Zacks, Radvansky, & Hasher, 1996). With this inhibitory capacity postulated to be a central component of the executive control system (Friedman & Miyake, 2004), resource control theory (Thomson et al., in press) would predict that those with efficient inhibitory control would be able to maintain an optimal distribution of resources toward task performance relative to those with inefficient control. The theory would also predict a general decline in inhibitory control over time, with this decline in control (and therefore decline in the distribution of resources toward the task) occurring at a faster rate for those with inefficient control. Our findings support the second hypothesis.

Generally, we observed an increase in the intrusion of task-irrelevant thoughts over the span of the mind wandering task. This conclusion is supported by an increase in response variability, anticipation rate, and proportion of off-task thought probes during the second block of the SART relative to the first block. This data suggests that as time on task increases, participants are less able to maintain an optimal distribution of resources toward the task. This unequal distribution bolsters a rise in mind wandering rates rise and a decline in task performance (Thomson et al., in press). However, the data also suggests that this trend is driven by participants with less efficient inhibitory control, or the “low” inhibition group. Those with efficient inhibitory control (the “high” inhibition group) were able to maintain an optimal distribution point across task duration.

This regulatory effect of inhibitory efficiency was only observed for deletion inhibition. In the current study, mind wandering frequency is behaviourally inferred from response variability and anticipation rate. These two measures are purported to reflect the initial stages of task disengagement that occur prior to, and are necessary for, the generation of a mind wandering episode (Cheyne et al., 2009). The data suggest that those with efficient deletion regulation appear to be able to maintain an optimal distribution by down-regulating the distribution of cognitive resources toward early and transient task-irrelevant thoughts, which would in turn prevent the generation of a decoupled state of attention. This finding may explain why a relation failed to emerge between deletion regulation and off-task thought probes, which are purported to reflect a decoupled state of attention (Cheyne et al., 2009).

Access inhibition failed to relate with any measures of mind wandering behaviour. However, the ability to observe a relation between these variables may be due to methodological limitations. For example, we were unable to assess whether individuals made reading errors while completing the RWD task, which would surely influence participants’ reading time. We also relied on a difference score as a measure of access inhibition (e.g. Darowski et al., 2008), which may account for the inability to observe a significant relation between access inhibition and mind wandering measures (see Johns, 1981). Finally, the failure to observe any significant correlations may be due to the distribution of the access inhibition data (skewness = 1.29, kurtosis = 2.74). However, intrusion errors on the RWD task also failed to correlate with mind wandering measures. This data provides additional evidence to suggest that perhaps access inhibition is an inappropriate inhibitory mechanism in the study of inhibitory control in mind wandering. It is also imperative to note that previous work has questioned the validity of directed forgetting tasks as a measure of inhibition (MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). As with any task, the paradigms we used are likely not necessarily pure measures of inhibition. Therefore, while the current work provides preliminary evidence to suggest that individuals' vulnerability to mind wander may depend on inhibitory control this conclusion may be premature.

The current work was inspired by the work of Kane and McVay (2012), which offer insight on working memory capacity as a predictor of mind wandering frequency. With the view that working memory tasks comprise both a memory and executive attention component (Engle, 2002), the aim of the current paper was to provide a more detailed account of how inhibitory control predicts mind wandering behaviour. In fact, previous work has shown that deletion regulation may play an important role in estimates of working memory capacity (see Lustig, Hasher, & Zacks, 2007). It is therefore plausible that the current work taps into the “inhibitory” component of the working memory capacity findings reported by Kane and McVay (2012).

Kane and McVay (2012) argue that the negative relation between off task thoughts and WMC represents a general failure of executive control. Thomson and colleagues (in press) build on this evidence to argue that the rise in mind wandering rates typically observed over task duration are due to a decline in executive control capacity. Our findings provide further support for this executive-control account of mind wandering and merge these two lines of inquiry. Our data suggests that the rise in mind wandering rates over the duration of a task is due to poor inhibitory regulation; however more research is required to understand the influence of various inhibitory mechanisms on mind wandering propensity.

	Task Duration				
SART Dependent Measures	Block 1	Block 2	Change Score (Block 2 – Block 1)	t	p
Error Rate (Proportion of Commission Errors on Target Trials)	0.531 (0.035)	0.561 (0.028)	0.091 (0.049)	0.766	0.446
Response Time Coefficient of Variability (SD/Mean)	0.182 (0.010)	0.204 (0.011)	0.023 (0.011)	2.101	0.040 *
Anticipation Rate (Proportion of Response Times <100ms on Non-Target Trials)	0.017 (0.004)	0.037 (0.007)	0.019 (0.006)	3.066	0.003 *
Proportion of Off Task Thought Probes	0.413 (0.026)	0.586 (0.038)	0.173 (0.040)	4.279	0.000 *
Proportion of Unaware of Attentional Focus Thought Probes	0.189 (0.024)	0.431 (0.045)	0.243 (0.045)	5.445	0.000 *

Table 1 | Descriptive statistics for the independent t-tests between Block 1 and Block 2 across all dependent measures of the Sustained Attention to Response Task.

* indicates significance at a $\alpha = 0.05$ criterion

SART Dependent Measures	Access Inhibition (RWD Task; Difference Score)			Deletion Inhibition (DF Task)		
	Block 1	Block 2	Change Score (Block 2 – Block 1)	Block 1	Block 2	Change Score (Block 2 – Block 1)
Error Rate (Proportion of Commission Errors on Target Trials)	- 0.07	- 0.07	- 0.10	0.08	0.18	0.17
Response Time Coefficient of Variability (SD/Mean)	0.01	- 0.04	- 0.05	0.00	0.28 *	0.29 *
Anticipation Rate (proportion of response times <100ms)	- 0.04	- 0.01	- 0.15	- 0.12	0.33 *	0.42 *
Proportion of Off Task Thought Probes	- 0.17	- 0.25	- 0.12	- 0.09	0.10	0.15
Proportion of Unaware of Attentional Focus Thought Probes	0.02	0.13	0.12	- 0.23	0.24	0.36*

SART Dependent Measures	Access Inhibition (RWD Task; Intrusion Errors)		
	Block 1	Block 2	Change Score (Block 2 – Block 1)
Error Rate (Proportion of Commission Errors on Target Trials)	0.11	- 0.23	- 0.22
Response Time Coefficient of Variability (SD/Mean)	- 0.07	- 0.13	- 0.04
Anticipation Rate (proportion of response times <100ms)	0.13	- 0.05	- 0.13
Proportion of Off Task Thought Probes	- 0.02	- 0.08	- 0.03
Proportion of Unaware of Attentional Focus Thought Probes	- 0.04	- 0.02	0.00

Table 2 | Bivariate correlations between access inhibition (the difference score between RT on the high and low distraction condition of the RWD task) and deletion inhibition (top panel) and access inhibition (intrusion error rate) (bottom panel) and all dependent measures of the Sustained Attention to Response Task across block 1, block 2, and change score (block 2 – block 1).

* indicates significance at a $\alpha = 0.05$ criterion

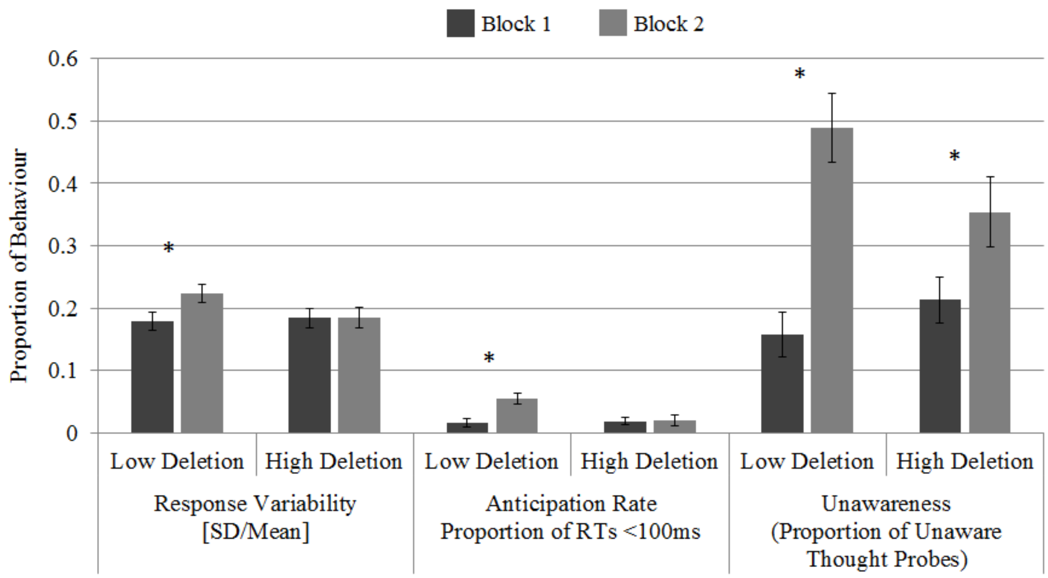

Figure 3 | Mean response variability, anticipation rate, and unawareness of attentional focus for both the low and high deletion inhibition groups, across both experimental blocks. Error bars reflect the standard error of the mean. This figure provides a visual representation of the significant findings in Chapter 2, but was not included in the original manuscript.

* indicates significance at a $\alpha = 0.05$ criterion

PANAS-X	Access Regulation	Deletion Regulation
Score on Negative Mood Subscale	0.003	- 0.10

Table 3 **|** Bivariate correlations between participants' score on the negative mood subscale of the PANAS-X and measures of access and deletion inhibition. This table provides additional information to support the findings in Chapter 2, but were not included in the original manuscript.

* indicates significance at a $\alpha = 0.05$ criterion

CHAPTER 3: ON THE EFFECT OF PSYCHOSOCIAL STRESS ON ATTENTIONAL FOCUS

> Vinski, M. T. & Watter, S. (2013). Being a grump only makes things worse: A transactional account of acute stress on mind wandering. *Frontiers in Psychology*, 4.

In Chapter 2, I learned that the ability to down-regulate the distribution of resources toward task-irrelevant thought suppresses mind wandering rates, especially in situations where our minds are likely to wander. In Chapter 3, I explore whether inducing psychosocial stress prior to a mind wandering task would in turn diminish task focus, using cognitive adaptive (Experiment 1) and bio-cognitive (Experiment 2) transactional frameworks to guide my interpretations. I was particularly interested in how stress would influence the "grumps", or those who report a high degree of state negative mood. I predicted that exposure to a psychosocial stressor would constitute a "current concern" for the high negative mood group, thus biasing the distribution of resources toward the internal world to engage in post-event (stressor-related) processing. I predicted that unlike the findings from Chapter 2, I would observe an increase in mind wandering rates at the beginning of the mind wandering task (or, immediately after the stressor).

The work in this chapter was published in the journal Frontiers in Psychology in 2013.

Chapter 3: The effect of psychosocial stress on attentional focus

The experience of stress is pervasive. In 2011, 23.6% of adult Canadians reported experiencing extreme stress in daily life (StatisticsCanada, 2011). With chronic stress linked to immunological (see Cohen, Miller, & Rabin, 2001, for reviews; Esch, Stefano, Fricchione, & Benson, 2002; Herbert & Cohen, 1993; Kiecolt-Glaser, Glaser, Gravenstein, Malarkey, & Sheridan, 1996; Segerstrom & Miller, 2004), cardiovascular (e.g. Bunker et al., 2003; Esch et al., 2002; Harlan, 1981), and neurodegenerative disease (e.g. Gilad & Gilad, 1995; Gilad, Gilad, & Tizabi, 1990), as well as poor mental health (e.g. Raison & Miller, 2003; Vaidya, 2000), an abundance of research has emerged with the aim of mapping both the psychological and physiological determinants of the body's response to stress.

Transactional models of stress (Lazarus, 1984) are multidimensional representations that emphasize the reciprocal relation between state and stressor on behaviour. Transactional models provide an algorithm that characterizes the stress response based on an individual's appraisal of environmental demands and subsequent choice of coping strategy (Hammond, 2000; Lazarus, 1966, 1999; Stokes & Kite, 1994, 2000). Appraisal mechanisms evaluate the degree of personal relevance within the stressful context, while coping mechanisms regulate whether the individual engages in either a task-focused or emotion-focused strategy (Lazarus, 1984). A task-focused coping strategy operates to prevent distraction and maintain successful task performance. An emotion-focused coping strategy is intimately tied to self-regulation and self-referential mentation, and facilitates the prioritization of processing internal worries at the expense of concurrent task performance (e.g. Matthews & Desmond, 2002).

While transactional models provide a framework for developing a state-mediated model of stress, transactional theories lack specific predictions on information processing (Matthews & Campbell, 2009). Matthews (2001) proposed two separate transactional frameworks for modelling the effects of stress on cognition in order to address this gap in the literature. Cognitive-adaptive transactions aim to model the stress-response as a function of the allocation of attention and energy, where behaviour is driven by goals and intentions and operates to direct attention as a function of coping strategy. Those who enlist a task-focused coping strategy are therefore more likely to allocate attention toward task supervision in efforts to maintain successful task performance, while those who enlist and an emotion-focused coping strategy are more likely to allocate attention toward self-referential mentation (and therefore are more likely to perform poorly on the task). This framework aligns with previous reports that stress promotes the select processing of information relevant to an individuals' current goal state (Chajut & Algom, 2003; Kofman, Meiran, Greenberg, Balas, & Cohen, 2006). Bio-cognitive transactions on the other hand, are modulated by fluctuations in both neural and cognitive architectures that directly influence the availability of attentional resources, where the term resources refers to the capacity of the executive attention network to process information (see Kane & Engle, 2002). Indeed, stress has been shown to deplete working memory capacity independent of task difficulty (Schoofs, Preuss, & Wolf, 2008) and modulate cognitive control functioning (Alexander, Hillier, Smith, Tivarus, & Beversdorf, 2007; Liston, McEwen, & Casey, 2009; Steinhauser, Maier, & Hubner, 2007). The two conceptual frameworks are therefore inherently linked and complementary: bio-cognitive transactions model the limitation of attentional resources during periods of stress, while cognitive-adaptive transactions model the allocation of attention within the constraints of resource availability. The current work aims to investigate the effect of stress on mind wandering behaviour, using both a cognitive-adaptive (Experiment 1) and bio-cognitive (Experiment 2) parameters to provide a comprehensive account of the effects.

In the situation of an emotion-focused coping strategy, attention is allocated toward the internal world rather than the task environment. Often referred to as mind wandering episodes (Smallwood, Baracaia, et al., 2003; Smallwood, Obonsawin, Baracaia, et al., 2003), these mental diversions are associated with poor task performance (see Smallwood & Schooler, 2006) and typically occur during well-practiced or mundane tasks (e.g. Teasdale et al., 1995). While mind wandering behaviour consumes almost half of our conscious experience in daily life (Killingsworth & Gilbert, 2010), such behaviour occurs more frequently in some populations relative to others. For example, clinically depressed (Carriere, Cheyne, & Smilek, 2008) and dysphoric populations (Smallwood et al., 2007) are more likely to engage in mind wandering behaviour compared to healthy controls. A similar bias toward internal processing has been observed following negative mood induction in healthy individuals. Smallwood, Fitzgerald, et al. (2009) found that participants induced with a negative mood were more likely to engage in task-irrelevant thought and were less able to effectively disengage from such thoughts relative to controls. Smallwood and O'Connor (2011) observed a similar increase in mind wandering behaviour following negative mood induction, and report a retrospective bias during episodes of off task thought in the negative mood group relative to controls.

Negative mood has also been implicated as a critical determinant of coping strategy in studies of stress (Parker & Brown, 1982). Coyne, Aldwin and Lazarus (1981) compared coping mechanisms in stressful situations between depressed and non-depressed populations over a one-year period. Using self-report as the primary measure, the authors report that being in a depressive state promotes an emotion-focused coping following a stressful experience. Depressive states have also been associated with a heightened perception of what is at stake in a stressful situation (e.g., self-esteem and well-being) relative to controls (Lazarus & Folkman, 1984), and is associated with fewer available personal and social resources to mediate the effects of stress (Mitchell, Cronkite, & Moos, 1983).

Negative mood appears to systematically bias the allocation of attention toward a self-referential mentation within both the mind wandering and stress literature. The current work therefore attempts to provide novel evidence for a cognitive-adaptive (Experiment 1) and bio-cognitive (Experiment 2) account of stress on mind wandering behaviour, with negative mood isolated as the state variable within the transactional framework. We grouped participants based on their level of state negative mood, and exposed them to either a high stress procedure or a low stress control procedure. In Experiment 1, we predicted that in the high negative mood group, the high stress condition would induce an emotion-focused coping strategy and an allocation of attention toward the internal environment, resulting in an increase in mind wandering behaviour relative to the low stress condition. In Experiment 2, we aimed to replicate the behavioural effects of Experiment 1, and predict a limitation of resource availability (indicated by larger pupil diamter, Beatty, 1982) following participation in the high stress condition for the high negative mood group relative to the low stress condition. Finally, the effect of stress on cognition has been shown to diminish over time (Elzinga & Roelofs, 2005; Oei, Everaerd, Elzinga, van Well, & Bermond, 2006), and as such we predict that stress effects are likely to be maximal immediately after stress induction (block 1) in both experiments. As a most direct test of these hypotheses, we used planned comparisons based on a priori predictions of high stress experiences affecting high negative affect more adversely than low negative affect participants immediately following stress induction, in addition to omnibus tests.

EXPERIMENT 1

METHOD

Participants

Participants (n = 124; 51 in the Experimental Group, 26 Females; and 73 in the Control Group, 43 Females) were undergraduate students from McMaster University. Participants were recruited using the University's online experiment scheduling system and received partial course credit in exchange for their participation.

Procedure

Participants spent approximately one hour in the laboratory. After providing written informed consent, participants were asked to complete the Extended Positive and Negative Affect Schedule (PANAS-X; Watson, Clark, & Tellegen, 1988). The PANAS-X provides a subscale measure of an individual's level of state positive and negative mood, and was used as a baseline measure of state mood prior to the stress induction procedure. In the current work, our predictions were inclusive to participants' scores on the negative subscale only. As a result, participants' scores on the positive subscale were not included in the analyses.

Participants were then randomly assigned to either the "high stress" experimental condition (Kirschbaum, Pirke, & Hellhammer, 1993) or the "low stress" control condition (Het, Rohleder, Schoofs, Kirschbaum, & Wolf, 2009) of the Trier Social Stress Test (TSST), a standardized paradigm that reliably activates the body's stress response (Dickerson & Kemeny, 2004; Kuhlmann & Wolf, 2005). Both conditions had two phases. The first phase included an anticipation period, where participants were asked to sit in a waiting room alone for 5 minutes. This first phase was the same for both conditions. In the second phase, participants were moved into a second experiment room. In the high stress condition, participants were required to complete complex verbal arithmetic and to give an impromptu speech (on their career plan following completion of their undergraduate degree) in front of a 3-member confederate panel. Participants were informed that their performance was being taped for further consideration. In the low stress condition, participants were required to count aloud in intervals of 15 without a panel for the verbal arithmetic task, and informally talk about their favourite movie or a personal positive experience in front of a single panel member for the speech task (as per Kirschbaum et al., 1993**).**

Participants were then guided to another experiment room where they completed the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley & Yiend, 1997) as a measure of mind wandering propensity. The SART is a go/no-go task that requires participants to respond quickly and accurately on non-target trials, and withhold their response on infrequent target trials. In the current work, target probability was 20%, with the non-target stimuli being the numbers 0 through 9 and the target stimulus being the number 3 (for a review, see Smallwood & Schooler, 2006). Probe trials immediately followed target trials to assess the participants' conscious experience of mind wandering behaviour. The probe read "Stop! Where was your attention focused immediately prior to this question?" with an alternative forced choice response format of either "My attention was focused on the task" or "my attention was not focused on the task". The proportion of off task thought was calculated by dividing the number of off task thought probes by the total number of thought probes (Vinski & Watter, 2012). The experiment was presented to participants using E-prime software (Schneider, Eschmann & Zuccolotto, 2002). Participants were shown two blocks of 179 stimuli, with stimuli presented for 700ms and an inter-stimulus interval of 2000ms. The stimuli were presented in black print on a white background.

Response time variability on non-target trials, known as the response time coefficient of variability (RTCV, calculated as reaction time SD divided by the mean), and the proportion of inappropriate responding on target trials (error rate) were calculated as the behavioural indicators of task inattention (see Smallwood & Schooler, 2006). Response time variability has been validated as a measure of the natural variation in attentional focus throughout task performance and has emerged as an increasingly relevant behavioural measure within the mind wandering literature (Cheyne et al., 2009). Error rate is indicative of failures in top-down supervision of task performance (Manly et al., 1999; Robertson et al., 1997), and has traditionally been utilized as a measure of off task focus

(Smallwood & Schooler, 2006; Smallwood et al., 2007). However, convergent evidence suggests that not all performance errors provide direct evidence of inattention (e.g. Helton, 2009; Peebles & Bothell, 2004), with error rates mediated by both signal salience and the speed-accuracy trade off (See, Howe, Warm, & Dember, 1995a; Seli et al., 2012) and vulnerable to impulsivity (e.g. Helton, 2009). Correlations were therefore computed between dependent measures for the first block of the experiment and across all experimental blocks to validate that the three dependent measures reflect the same construct. Correlations are shown in Table 2 (pg. 59). The proportion of times participants failed to respond on non-target trials, typically referred to as the omission rate (Cheyne et al., 2009), was not included as a dependent measure due to the limited time in which participants were required to make their response on non-target trials (700ms).

Retrospective probes were inserted following the first and second experimental block to provide a measure of thought content during mind wandering episodes. Retrospective report of off task thought has been validated with both intermittent thought probes and response latencies during task performance (Smallwood et al., 2004), and therefore provides an opportunity to collect an additional measure of attentional focus during task performance. Participants were given three minutes to type the content of their thoughts during the experimental block immediately prior. Participants were reassured that the report would be confidential and were encouraged to be as detailed in their report as possible. Thought content was coded based on three parameters: tense, valence, and focus. Tense refers to whether participants' thoughts were focused on episodes that occurred prior to the experimental session (past), episodes that occurred within the experimental session (present), or expectation of future episodes (future) (modified from criterion defined by Smallwood et al., 2011). Valence refers to the affective tone of participants' thoughts. Content was coded as either positive, negative, neutral, or a select combination of either affective valence. Focus refers to the focus of participants' thoughts with respect to the experimental paradigm. Content was coded as either related to the SART (task-related), to their experience during the TSST (TSST-related) or unrelated to the experimental session (task-unrelated) (see Smallwood, Obonsawin & Reid, 2003, for a similar coding criterion). If participants reported thoughts that coincided with more than one level of a given factor (for example, reported both positive and negative thoughts within the same retrospective probe) then the participant was classified as "Other".

Two assistants in the laboratory were recruited to code the thought probes, and were extensively debriefed on the coding scheme prior to completing the classification. A cross-coding validation procedure was employed to validate the categorization of the participants' retrospective reports, whereby the two coders compared classification for each subject (as per Smallwood et al., 2003). Discrepancies between coders were resolved through discussion, and a third party was included if the case of indecision. In the current work, all discrepancies were resolved through discussion and no third party mediation was necessary. Coders were blind to the experimental hypotheses and participant information. Participants were extensively debriefed following participation.

RESULTS

The first set of analyses were designed to investigate the effects of stress on mind wandering behaviour across task duration, as a function of negative mood reported prior to stress induction. Behavioural (response time variability and error rate) and experience sampling data (self-report probes) were analysed using mixed Analysis of Variance (ANOVA), with the within-subjects factor of *Block* (Block 1, Block 2) and the between subjects factors *Stress* (Low, High) and *Baseline Negative Affect* (High, Low). Participants were grouped into either the high mood group (M = 26.74, SD = 4.07) or low mood group (M = 15.91, SD = 3.45) using a median-split technique on the PANAS-X negative subscale scores ($\tilde{x}$ = 21.7). All analyses were performed with negative affect included as a continuous variable. Because the results and significance of findings were not affected, we report median-split analyses only. In addition to our omnibus analyses, we conducted a small number of directional planned comparisons, focusing on high versus low negative mood participants in the high-stress condition in block 1 data. These planned comparisons were based on a priori predictions of greater stress-mediated disruption to focused performance in high negative affect participants that are likely to diminish over time. Mean data are shown in Figure 4 (pg. 97).

Response Time Variability (RTCV)

A strong main effect of block was observed, with response time variability increasing across blocks for all conditions, $F(1, 120) = 24.648$, $p < 0.001$. A main effect of stress, $F(1, 120) = 5.030$, $p < 0.05$ and a main effect of negative mood was observed, $F(1, 120) = 6.307$, $p < 0.05$. A significant interaction between negative mood and stress were observed, $F(1, 120) = 4.093$, $p < 0.05$, with the high negative mood group more likely to engage in variable response time behaviour relative to the low mood group during the high stress condition, $F(1, 50) = 6.964$, $p < 0.05$, but not for the low stress condition, $F(1, 50) = 0.204$, $p = ns$. These findings support the observation that while both high stress and high pre-existing negative mood produced more variable response behaviour, the degree to which stress influenced response behaviour was dependent on participants' level of negative mood. A reliable interaction was also observed between block and negative mood, $F(1, 120) = 5.465$, $p < 0.05$, with the high mood group exhibiting a more variable response behaviour relative to the low mood group during the first experimental block, $t(122) = 3.323$, $p < 0.01$, but not the second, $t(122) = 0.238$, $p = ns$. The block by stress interaction did not reach significance, $F(1, 120) = 2.498$, p = ns, nor did the three-way interaction, $F(1, 120) = 2.669$, $p = ns$.

Considering our a priori expectation that stress effects should be maximal immediately following stress induction, we examined data from just the first experimental block. In the high stress experimental group, high negative mood participants were significantly more likely to engage in more variable response behaviour relative to low negative mood participants during the first experimental block, $t(49) = 2.680$, $p < 0.01$, one-tailed. High negative mood participants were also more likely to demonstrate a variable response time relative to the low negative mood group in the low stress condition, $t(71) = 2.178$, $p < 0.05$, one-tailed.

Error Rate

In contrast to response time variability, there was no main effect of block on error rate data, $F(1, 120) = 0.776$, $p = ns$, no main effect of stress, $F(1, 120) = 0.005$, $p = ns$, and no main effect of negative affect, $F(1, 120) = 1.626$, $p = ns$. Error rates were relatively larger for high stress versus control participants in the first block, but more comparable in the second block, supported by the interaction of block with stress condition, $F(1, 120) = 5.786$, $p < 0.05$. Similarly, error rates were relatively larger for high versus low negative affect groups in the first block, $F(1, 50) = 3.901$, $p = 0.054$, but comparable in the second block, $F(1, 50) = 1.540$, $p = ns$, supported by the interaction of block with negative affect, $F(1, 120) = 5.379$, $p < 0.05$. The stress by negative affect interaction was not significant, $F(1, 120) = 2.410$, $p = ns$, and there was no three-way interaction, $F(1, 120) = 0.725$, $p = ns$.

Planned comparisons showed that in congruence with response time variability, in the high stress experimental group, high negative mood participants were significantly more likely to make errors relative to low negative mood participants during the first experimental block, $t(49) = 1.966$, $p < 0.05$, one-tailed. This effect of negative mood failed to reach significance in the low stress group, $t(71) = 1.265$, $p = ns$, one-tailed.

Self-Report of Off Task Thought

As the subjective counterpart to the behavioural measures of task inattention, self-report probes provide the opportunity for online experience sampling throughout task performance (Smallwood & Schooler, 2006). Effects on self-report data were less robust than for behavioural dependent measures. There was a strong main effect of block, with all conditions showing greater proportions of reported off-task thought over blocks, $F(1, 120) = 13.917$, $p < 0.001$. The main effect of stress, $F(1, 120) = 2.289$, $p = ns$, the main effect of negative mood, $F(1, 120) = 0.623$, $p = ns$, and the interaction between these two factors failed to reach significance, $F(1, 120) = 1.156$, $p = ns$. There were also no significant interactions of stress and block, $F(1, 120) = 0.869$, $p = ns$, negative mood and block, $F(1, 120) = 1.533$, $p = ns$, and no three-way interaction, $F(1, 120) = 1.715$, $p = ns$.

Planned comparisons of block 1 data for proportion of off-task thought did not show a difference for high versus low negative mood participants in the high stress condition, $t(49) = 0.906$, $p = ns$, one-tailed.

Retrospective Report of Thought Content

The next series of analyses were designed to investigate the content of participants' mind wandering episodes between high and low negative mood participants assigned to the high stress condition. Retrospective thought content was analysed using a Chi-Square Test of Independence on the factors *Negative Mood* (Low, High) as well as *Tense* (Past, Present, or Future), *Valence* (positive, negative, or neutral), and *Focus* (Task-Related, TSST-Related, and Task-Unrelated) during the first and second experimental block. Descriptive statistics for the first experimental block are shown in Table 4 (pg. 98).

During the first block, negative mood was significantly related to Focus, $X^2(2) = 6.190$, $p < 0.05$, Cramer's V = 0.404, with the high negative mood group more likely to entertain thoughts about the TSST and the low mood group more likely to entertain thoughts relating to task performance. The effect of negative mood on retrospective report failed to reach significance for Tense, $X^2(2) = 1.035$, $p = ns$, V = 0.165, and with participants only reporting either neutral or negative thoughts, Valence also failed to reach significance, $X^2(1) = 2.459$, $p = ns$, V = 0.254. Group differences failed to reach significance for Focus $X^2(2) = 2.46$, $p = ns$, or the remaining factors during the second experimental block ($X^2 < 1$).

DISCUSSION

Findings suggest that for those who are in a negative mood, acute stress activates an emotion-focused coping strategy that fosters an inattentive state (variable response time and a boost in error rates) relative to those in the low negative mood group. Consistent with predictions, the observed effects were prominent during the first experimental block only.

The aim of Experiment 1 was to provide evidence for a cognitive-adaptive transactional account of stress on mind wandering behaviour. The present findings are compatible with such an account, with acute stress inducing a temporary stressor-oriented bias in attentional allocation relative to the low stress group, with performance deficits potentiated by the degree of negative mood reported prior to stress induction. To complement the cognitive-adaptive findings in Experiment 1, Experiment 2 was designed to provide evidence for a bio-cognitive account of stress on mind wandering behaviour.

EXPERIMENT 2

Bio-cognitive transactions are mechanisms that are modulated by the fluctuation in both neural and cognitive architectures that influence availability of resources. Pupil dilation has been shown to reliably reflect resource utilization during cognitively demanding tasks regardless of the sensory domain under investigation (Beatty, 1982), with dilation systematically increasing as a function of cognitive load (Granholm, Asarnow, Sarkin, & Dykes, 1996; Kahneman, 1973). Experiment 2 was designed to replicate the behavioural and self-report trends observed during Experiment 1, while providing a psychophysiological measure of resource availability compatible with a bio-cognitive transactional theory of stress.

The first set of analyses were conducted to replicate the stress effects observed in Experiment 1, and investigate how the observed trends extended into a third experimental block. It was hypothesized that behavioural trends and retrospective reports would replicate the findings observed in Experiment 1, predicting that participants that report a high level of negative mood will be more likely to engage in mind wandering behaviour (high response time variability and error rates) in the high stress condition relative to the low negative mood group, with maximal effects likely during the first experimental block. As per Experiment 1, we predict that task disengagement in the high negative mood group is due to the initiation of an emotion-focused coping strategy, and therefore expect that this group will also be more likely engage in ruminatory processing of the stressor when compared to the low negative mood group. In light of previous reports of reduced resource availability during episodes of stress in those with a negative disposition (Coyne et al., 1981; Lazarus & Folkman, 1984), we predict that individuals in the high negative mood group will also demonstrate a larger pupil diameter immediately following stress induction relative to the low negative mood group, a trend that would parallel the behavioural indicators of mind wandering behaviour observed during the first experimental block.

METHOD

Participants

Participants (n = 47; 23 in the Experimental Group, 13 Females; and 24 in the Control Group, 15 Females) were undergraduate students from McMaster University. Participants were recruited using the University's online experiment scheduling system and received partial course credit in exchange for their participation.

Procedure

The experimental procedure was the same as Experiment 1. Participants completed the PANAS-X as a measure of baseline mood and were randomly assigned to either the control or experimental version of the TSST, and then completed the SART. While our predictions are exclusively focused on the first experimental block, we included a third block to provide a measure of group differences over a longer period of time. Participants were shown three blocks of 179 stimuli, with a 2000ms inter-stimulus interval. Pupil diameter was measured on participants' right eye using a head-mounted EyeLink II video eye tracking system (SR Research). Pupil diameter was sampled at 250 Hz continuously throughout SART performance, and the average pupil diameter within each trial was recorded, and then averaged across trials to provide a mean pupil diameter per block.

RESULTS

Behavioural, experience sampling, and pupillometric data were analysed using a mixed ANOVA on the within subjects factor *Block* (Block 1, Block 2, Block 3) and the between subjects factors *Stress* (High, Low) and *Negative Mood* (Low, High). As per Experiment 1, participants were grouped into either the high mood group (M = 24.44, SD = 2.91) or low mood group (M = 16.37, SD = 2.79) using a median-split analysis ($\tilde{x}$ = 19.4). As per Experiment 1, analyses with negative affect as a continuous variable yielded the same significance of results, and therefore median-split analyses are reported only. As in Experiment 1, in addition to our omnibus analyses, we conducted a small number of directional planned comparisons, focusing on high versus low negative mood participants in the high-stress condition in block 1 data. These planned comparisons were based on a priori predictions of greater stress-mediated disruption to focused performance in high negative affect participants that are likely to diminish over time. Mean data are shown in Figure 5 (pg. 99).

Response Time Variability (RTCV)

RTCV was observed to increase over blocks for all conditions, supported by a strong main effect of block, $F(2, 86) = 28.055$, $p < 0.001$. While RTCV scores were numerically largest for high negative affect participants in the high stress group in all blocks, there was no main effect of stress, $F(1, 43) = 0.234$, p = *ns*, no main effect of negative affect, $F(1, 43) = 0.903$, p = *ns*, and no significant interaction between these two factors, $F(1, 43) = 2.364$, $p = ns$. None of these effects interacted with block, all Fs < 1.5.

Planned comparisons of block 1 data suggested that in the high-stress group, high negative mood participants showed more variable response behaviour compared to low negative mood participants, $t(20) = 2.369$, $p < 0.05$, one-tailed, congruent with the pattern of data observed in Experiment 1. This effect of mood was not observed for participants in the low stress group, $t(23) = 0.882$, $p = ns$, one-tailed.

Error Rate

Error rate was also observed to increase over blocks for all conditions, with a strong main effect of block, $F(2, 86) = 32.436$, $p < 0.001$. In the first block, error scores appeared to be substantially larger for high negative affect participants in the high stress condition compared to other groups. This difference appeared to diminish across subsequent blocks, with participants in each condition equally likely to make errors over time, with some apparent sparing of performance (relatively fewer errors) in the low negative affect, low stress group in the last block. This pattern of data was supported by a significant main effect of negative affect, $F(1, 43) = 4.215$, $p < 0.05$, and the three-way interaction of stress, negative affect, and block, $F(2, 86) = 4.444$, $p < 0.05$. No other effects were significant, Fs < 0.7.

Planned comparisons of error data in block 1 demonstrate a higher error rate during task performance for high versus low negative mood participants in the high stress condition, $t(20) = 2.012$, $p < 0.05$, one-tailed. This effect of mood was not observed for the low stress condition, $t(23) = 0.384$, $p = ns$, one-tailed.

Self-Report of Mind Wandering

In contrast to the general pattern of performance over time, and to self-report of mind wandering in Experiment 1, proportion of self-report of mind-wandering episodes in Experiment 2 was observed to generally increase over blocks, $F(2, 86) = 7.945$, $p < 0.01$, with a strong linear trend, $F(1, 43) = 9.056$, $p < 0.01$. Compared to this general increase in mind wandering over blocks observed in most conditions, the high stress, high negative mood condition appeared relatively consistent over blocks. This pattern of data was partially supported by a marginal three-way interaction of stress, negative mood and block, F(2, 86) = 2.417, $p = ns$. Also in contrast to other dependent measures, self-report of mind wandering was observed to be more frequent in high negative mood participants compared to low negative mood participants in this Experiment, $F(1, 43) = 6.754$, $p < 0.05$. The interaction of stress and negative mood was not significant, $F(1, 43) = 1.664$, $p = ns$, with no other effects observed, Fs < 0.6.

Planned comparisons of high versus low negative mood participants in block 1 data were not significant, with mean differences opposite to those predicted for both high stress, $t(20) = -1.247$, $p = ns$, and low stress groups, $t(23) = -2.616$, $p = ns$.

Pupil Dilation

Pupil diameter was observed to vary across block, with overall larger mean diameters in block 2 compared with block 1 and block 3, $F(2, 86) = 8.236$, $p < 0.01$, with no significant linear trend, $F(1, 43) = 0.225$, $p = ns$. Main effects of stress, $F(1, 43) = 2.682$, $p = ns$, and negative mood, $F(1, 43) = 0.159$, $p = ns$, were not significant. A significant interaction of stress and negative mood supported the observation of larger pupil diameters in high versus low negative mood participants in the high stress condition, but the opposite of this pattern in the low stress condition, $F(1, 43) = 8.291$, $p < 0.01$. This pattern of data appeared consistent over blocks, with no interaction of block by stress, $F(2, 86) = 1.678$, $p = ns$, and no other effects, *F*s < 0.7.

Planned comparisons of block 1 data showed that in the high stress group, high negative mood participants had larger pupil diameters compared to low negative mood participants, $t(20) = 2.065$, $p < 0.05$, one-tailed. This pattern was the opposite to predicted for the low stress group, with larger pupil diameters larger for low versus high negative affect participants, $t(23) = -2.162$, $p < 0.5$.

Retrospective Report of Thought Content

The next series of analyses investigate whether the content of participants' mind wandering episodes differs between high and low negative mood participants in the high stress condition, during the first experimental block. Descriptive statistics for the first experimental block are shown in Table 1 (pg. 58). As per Experiment 1, retrospective thought content was analysed using a Chi-Square Test of Independence on the factors *Negative Mood* (Low, High) as well as *Tense* (Past, Present, or Future), *Valence* (positive, negative, or neutral), and *Focus* (Task-Related, TSST-Related, and Task-Unrelated). The high mood group were more likely to entertain thoughts about the TSST relative to the low mood group, however the trend just failed to reach significance, $X^2(2) = 5.683$, $p = 0.058$, V = 0.508. The effect of negative mood on retrospective report failed to reach significance for Tense, $X^2(2) = 1.833$, $p = ns$, V = 0.289, or Valence, $X^2(2) = 2.640$, $p = ns$, V = 0.346. Group differences failed to reach significance for the remaining factors ($X^2 < 3$).

Correlations Between Dependent Measures

The mind wandering paradigm used in the current set of experiments assumes that all dependent measures reflect mind wandering behaviour. To quantify the degree to which the dependent measures are related, a bivariate correlational matrix was computed between all dependent measures of the SART for the first experimental block and across all experimental blocks. Correlations are shown in Table 5 (pg. 100).

DISCUSSION

The goal of Experiment 2 was to replicate the trends observed in Experiment 1, with the inclusion of pupillometric evidence of resource availability, to develop a bio-cognitive account of stress on mind wandering behaviour. When exposed to our high stress manipulation, participants in the high negative mood group displayed more variable response behaviour and made more errors compared to participants with low negative mood, and showed relatively stable versus decreasing patterns of self-report mind wandering compared to other participants over time. These participants also exhibited larger pupil dilation on average relative to controls. These effects of mood were relatively absent in the low stress group, providing evidence for a resource dependent, bio-cognitive account of stress on mind wandering behaviour.

GENERAL DISCUSSION

The current work aims to investigate the effects of stress on mind wandering behaviour within both the cognitive-adaptive (Experiment 1) and bio-cognitive (Experiment 2) components of transactional theory. Participants were grouped based on their level of negative mood prior to experiment participation, and were randomly assigned to either the high stress or low stress version of the TSST. Participants were then required to complete the SART as a measure of mind wandering propensity. With the current work representing the first investigation of stress effects on mind wandering behaviour, Experiment 1 was exploratory in nature with the minimal prediction that negative mood would potentiate the effects of stress. Predictions in Experiment 2 were bolstered by the trends observed in Experiment 1.

The cognitive-adaptive component of transactional theory predicts cognitive performance based on resource allocation (coping strategy) while the bio-cognitive component predicts performance based on resource availability. When both components are used in conjunction, transactional theories provides a comprehensive understanding of stress effects on cognition. Findings from Experiment 1 reveal that participants in the high negative mood group are more likely to disengage from the task (indicated by an increased response time variability and error rate) and think about the stressor when exposed to the high stress condition relative to the low negative mood group. This stressor-oriented focus, reflecting an emotion focused coping strategy, was observed during the first experimental block only and failed to replicate in the low stress condition, suggesting that the inattentive state observed was driven by the stress manipulation. This behavioural trend was observed in both experiments. Findings from Experiment 2 further reveal that participants in the high negative mood, high stress condition also demonstrated reduced resource availability (larger pupil diameter) during the first block relative to the low negative mood group. Stress-induced limitations in resource availability promote the select processing of information that is most relevant to the self (Chajut & Algom, 2003; Kofman et al., 2006). These data therefore suggest that acute stress limits resource availability in individuals with a negative disposition and, in the initiation of an emotion-focused coping strategy, promotes the select processing of stressor-oriented information at the expense of task performance.

Previous work on the relation between attentional state and pupil diameter support this interpretation, with pupillary constriction associated with indices of task engagement and dilation with indices of task disengagement (Gilzenrat, Nieuwenhuis, Jepma, & Cohen, 2010). Smallwood, Brown, Tipper, Giesbrecht, Franklin, Mrazek, Carlson and Schooler (2011) provide additional evidence for the systematic relationship between pupil diameter and attentional state using the SART, reporting pupillary dilation during mind wandering episodes and constriction during task docus. Pupil dilation also reflects activation of the Locus Coeruleus-Norepinephrine (LC/NE) system (Frith & Frith, 2006; Koss, 1986; Loewenfeld, 1993). The LC/NE system is a prominent network within the Hypothalamic Pituitary Adrenal Axis (HPAA), a constellation of regions activated in stressful situations that operates to maintain homeostasis within the body (Morilak et al., 2005). Acute stress has been shown to induce a phasic release of norepinephrine (NE) from the LC/NE system (Abercrombie & Jacobs, 1987a, 1987b; Cecchi, Khoshbouei, Javors, & Morilak, 2002; Cecchi, Khoshbouei, & Morilak, 2002). In the attention literature, phasic release of NE enhances the processing of stimuli deemed to be of high reward and utility

(Aston-Jones & Cohen, 2005). Previous work suggests that those in a depressive state are more likely to ruminate relative to healthy controls (for a review, see Salguero, Extremera, & Fernandez-Berrocal, 2013). Depressive rumination is intrusive and persistent (Lam, Smith, Checkley, Rijsdijk, & Sham, 2003; Nolen-Hoeksema & Morrow, 1991), and is often fixated on a social problem perceived by the individual to be severe (Edwards & Weary, 1993; Lyubomirsky, Tucker, Caldwell, & Berg, 1999; Rudolph & Conley, 2005; Treynor, Gonzales, & Nolen-Hoeksema, 2003). In the face of a psychosocial stressor such as the TSST, it is possible that participants in a negative mood, who typically employ an emotion-focused coping strategy (Parker & Brown, 1982), appraise stressor-focused thoughts to be of higher utility than the post-stressor SART and that phasic release of NE potentiates the internal focus of attention. As the HPAA feedback mechanisms terminate the stress response and phasic release of NE begins to diminish (Chamberlain, Fineberg, Blackwell, Robbins, & Sahakian, 2006), performance of participants with high levels of negative mood align with the low negative mood group and low stress controls. A stress-based mind wandering paradigm therefore not only offers a unique framework for investigating the neurochemical basis of mind wandering behaviour, but may also provide a framework for investigating how depressive populations value information in situations of limited processing capacity.

Regardless of stress induction, depressive populations typically mind wander more than healthy controls (Smallwood, et al., 2007; Smallwood et al.

2009; Smallwood & O'Connor, 2011). It would therefore be reasonable to predict that in the low stress condition, participants reporting a high level of negative mood would demonstrate a heightened propensity to mind wander relative to the low mood group. Instead, participants in the low negative mood group were more likely to mind wander (higher response time variability and errors rates) and have limited resource availability (larger pupil diameter) in the low stress condition, although this trend did fail to reach significance for all dependent measures. This trend validates the current interpretation that mood interacts with stress to promote mind wandering behaviour, but raises the question of why participants with low negative mood would mind wander more than high negative mood participants in circumstances of low stress. One possibility could be that the low stress condition induces a positive state in those with a depressive mood. Fredrickson and Levenson (1998) argue that positive mood can regulate negative mood, with positive mood having been linked to a broadened scope of attention and heightened resource availability (for a review, see Fredrickson, 1998). Eliciting positive emotions has even been shown to undo the effects of negative mood (Cabanac, 1971; Nezu, Nezu, & Blissett, 1988). In the low stress condition used in the current work, participants are asked to spend five minutes talking about a favourite experience or movie. While speculative, it is possible that the low stress condition temporarily alleviates depressive mood and promotes an on-task focus in high negative mood participants. Stress-related research typically utilizes the high stress version of the TSST, and transactional models typically focus on the interaction between high stress situations and mood. Findings in the current work therefore offer a new route of investigation within the stress literature: does the low stress version of the TSST (engaging in positive thought) induce a focused state of attention in depressive populations?

While the low stress condition may elicit positive moods in participants with high negative mood, Schoofs et al. (2008), found that exposure to the high stress version of the TSST can induce a negative mood in participants. The current work fails to include measures of TSST effectiveness beyond behavioural measures, and therefore it could be argued that the observed effects are an artifact of temporary mood induction. Indeed, the behavioural deficits observed during the first block are congruent with previous reports of attentional deficits following negative mood induction (Smallwood & O'Connor, 2011). The inclusion of a post-TSST mood questionnaire or retrospective report of stressor effectiveness would alleviate the current limitation. However, in the interest to investigate the depleting effect of stress on task inattention, increasing the time interval between the TSST and task performance was perceived as a threat to the validity of data interpretation. In addition to the passage of time, it is possible that having participants actively reflect on their current mood may interfere with the stress manipulation. Investigating the mediating role of stress-induced mood on cognition, rather than the mediating role of mood on stress effects (as in the current work), would be an interesting route of investigation and may help shed light on the mechanisms underlying the effect of stress on mind wandering.

Introducing a time interval between the TSST and SART performance may also influence the degree to which participants are likely to report of mind wandering during the first experimental block. In the current work, the high and low negative mood groups were equally likely to report off-task thought in the high stress condition, even though behavioural measures of task inattention appear to differ between groups. One reason for this finding could be stereotype threat induced by the TSST. Stereotype threat refers to the psychosocial phenomena whereby an individual feels under threat of a stigmatized social identity (Steele, 1997; Steele & Aronson, 1995), with the individual maintaining an effort to sustain a self-image of competence beyond race, gender, socioeconomic status, or age (Steele, 1988; Steele & Aronson, 1995). The TSST is designed to stimulate a manageable level of stress through social evaluative threat and perceived uncontrollability (Kirschbaum et al., 1993), providing the ideal environmental context for facilitation of stereotype threat. In light of evidence that stereotype threat facilitates worries related to perceived task performance (Beilock, Rydell, & McConnell, 2007; Cadinu, Maass, Rosabianca, & Kiesner, 2005), it is reasonable to presume that participants were likely to diminish the degree to which they reported mind-wandering behaviour in the high stress condition, regardless of negative mood. This interpretation is also congruent with previous reports that self-report measures are vulnerable to threats of performance evaluation (Vinski & Watter, 2012), and the failure to observe consistent correlations between self-report and the remaining dependent measures across both experiments. Future research on the effects of stress using the mind wandering paradigm might benefit from measuring the degree to which participants felt intimidated by the high stress condition of the TSST as a mediator of self-report measures.

The current findings are interpreted with a focus on the detrimental effects of stress on participants that report a high level of negative mood. However, an alternative interpretation could be that low levels of negative mood buffers against the detrimental effects of stress, resulting in enhanced task-focus immediately following stress induction. This interpretation is congruent with previous stress-related work in non-depressive populations that demonstrates improved vigilance at moderate levels of arousal (for a review, see Warm, Matthews, & Finomore, 2008). This interpretation would also account for the steady decline in vigilance (and increase in mind wandering frequency) as the effects of stress diminish over time. However, participants with low levels of negative mood were equally likely to engage in mind wandering behaviour regardless of the stress condition across all experimental blocks, and mind wandering typically increases throughout task duration regardless of participants' mood due to a decline in available cognitive resources necessary to maintain stimulus-independent thought (Teasdale et al., 1995). The current experiments do not permit the ability to tease apart whether the temporary low levels of mind wandering observed in the low negative mood, high stress condition is due to the effects of stress or due to a natural task-oriented focus of attention at the early stages of experiment participation typically observed in non-depressive populations, however this route of investigation would be interesting in future studies of stress effects on mind wandering.

While we discuss the current effects within a theoretical framework of attentional control, it is possible that other causal arrangements could account for the observed effects. For example, the difference in self-report of on-task performance over blocks could more causally relate to the differences we observe in behavioural performance measures. Our view is that all of these measures reflect aspects of attentional control, but concede that it is not possible from our data to properly tease apart potentially separate effects of block and more basic attentional effects.

While a priori predictions were replicated between the two experiments, it is imperative to consider the findings that failed to replicate, including the main effects of stress and negative mood. One possibility for the discrepant findings could be the difference in sample size: Experiment 1 has a sample size almost twice the size of Experiment 2. It is therefore entirely plausible that the power of the observed effects in Experiment 1 is not large enough to translate into a smaller sample. It is also plausible that including an eye-tracker in Experiment 2 introduced a degree of discomfort for participants, which may have diminished the difference in mind wandering behaviour originally observed between groups in Experiment 1.

In summary, findings in the current work provide evidence for a transactional account of stress on mind wandering behaviour. Specifically, acute stress appears to limit the availability of cognitive resources in participants that report a high level of negative mood (Experiment 2) and, alongside the initiation of an emotion-focused coping strategy, is likely to induce a temporary stressor-oriented focus of attention at the expense of task performance (Experiment 1).

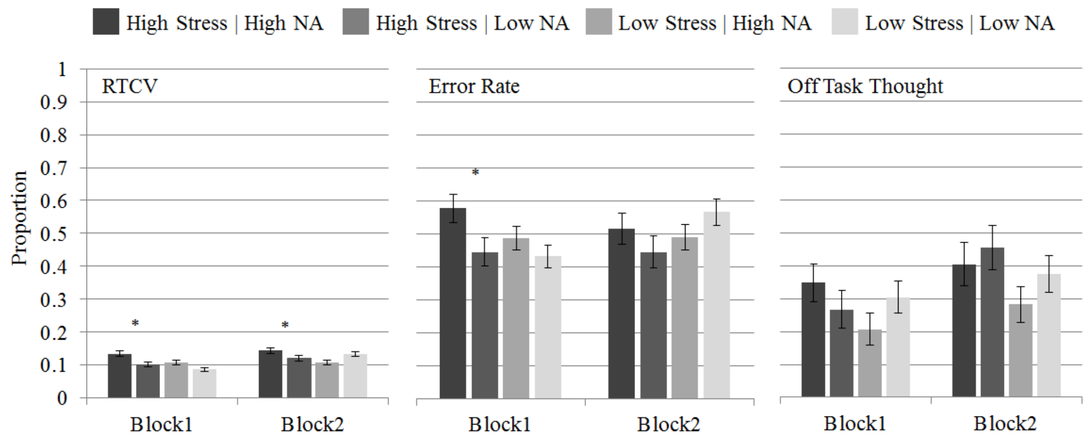

Figure 4 | Mean data for Experiment 1 by stress manipulation, negative mood group, and block. Top Panel: RTCV (reaction time coefficient of variability, calculated as reaction time standard division divided by the mean), Middle Panel: error rate (proportion of times participants responded on target trials), and Bottom Panel: off task thought (proportion of probe trials participants reported off task thought). Error bars represent standard errors.

* indicates significance at a $\alpha = 0.05$ criterion

		Experiment 1		Experiment 2	
Factor	Level	Low Negative Mood	High Negative Mood	Low Negative Mood	High Negative Mood
Tense	Past	0.05	0.11	0.08	0.30
	Present	0.60	0.50	0.58	0.50
	Future	0.00	0.00	0.33	0.20
	Other	0.35	0.39	0.01	0.00
Valence	Positive	0.00	0.00	0.00	0.00
	Neutral	0.95	0.78	0.50	0.40
	Negative	0.05	0.22	0.33	0.60
	Other	0.00	0.00	0.12	0.00
Focus	Task-Related	0.40	0.05	0.00	0.00
	Stressor-Oriented	0.00	0.28	0.33	0.70
	Task-Unrelated	0.60	0.67	0.25	0.30
	Other	0.00	0.00	0.42	0.00

Table 4 | Percentage of retrospective reports for each factor during the first experimental block for both the low and high negative mood groups, across Experiment 1 and 2.

* indicates significance at a $\alpha = 0.05$ criterion

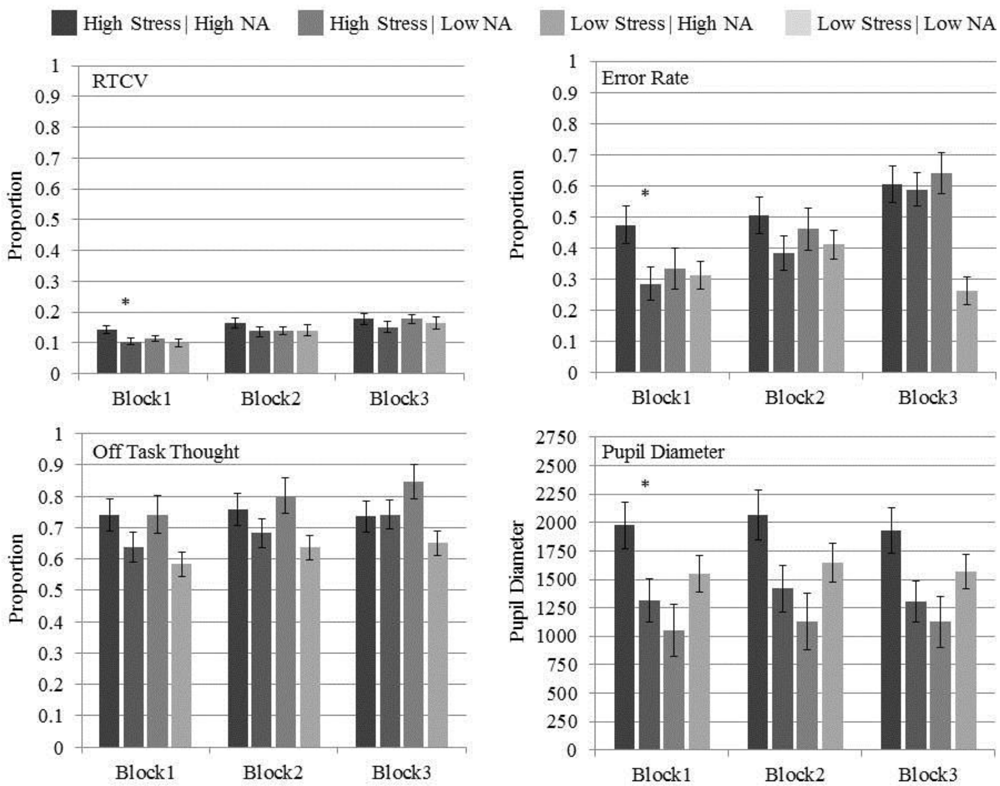

Figure 5 | Mean data for Experiment 2 by stress manipulation, negative mood group, and block. Top Left Panel: RTCV (reaction time coefficient of variability, calculated as reaction time standard division divided by the mean), Top Right Panel: error rate (proportion of times participants responded on target trials), Bottom Left Panel: off task thought (proportion of probe trials participants reported off task thought), and Bottom Right Panel: Error bars represent standard errors.

* indicates significance at a $\alpha = 0.05$ criterion

	SART Dependent Measures	Experiment 1 RTCV	Experiment 1 Error Rate	Experiment 1 Off Task Thought	Experiment 2 RTCV	Experiment 2 Error Rate	Experiment 2 Off Task Thought
Performance During Block 1	RTCV	-	0.37*	0.06	-	0.48*	0.14
	Error Rate	0.37*	-	0.10	0.48*	-	0.45*
	Off Task Thought	0.06	0.10	-	0.14	0.45*	-
Performance Across All Task Blocks	RTCV	-	0.41*	0.13*	-	0.54*	0.11
	Error Rate	0.41*	-	0.05	0.54*	-	0.50*
	Off Task Thought	0.13*	0.05	-	0.11*	0.50*	-

Table 5 | Bivariate correlational matrix between dependent measures of the Sustained Attention to Response Task for both Experiment 1 and Experiment 2.

* indicates significance at a $\alpha = 0.05$ criterion

CHAPTER 4: THE EFFECT OF THE EMOTIONAL ENVIRONMENT ON MENTAL TIME TRAVEL

> Vinski, M. T., Watter, S. & Smallwood, J. (in review). Is mind wandering a truly stimulus-independent phenomenon? Exploring how information in the external environment influences our tendency to mentally travel through time. *Consciousness and Cognition*.

In Chapter 2 and Chapter 3, I focused on the internal (inhibitory) and external (stress) factors that influence that distribution of resources between the internal and external world. In Chapter 4, I wanted to question the “stimulus-independent” characterization of mind wandering, and explore whether information in the external environment can bias the content of mind wandering episodes, and the frequency with which they occur. Again, I was particularly interested in the sample of participants that expressed a high degree of state negative mood. This population not only has a predisposition to mind wander more, but also tends to engage in a retrospective focus during mind wandering episodes. I predicted that showing them negative stimuli would further bias them toward thinking of the past.

The work in this chapter is currently in review at the journal Consciousness and Cognition.

CHAPTER 4: The effect of the emotional environment on mental time travel

Our minds often wander away from the current context, leading us through narratives of past experiences or simulating scenarios for upcoming events. This ability to withdraw from the world and mentally travel through time is considered an adaptive phenomenon that is imperative for survival (Tulving, 1985, 1987). Thinking about a previous experience involves the activation of episodic memory associated with that experience (Tulving, 1987), allowing an individual to revisit and learn from previous mistakes (or successes). Conversely, thinking about the future involves the reconstruction of various memories in service of autobiographical planning for upcoming events (Baird et al., 2011; Schacter & Addis, 2007a, 2007b; Schacter et al., 2007).

Empirical investigation of mental time travel has primarily considered a top-down account of the conscious experience, with recent work focusing on the influence of trait and state mood. A positive association exists between mind wandering frequency and negative mood, with both sad (Poerio, Totterdell, & Miles, 2013; Smallwood, O'Connor, Sudbery, & Obonsawin, 2007) and depressed (e.g. Carriere, Cheyne, & Smilek, 2008) populations more likely to engage in mind wandering relative to healthy controls. This behavioural trend has also been observed following negative mood induction by both Smallwood, Fitzgerald, Miles, and Phillips (2009) and Smallwood and O'Connor (2011), with the latter reporting a retrospective bias during mind wandering episodes using both post-task questionnaires (Experiment 1) and online experience sampling procedures

(Experiment 2). Interestingly, the authors report a positive correlation between retrospective thought and measures of negative mood even without mood induction, providing evidence for a strong retrospective bias in those with a negative disposition independent of a clinical diagnosis or induction procedure.

Negative mood appears to sway the pendulum of temporal thought toward the past, but what about the affective tone of information in the external world? Can the environmental context systematically cue retrospective thought during mind wandering episodes? The frequency with which individuals engage in mind wandering episodes has been tied to the external environment, where being exposed to radio broadcasts of the Vietnam war (Antrobus, Singer, & Greenberg, 1966) and watching disturbing and negatively toned videos (Horowitz, Becker, & Moskowitz, 1971; Smallwood, Fitzgerald, et al., 2009) have been shown to increase global mind wandering rates. Further, recent work has revealed that the retrieval of autobiographical memories can be systematically cued by words or phrases that are congruent with the current concerns of an individual (e.g. Bernsten & Hall, 2004; Klinger, 1971, 2009; Kvavilashvili & Mandler, 2004) even when these cues are imbedded as visual distractors (Kvavilashvili & Schlagman, 2011; Schlagman & Kvavilashvili, 2008). Interestingly, Schlagman and Kvavilashvili (2008) found that negative cues were more likely to elicit involuntary memory retrieval relative to positive or neutral cues, and that the retrieved memories were more distinct, suggesting that negatively-toned information has an especially pronounced effect on subsequent memory retrieval.

The integration of cuing effects within the mind wandering literature is limited. However, in a series of clever experiments, McVay and Kane (2013) showed that systematically embedding cues that align with an individual's personal goals and current concerns subsequently promotes mind wandering behaviour by 3-4% relative to those who were cued with non-relevant information. These experiments, while intriguing, rely on a time consuming and individualist approach to experimental design that does not permit interpretation about the content of the cued mind wandering episodes. The question therefore remains whether generic, negatively-toned stimuli can induce a mind wandering state and influence the temporal-orientation of mind wandering episodes in a similar way that mood influences these behaviours.

The current set of experiments attempt to investigate this question by (i) replicating the general retrospective bias associated with negative mood (Smallwood & O'Connor, 2011; Smallwood et al., 2007), and (ii) seeking to replicate and expand on findings observed by Kane and McVay (2013) to explore whether generic, negatively-toned information in the environment can enhance mind wandering rates and bias the temporal focus of off task thought. Specifically, we predicted that negative stimuli would boost mind wandering rates and promote a retrospective bias during episodes of off task thought. In a recent study, Marchetti, Koster, and De Raedt (2012) found that perceiving ambiguous, negatively-toned information heightens the accessibility of negative thoughts only in those reporting depressive symptoms, suggesting that depressive populations are especially sensitive to negative information in the environment. This interpretation is congruent with a large body of research within the attention and emotion literature, which postulates that dysphoric tendencies are associated with a biased allocation of attention to negative stimuli (see Peckham, McHugh, & Otto, 2010, for a review). The current experiment therefore aims to also investigate whether (iii) the observed effects of negative information on mind wandering behaviour is dependent on participants' state mood, with the prediction that participants with a high degree of negative mood would show a higher sensitivity to the negative stimuli. To achieve this aim, participants were shown a series of positive, negative and neutral words in a semantic version of the Sustained Attention to Response task (SART; McVay & Kane, 2009; Smallwood, Riby, Heim, & Davies, 2006). Participants' tendency to mind wander was measured using both behavioural and subjective measures, with participants indicating the temporal focus of their thoughts throughout the experiment.

EXPERIMENT 1

METHODS

Participants

Participants (n = 38; 17 Females) were undergraduate students from McMaster University. Participants were recruited using the University's online experiment scheduling system and received partial course credit in exchange for their participation.

Procedure

Participants spent approximately 1 hour in the laboratory. After providing informed consent, participants completed the Extended Positive Affect Negative Affect Scale (PANAS-X; Watson, Clark, & Carey, 1988). The PANAS-X is a measurement tool for state mood that requires participants to indicate the degree to which a series of adjectives describes their current state of mind. The negative mood subscale, which includes adjectives such as "irritable", "afraid", "upset", "guilty", and "nervous", is utilized in the current set of experiments as a measure of participants' state negative mood.

Participants were then asked to complete a semantic version of the SART as a measure of mind wandering behaviour (McVay & Kane, 2009; Smallwood, Riby, et al., 2006). The SART is a go/no-go task that requires participants to respond quickly and accurately on frequent non-target trials, and withhold their response on rare critical target trials. In the current experiment, non-target stimuli were five letter nouns, and the target stimulus was a string of x's ("xxxxx"). Stimuli were presented for 500ms, followed by a 1000ms interval, a fixation cross for 350ms, and again by another 1000ms interval. Participants completed three blocks of 150 non-target stimuli and 30 target stimuli (20% target trial frequency) with each block containing either positive, negative or neutral nouns as non-targets (Affective Norms for English Words; Lang, Bradley, & Cuthbert, 1999). Block order was counterbalanced across participants. Response variability on non-target trials (Cheyne, et al., 2009), and the failure to withhold responses on target trials (i.e. “error rate”) were used as behavioural measures of mind wandering behaviour (for a review, see Smallwood & Schooler, 2006).

A two-part probe appeared pseudorandomly throughout task performance as a subjective index of both the frequency in which participants were mind wandering, and the content of their mind wandering episodes. The first probe was designed to determine participants’ attentional focus at the time of the probe, and was presented as “Stop! Where was your attention focused immediately prior to this question?” Participants were given an choice between (1) “My attention was focused on task” and (2) “My attention was focused off task” (Vinski & Watter, 2012) for their response. If participants indicated their attention was off task, a second probe was presented to determine the temporal focus of the mind wandering episode. The probe was presented as “So your attention was off task. What exactly were you thinking about?”, with participants able to make the choice between (1) “My attention was focused on the present task, (2) “My attention was focused on a personal event from the past”, or (3) “My attention was focused on a personal event expected to occur in the future” (as per Baird et al., 2011; Smallwood, Nind, & O'Connor, 2009). Subjective measures were calculated as proportions, where the proportion of off-task thought is determined by dividing the total number of off-task thought probes by the total number of probes. The same procedure was applied for the second thought probe, where we calculated the proportion of times participants thought about the past, present and future during mind wandering episodes. All task stimuli and probe questions were presented in black 35-point font on a white screen. All questionnaires and experiments were presented using E-prime software (Schneider et al., 2002).

RESULTS

The behavioural and experience sampling data were analysed using repeated measures analysis of variance (ANOVA) with a within-subjects factor of *Stimulus Valence* (negative, neutral, positive) and a between-subjects factor of *Negative Mood* (low, high). Participants were classified into either the low (M = 12.36, SD = 1.22) or high (M = 21.76, SD = 4.83) mood group using a median-split technique on the negative mood subscale ($\tilde{X}$ = 15) of the PANAS-X. The participants that scored equal to or higher than the median value were categorized as the high mood group, and the participants that scored below median were categorized as the low mood group. Descriptive statistics for all dependent measures are shown in Table 6 (pg. 125).

Response Time Variability (RTCV)

Response variability on non-target trials provides a measure of participants' transient fluctuation of attention throughout the task, with a low RTCV indicative of a sustained on-task focus (see Cheyne et al., 2009). A main effect of stimulus valence was observed, $F(2,72) = 3.49$, $p < 0.05$, $\eta_p^2 = 0.09$, with LSD pair-wise comparisons revealing that participants engaged in a more variable response behaviour during the negative block relative to the neutral block [$p < 0.05$]. The main effect of mood, $F(1,36) = 0.35$, $p = 0.56$, $\eta_p^2 = 0.01$, and the interaction between negative mood and valence failed to reach significance, $F(2,72) = 0.72$, $p = 0.49$, = 0.02.

Error Rate

Commission errors reflect participants' inability to withhold their response on target trials, and have been used as a measure off task focus (see Smallwood & Schooler, 2006). The main effect of stimulus valence, $F(2,72) = 2.14$, $p = 0.13$, $\eta_p^2 = 0.06$, the main effect of mood, $F(1,36) = 1.39$, $p = 0.25$, $\eta_p^2 = 0.04$, and the interaction between block and mood failed to reach significance, $F(2,72) = 0.37$, $p = 0.69$, $\eta_p^2 = 0.01$.

Report of Mind Wandering

Mind wandering probes provide a subjective measure of off task thought (Smallwood & Schooler, 2006). The main effect of stimulus valence, $F(2,72) = 0.60$, $p = 0.55$, $\eta_p^2 = 0.02$, the main effect of mood, $F(1,36) = 1.63$, $p = 0.21$, $\eta_p^2 = 0.04$, and the interaction between block and mood failed to reach significance, $F(2,72) = 0.49$, $p = 0.61$, $\eta_p^2 = 0.01$.

Retrospective Thought

Immediately following the mind wandering probe, thought content probes provide a measure of participants' thought patterns during mind wandering episodes (Baird et al., 2011; Smallwood, Nind, et al., 2009). The main effect of stimulus valence reached significance, $F(2,72) = 3.96$, $p < 0.05$, $\eta_p^2 = 0.10$, with

LSD pairwise comparisons revealing that participants were more likely to mind wander to the past during the negative block relative to the neutral block [$p < 0.05$]. As predicted based on findings reported by Smallwood and O'Connor (2011), the main effect of mood was observed, $F(1,36) = 3.76$, $p < 0.05$, $\eta_p^2 = 0.10$, one-tailed, with the high negative mood group (M = 0.242, SE = 0.058) more likely to think about the past relative to the low mood group (M = 0.393, SE = 0.052). The interaction between stimulus valence and mood failed to reach significance, $F(2,72) = 1.46$, $p = 0.24$, $\eta_p^2 = 0.04$.

We predicted that the negative stimuli would have a pronounced effect on the retrieval of autobiographical memories during mind wandering episodes (Schlagman & Kvavilashvili, 2008), and that this effect would be particularly pronounced in the high negative mood group (Marchetti, Koster & Raedt, 2012). As a more sensitive measure of the interaction between negative mood and stimulus valence, we computed independent t-tests on the frequency of retrospective thought across the negative, positive and neutral blocks. Indeed, the high affect group were significantly more likely to report retrospective thought during the negative block (Low: $M = 0.246$, $SE = 0.061$; High: $M = 0.464$, $SE = 0.078$), $t(36) = -2.125$, $p < 0.05$, but not during the neutral block (Low: $M = 0.210$, $SE = 0.064$; High: $M = 0.265$, $SE = 0.062$), $t(36) = -0.620$, p = ns, or positive block (Low: $M = 0.271$, $SE = 0.056$; High: $M = 0.448$, $SE = 0.073$), $t(36) = -1.846$, p = ns.

DISCUSSION

The aim of Experiment 1 was to examine whether emotionally toned stimuli influence the frequency and temporal focus of mind wandering behaviour, and whether the stimulus effects are dependent on participants' mood. While we are unable to state that participants were indeed mind wandering more during the negative block (in the absence of an effect on error rate or the proportion of off task thoughts reported), findings reveal that when participants were presented with negative words, participants were more likely to engage in a transient state of task attention (as indicated by a more variable response pattern; see Cheyne et al., 2009) and were more likely to entertain retrospective thoughts during episodes of off task thought. This finding suggests that ambiguous, negatively-toned information can bias the retrieval of autobiographical memories, much like personally-relevant cues (Bernsten & Hall, 2004; Klinger, 1971, 2009; Kvavilashvili & Mandler, 2004; McVay & Kane, 2013). Interestingly, presenting negative words biased the content of mind wandering episodes without influencing the frequency in which they occur, suggesting that the potency of the cueing effect on mind wandering rates may be dependent on the degree to which the cues are relevant to the individual.

Another aim of Experiment 1 was to replicate the association between retrospective thought and negative mood reported by Smallwood and O'Connor (2011). Indeed, those reporting a high level of negative mood more likely to think about the past, however this relationship emerged as significant only when using a one-tailed criterion. Interestingly, further analyses reveal that the retrospective bias observed during the negative block emerged primarily in the high negative mood group. This finding suggests that thought patterns of those with a negative disposition are especially vulnerable to negative information within the environment, promoting a bias toward thoughts of the past.

EXPERIMENT 2

While the findings from Experiment 1 are intriguing, a question remains regarding the degree to which processing the task stimuli accounts for the effects observed in Experiment 1. Schlagman and Kvavilashvili (2008) found that presenting irrelevant phrases successfully cued involuntary autobiographical memories through what the authors call a “direct retrieval” mechanism (see Conway & Playdell-Pearce, 2000), suggesting that even when superficial processing is encouraged, experimental stimuli can still elicit involuntary retrieval of autobiographical memories. In Experiment 2, the SART was modified to promote superficial processing of the emotionally toned stimulus by requiring participants to respond to a series of numerical stimuli and perceive (but not respond to) emotionally toned stimuli during the fixation trial between the numerical trials. This modification permits the investigation of whether effortful processing of emotional stimuli drive the effects observed in Experiment 1, and conversely, whether the observed effects diminish when task performance is not dependent on the processing of emotional stimuli. With all predictions developed a priori based on findings from Experiment 1, analyses were designed to test whether negatively toned stimuli (i) boost response variability, (ii) impose a retrospective bias during episodes of off task thought, and (iii) whether the bottom-up effects of emotionally toned stimuli is dependent on negative mood, even when the processing of emotional stimuli is irrelevant for task performance.

METHODS

Participants

Participants (n = 51; 29 Females) were undergraduate students from McMaster University. Recruitment procedures replicate those used in Experiment 1.

Procedure

Participants spent approximately 1 hour in the laboratory. The procedure was the same as Experiment 1, with participants completing the PANAS-X followed by a slightly modified semantic SART. In Experiment 2, non-target stimuli were modified from five letter nouns to a series of single digits (0 through 9), with the number 3 representing the target stimulus. Participants were asked to respond as quickly and accurately as possible on the non-target trials, and withhold their response on target trials. The five letter words shown in Experiment 1 were instead presented during the fixation trials between the numerical trials, with participants instructed to "not pay attention to the words presented because they are not relevant for the task." The numerical stimuli were presented for 500ms regardless of response, followed by a 1000ms interval, the presentation of a word for 350ms (instead of the fixation cross used in Experiment 1), a 150ms mask, and a 850ms interval to maintain the 2000ms inter-stimulus interval utilized in Experiment 1. As per the first experiment, participants completed three blocks of 150 non-target stimuli and 30 critical target stimuli (20% critical trial frequency), with each block containing positive, negative or neutral nouns (ANEW; Bradley & Lang, 1999). Block order was counterbalanced across participants. All questionnaires and experiments were presented using E-prime software (Schneider, Eschmann & Zuccolotto, 2002).

RESULTS

The behavioural and experience sampling data were analysed using repeated measures ANOVA, with a within-subjects factor of *Valence* (negative, neutral, positive) and a between-subjects factor of *Negative Mood* (low, high). As per Experiment 1, participants were classified into either the low (M = 14.57, SD = 3.52) or high (M = 26.22, SD = 3.13) mood group using the same median-split technique on the negative mood subscale scores ($\tilde{X}$ = 20) used in Experiment 1. Descriptive statistics for all dependent measures are summarized in Table 7 (pg. 126).

Response Variability (RTCV)

In contrast to Experiment 1, the main effect of stimulus valence, $F(2,98)$ = 0.14, p = 0.87, η_p^2 = 0.00, the main effect of mood, $F(1,49)$ = 0.02, p = 0.892, η_p^2

= 0.00, and the interaction between negative mood and block failed to reach significance, $F(2,98) = 0.65$, $p = 0.52$, $\eta_p^2 = 0.01$.

Error Rate

The main effect of block, $F(2,98) = 0.86$, $p = 0.43$, $\eta_p^2 = 0.02$, and the main effect of mood, $F(1,49) = 2.78$, $p = 0.10$, $\eta_p^2 = 0.05$, failed to reach significance. A significant interaction between block and mood was observed, $F(2,98) = 3.86$, $p < 0.05$, $\eta_p^2 = 0.07$. To investigate this interaction, independent samples t-tests was computed between the high and low negative mood groups on error rate across the three valence stimulus types. These analyses reveal that the high negative mood group were more likely to make errors during the negative block, $t(49) = 2.428$, $p < 0.05$, but not during the neutral, $t(49) = 1.870$, $p = 0.67$, or the positive block, $t(49) = 0.243$, $p = 0.809$.

Report of Mind Wandering

As per Experiment 1, the main effect of block, $F(2,98) = 0.27$, $p = 0.76$, $\eta_p^2 = 0.01$, the main effect of mood, $F(1,49) = 0.23$, $p = 0.64$, $\eta_p^2 = 0.00$, and the interaction between block and mood failed to reach significance for the proportion of off task thought probes, $F(2,98) = 2.10$, $p = 0.13$, $\eta_p^2 = 0.04$.

Retrospective Thought

As per Experiment 1, a main effect of block was observed, $F(2,98) = 5.47$, $p < 0.05$, $\eta_p^2 = 0.10$, with LSD pairwise comparisons revealing that participants were more likely to mind wander to the past during the negative block relative to the neutral block [$p < 0.05$]. Also in replication of Experiment 1, a main effect of mood was observed, with the high negative mood group more likely to think about the past relative to the low mood group, $F(1,49) = 5.19$, $p < 0.05$, $\eta_p^2 = 0.10$. A significant interaction between block and mood was also observed, $F(2,98) = 2.68$, $p < 0.05$, $\eta_p^2 = 0.05$, one-tailed. As per Experiment 1, the high negative mood group were more likely to engage in retrospective thought during the negative block relative to the low mood group, $t(49) = 2.341$, $p = 0.023$, with group differences failing to reach significance for the neutral, $t(49) = 1.539$, $p = 0.130$, or the positive block, $t(49) = 0.710$, $p = 0.481$.

DISCUSSION

The aim of Experiment 2 was to investigate whether decreasing the degree to which participants engage in effortful processing of emotional stimuli mitigates the stimuli-dependent effects observed in Experiment 1. We were unsuccessful in this aim. Even when asked to ignore the word stimuli, participants were more likely to entertain a retrospective focus during mind wandering episodes when presented with negatively-toned words relative to neutral words. Also in replication of Experiment 1, a high level of negative mood was generally associated with a retrospective bias when using a more liberal confidence interval, with this bias especially prominent during the negative word block.

GENERAL DISCUSSION

We set out to explore whether the external environment can bias the way in which the mind wanders through time. While previous work has shed light on top-down factors that induce a bias in the temporal focus of task irrelevant thought (Smallwood, Nind & O'Connor, 2007; Smallwood & O'Connor, 2011), the current work aims to explore whether these biases can be stimulus-driven as well. We explored this question within an emotional context, building on previous work showing a positive association between negative mood and the tendency to engage in retrospective thought (Smallwood & O'Connor, 2011). To achieve this aim, we showed participants a series of positive, negative or neutral words and measured the frequency in which they mind wandered and the temporal focus of their off task thoughts.

In both experiments, participants were more likely to report thinking about the past when perceiving a string of negatively-toned words relative to neutral or positive words. This finding suggests that even when deemed irrelevant, negative information can bias individuals' thought patterns toward the past. Crick (1996) and Crick and Koch (1998, 2003) have argued that separating the cognitive processes that underlie stimulus-dependent and stimulus-independent thought are imperative to understanding how consciousness is generated. A mind wandering episode is conceptualized as stimulus-independent thought (Smallwood, 2013), and as such the empirical investigation of mind wandering behaviour permits the study of stimulus-independent features of consciousness (Smallwood, 2013).

However, seminal work by Antrobus and colleagues (1966), Klinger (1971; 1999; 2009) and more recently by Schlagman and Kvavilashvili (2008), Kvavilashvili and Schlagman (2011) and McVay and Kane (2013) contests this definition of mind wandering behaviour, suggesting that the environmental context can systematically cue the retrieval of autobiographical memories during episodes of off-task thought. Findings in the current work support these series of findings, suggesting that qualities of the external world can bias an individuals' tendency to mentally travel through time. Temporal focus during spontaneous thought therefore appears to be stimulus-dependent within a framework designed to encourage stimulus-independent cognition.

The degree to which the environment can influence spontaneous thought appears to be dependent on an individuals' disposition. In line with previous reports of an enhanced retrospective focus for those in a negative mood (Smallwood & O'Connor, 2011), the stimulus-driven effects on temporal focus was predominant for participants that reported a high level of negative mood. These effects were not dependent on the degree of information processing, as the effect persisted during both effortful (Experiment 1) and superficial (Experiment 2) processing of the negative words. Findings from the current work therefore foster the possibility that when people are feeling especially negative, negative information in the environment can influence the content of their conscious experience by biasing the retrieval of experiences that have occurred in the past. This finding is particularly relevant for the clinical domain of cognitive research.

Specifically, the current findings may help illuminate the mechanisms that underlie thought patterns in clinical disorders associated with post-event rumination, such as depression (Ingram & Smith, 1984; Larsen & Cowan, 1988; Wood, Saltzberg, Neale, Stone, & Rachmiel, 1990), anxiety (Mellings & Alden, 2000), or the persistent and intrusive retrieval of traumatic memories experienced by those with Post Traumatic Stress Disorder (PTSD; e.g. Ehlers et al., 2002). Understanding these mechanisms may aid in the development of cognitively-based treatment methods currently used with the afflicted populations. While retrospective thought does not constitute rumination (Lyubomirsky, Kasri, & Zehm, 2003) and the study sample does not permit extrapolation to such clinical populations, the current findings provide preliminary evidence to suggest that subtle environmental triggers may cue retrospective thought and (potentially) rumination in both depressed and anxious populations.

Surprisingly, behavioural data from both experiments were inconsistent and inconclusive, and do not permit the interpretation of an increase in mind wandering behaviour during the negative word block. This finding is arguably the most interesting of the current experiments, as it suggests that negative information can bias the content of mind wandering episodes but not necessarily the frequency in which they occur. This finding is inconsistent with the boost in mind wandering rates reported by McVay and Kane (2013) and enhanced retrieval of involuntary memories reported by Schlagman and Kvavilashvili (2008) associated with the presentation of personally relevant negative cues. One possibility for the observed discrepancy could therefore be the degree of personal saliency embedded within the cues. For both of the mentioned experiments (McVay and Kane, 2013; Shlagman & Kvavilashvili, 2008), the cues were personally-relevant to the participant whereas in the current experiment, the cues were general and not necessarily applicable to the participant.

The aim of Experiment 2 was to degrade emotional processing in an attempt to mitigate the influence of negative stimuli on participants' tendency to mentally travel to the past. However, this degradation failed to mitigate the retrospective bias. An avenue of research therefore remains to determine the threshold in which the processing of negative stimuli fails to influence temporal focus of off task thought. One possibility would be to increase the working memory requirement of numerical stimuli using the paradigm in Experiment 2, by incorporating a 1- or 2-back version of an n-back task (for an example of a 1- and 2-back version of the SART, see Experiment 2 in McVay, Meier, Touron, & Kane, 2013). Increasing the cognitive load for the numerical stimuli increases the amount of resources required for successful task performance, which would necessarily mitigate the allocation resources for perceptual processing during fixation trials. This reduction in processing power of the emotional stimuli could perhaps eliminate the bottom-up effects observed in the current set of studies. Alternatively, a paradigm could be used whereby both stimulus types (numbers and emotional words) appear simultaneously on either side of a fixation cross. The principles of selective attention would predict that participants would be forced to preferentially process the numerical stimulus at the sacrifice of emotional processing, and as per increasing the cognitive load of the numerical stimuli using a working memory task; the retrospective bias and associated performance errors observed during the negative block would be expected to diminish.

Within the broad scope of cognitive research, plenty of evidence supports the idea that mood promotes the retrieval of mood-congruent memories. For example, individuals in a negative mood are more likely to entertain negative thoughts relative to those in a positive mood (for a review, see Blaney, 1986), to demonstrate enhanced accessibility of negative memories in working memory (Siemer, 2005), and are unable to inhibit the processing of emotional material deemed irrelevant for the task (Joormann & Gotlib, 2008). As stated previously, Schlagman and Kvavilashvili (2008) also found that negative cues are more likely to elicit involuntary memory retrieval relative to positive or neutral cues, and that negative cues generally cue negative and distinct autobiographical memories. A limitation of the current experimental design therefore lies in the inability to tease apart whether participants' mind wandering episodes were biased toward the past, and also whether these thoughts were more likely to be negatively toned. A potential direction for future investigation therefore remains to further delineate the interaction between mood and the environment on the temporal orientation and emotional tone of conscious content during mind wandering episodes. These experiments provide a foundation for future research on environment-dependent thought, and the question of whether mind wandering episodes are a truly stimulus-independent phenomenon. The findings also suggest that for those in a negative disposition, perception of negatively toned stimuli does not necessarily bias the distribution of resources between the internal or external world, but can bias the retrieval of autobiographical memories during episodes of off task thought.

	Low Negative Mood			High Negative Mood		
Dependent Measure	Neutral Words	Negative Words	Positive Words	Neutral Words	Negative Words	Positive Words
RTCV [SD/Mean]	0.43 (0.03)	0.46 (0.04)	0.47 (0.03)	0.46 (0.03)	0.51 (0.04)	0.47 (0.03)
Error Rate	0.28 (0.05)	0.24 (0.04)	0.23 (0.05)	0.20 (0.04)	0.19 (0.03)	0.17 (0.04)
Off-Task Thought	0.42 (0.09)	0.43 (0.09)	0.37 (0.09)	0.59 (0.08)	0.49 (0.08)	0.53 (0.08)
Retrospective Thought	0.27 (0.07)	0.25 (0.08)	0.27 (0.07)	0.27 (0.06)	0.46 (0.07)	0.45 (0.06)

Table 6 | Means (Standard Error) of dependent measures by word valence, for both the low and high negative mood groups for Experiment 1.

	Low Negative Mood			High Negative Mood		
Dependent Measure	Neutral Words	Negative Words	Positive Words	Neutral Words	Negative Words	Positive Words
RTCV [SD/Mean]	0.36 (0.02)	0.34 (0.02)	0.34 (0.03)	0.34 (0.02)	0.35 (0.02)	0.35 (0.02)
Error Rate	0.35 (0.04)	0.29 (0.04)	0.28 (0.04)	0.37 (0.04)	0.42 (0.04)	0.39 (0.04)
Off-Task Thought	0.33 (0.07)	0.30 (0.07)	0.35 (0.08)	0.26 (0.06)	0.33 (0.07)	0.26 (0.07)
Retrospective Thought	0.07 (0.05)	0.08 (0.08)	0.01 (0.04)	0.11 (0.04)	0.31 (0.07)	0.09 (0.03)

Table 7 | Means (Standard Error) of dependent measures by word valence, for both the low and high negative mood groups for Experiment 2.

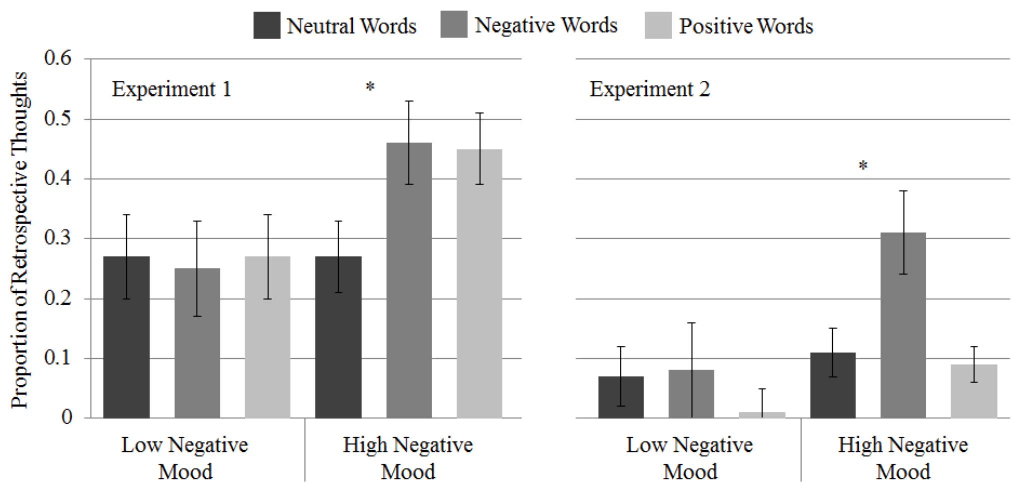

Figure 6 | Mean proportion of retrospective thoughts reported during probe trials for both the low and high negative mood groups, for Experiment 1 (left) and Experiment 2 (right). This table provides a visual representation of the significant findings in Chapter 4, but was not included in the original publication.

* indicates significance at a $\alpha = 0.05$ criterion

CHAPTER 5: THE EFFECT OF CONTEXTUAL CUES ON EPISODIC RETRIEVAL

> Vinski, M. T., LaPointe, M., & Watter, S. (in review). Freedom of Thought, or Not? Binding an Emotional State with the Experimental Context Subsequently Biases the Content of Mind Wandering Episodes. *Psychological Science*.

In Chapter 4, I showed that perhaps the distribution of resources can be influenced by the emotional quality of the external environment. In Chapter 5, I wanted to further explore this line of inquiry within framework of context-dependent retrieval. To achieve this aim, I had participants associate a mood state with a contextual cue (a colour), and then reinstated that cue during a mind wandering task. I predicted that reinstating the contextual cue, previously bound with an emotional state, would boost mind wandering rates and promote the retrieval of mood-congruent memories during episodes of off task thought.

The work in this chapter is currently in review at the journal Psychological Science.

Chapter 5: The effect of contextual cues on episodic retrieval

We have all experienced a bad day. On these days it can feel as though you are stuck in your own mind at the mercy of relentless and recycled thoughts. At its extreme, the captivating quality of a negative disposition can cause enduring disruptions in cognitive functioning (American Psychological Association, 2013). For most however, these episodes are no more than a fleeting nuisance. While the former represents an important question within the clinical domain, the latter case has been the subject of recent empirical investigation within the mind-wandering field. Indeed, those in a negative mood are more likely to engage in mind-wandering behaviour (e.g. Smallwood & O'Connor, 2011). Mind-wandering episodes are self-generated thoughts that are typically unrelated to direct perceptual input (see Smallwood, 2013) and arise from the autobiographical memory system (Schacter & Addis, 2007a). So, why are the minds of those with a negative disposition so likely to wander?

One possible explanation is that those in a negative mood have a heightened perception of concerns in their daily life (Smallwood, Fitzgerald, et al., 2009). This explanation, originally proposed as the “current concerns theory” (Klinger, 1971) argues that the mind will wander towards the most pertinent concerns at that moment in time, and that cues related to these concerns can trigger episodes of task-irrelevant thought. Research within the memory literature supports this theory. For example, memories can be involuntarily prompted by words that are congruent with a participant’s concerns (Kvavilashvili & Mandler, 2004), with negative cues more likely to elicit retrieval of negative memories (Schlagman & Kvavilashvili, 2008). While contradictory to the conceptualization of mind-wandering as stimulus-independent, these experiments bolster the possibility that environmental cues can trigger the systematic retrieval of memories during mind-wandering episodes.

While there are a limited number of studies that have explored the connection between the environment and mind-wandering, the initial results are promising. For example, Antrobus et al. (1966) found that activating a personally salient concern subsequently increases mind-wandering rates. More recently, McVay and Kane (2013) have shown that systematically embedding a task with cues that align with an individual's current concerns can boost mind-wandering rates by up to 4%. Similar results are found for concerns that are induced by the experimenter, such as the occurrence of a psychosocially stressful event prior to experiment participation (Vinski & Watter, 2013), or the assurance of an impending stressful event post-experiment (Stawarczyk et al., 2013). Moreover, Vinski, Smallwood, and Watter (in review) showed that negative words were enough to induce a retrospective thought pattern during mind-wandering.

In this two-part experiment, we aim to further explore how the experimental context can alter the nature in which we mind wander. An extensive body of research has shown the importance of contextual cues in the encoding and subsequent retrieval of memories. For example, Chun and Jiang (1998) have shown that while completing a visual search task, participants can learn the spatial configuration of distractor items and translate that learning into better performance on subsequent trials using similar configurations. This finding demonstrates that after information has been "bound" to a global context, reinstating that context makes the associated information more accessible for retrieval. Mood-state has also been shown to be a salient contextual feature, with the retrieval process and retrieved memories often congruent with the emotional valance experienced during the original episode (Holland & Kensinger, 2010). Similar effects have been observed within the mind-wandering literature, where the content of a mind-wandering episode tends to be congruent with the mood experience immediately prior to an episode of off task thought (Song & Wang, 2012).

In the current experiment, we aimed to expand our current understanding of the memory retrieval process during mind-wandering, by applying theories of context-based retrieval to a typical mind-wandering paradigm. We encouraged participants to bind either a negative emotional state (Experiment 1a) or a positive emotional state (Experiment 1b) with a colour, and then reinstated that colour (and presumably the emotional state), during a mind-wandering task. Assuming the context-binding procedure is effective and that the cued mood state will elicit mood-congruent memories (Schlagman & Kvavilashvili, 2008), we predict that in Experiment 1a, reinstating the negative context during the mind-wandering task will (i) induce higher mind-wandering rates (Seibert & Ellis, 1991; Smallwood, Fitzgerald, et al., 2009), (ii) facilitate the retrieval of negative memories relative to positive memories during episodes of off task thought (Schlagman & Kvavilashvili, 2008), and (iii) that this effect will be strongest for those in a negative mood (e.g. Smallwood et al., 2007).

EXPERIMENT 1A

METHOD

Participants

Participants (n = 26; 14 Females) were undergraduate students from McMaster University. Participants were recruited using the University's online experiment scheduling system and received partial course credit in exchange for their participation. Sample size was dependent on participant availability, and sample sizes reported in referenced work.

Procedure

Participants spent approximately 1 hour in the laboratory. After providing informed consent, participants completed the extended version of the Positive Affect Negative Affect Scale (PANAS-X; Watson, Clark, & Carey, 1988). Used as a measurement tool for state mood, the PANAS-X requires participants to indicate the degree to which a series of adjectives describes their current state of mind. In the current experiment, we use the negative mood subscale (which includes adjectives such as "irritable", "afraid", "upset" and "nervous") as a measure of participants' state negative mood.

Participants were then asked to rate a series of images on a scale from negative (1) to positive (5), with the mid-point defined as neutral (3). The images were presented in blocks of five, with each block consisting of either positive, negative or neutral images from the International Affective Picture System (Lang et al., 1999). Each presented image was bordered by a colour. The positive images were bordered by the colour purple, the negative images were bordered by the colour blue, and the neutral images were bordered by the colour yellow. This exercise was designed to bind an emotional state with a colour, with the colour becoming a context for that emotional state.

Participants were then asked to complete the Sustained Attention to Response Task (SART; Robertson et al., 1997) as a measure of mind-wandering behaviour (McVay & Kane, 2009; Smallwood et al., 2006). The SART is a go/no-go task that requires participants to respond quickly and accurately on frequent non-target trials, and withhold their response on rare critical target trials. In the current experiment, non-target stimuli were single digits between 0-2 and 4-9, and the target stimulus was the number 3. Stimuli were presented for 500ms, followed by a 2000ms inter-stimulus interval (Jackson & Balota, 2012; Smallwood et al., 2004). Participants completed three blocks of 150 non-target stimuli and 30 target stimuli (17% target trial frequency), with each trial bordered by a particular colour. Each participant was presented with a yellow block (for the neutral context), a red block (as a control block), and a blue block (for the negative context). Block order was counterbalanced across participants. Response variability on non-target trials (Response Time Coefficient of Variability, RTCV, calculated as SD/Mean of reaction time data on non-target trials; Cheyne, Solman, Carriere & Smilek, 2009), and the proportion of times participants failed to withhold their response on target trials (errors rate) were used as behavioural measures of mind-wandering behaviour (for a review, see Smallwood & Schooler, 2006).

A two-part probe was pseudo-randomly interleaved throughout task performance as an index of the frequency in which participants engaged in mind-wandering behaviour, and the content of these episodes. The first probe was designed to determine whether participants' attention was focused on task at the time of the probe. The probe was presented as "Stop! Where was your attention focused immediately prior to this question?", with participants given the choice between (1) "My attention was focused on task" and (2) "My attention was focused off task" for their response (Vinski & Watter, 2012). If participants indicated their attention was off task, a second probe was presented to determine the valence of the mind-wandering episode. The probe was presented as "So your attention was off task. What exactly were you thinking about?", with participants able to make the choice between (1) "My thoughts were negative, (2) "My thoughts were neutral", or (3) "My thoughts were positive" (Marchetti et al., 2012). All task stimuli and probe questions were presented in black 35-point font on a white screen. All questionnaires and experiments were presented using E-prime software (Schneider, Eschmann, & Zuccolotto, 2002).

RESULTS

The behavioural and experience sampling data were analysed using a repeated measures Analysis of Variance (ANOVA) with a within subjects factor of *Context* (negative, neutral) and a between subjects factor *Negative Mood* (low, high). *Context* refers to whether the SART block was bordered by a colour previously associated with a negative state (negative) or a neutral state (neutral). Participants were classified into either the low (M = 14.25, SD = 2.09) or high (M = 26.62, SD = 6.19) negative mood group using a median-split technique on the negative mood subscale scores ($\tilde{X}$= 18). One participant scored the median value on the subscale, and was therefore removed from the analysis.

Response Time Variability (RTCV)

RTCV [SD/Mean], or the variability in response time during non-target trials, provides a measure of participants' tendency to transiently shift between on-task and off-task thought, with a high variability coefficient indicative of a wavering attentional focus throughout the experiment (see Cheyne et al., 2009). An main effect of context was observed on the RTCV, $F(1, 23) = 15.58$, $p < 0.01$, $\eta_p^2 = 0.40$, with participants in the negative block (M = 0.36, SE = 0.02) more likely to engage in a variable response behaviour relative to the neutral block (M = 0.28, SE = 0.02). The main effect of mood, $F(1, 23) = 0.07$, $p = 0.79$, $\eta_p^2 = 0.00$, and the interaction between mood and context failed to reach significance, $F(1, 23) = 0.11$, $p = 0.74$, $\eta_p^2 = 0.01$.

Error Rate

The error rate, or the proportion of times participants failed to withhold their response on target trials, provides a measure of the degree to which participants' attention is decoupled from the task (Smallwood & Schooler, 2006). As per RTCV, a main effect of context was observed for error rate, $F(1, 23) = 9.11$, $p < 0.01$, $\eta_p^2 = 0.28$, with participants more likely to make errors during the negative block ($M = 0.20$, $SE = 0.02$) relative to the neutral block ($M = 0.13$, $SE = 0.03$). The main effect of mood, $F(1, 23) = 0.30$, $p = 0.59$, $\eta_p^2 = 0.01$, and the interaction between context and mood failed to reach significance, $F(1, 23) = 0.25$, $p = 0.62$, $\eta_p^2 = 0.01$.

Self-Report of Mind-wandering

Calculated as the proportion of times participants indicated their attention was off-task during probe trials, self-report measures provide a subjective measure of mind-wandering frequency (Smallwood & Schooler, 2006). Unlike the behavioural measures however, the main effect of context failed to reach significance (Negative: $M = 0.34$, $SE = 0.05$; Neutral: $M = 0.35$, $SE = 0.04$), $F(1, 23) = 0.04$, $p = 0.84$, $\eta_p^2 = 0.00$. The main effect of mood, $F(1, 23) = 0.75$, $p = 0.39$, $\eta_p^2 = 0.03$, and the interaction between context and mood also failed to reach significance $F(1, 23) = 0.01$, $p = 0.94$, $\eta_p^2 = 0.00$.

Relative Frequency of Positive and Negative Memories

As predicted, participants were more likely to engage in mind-wandering behaviour (indicated by RTCV and error rate) when participants were presented with the negative context relative to the neutral context during the mind-wandering task. To test the remaining prediction that the negative context facilitates the retrieval of negative memories relative to positive memories, and that this effect will be most pronounced in the high negative mood group, we ran an independent t-test between the frequency of negative and positive thoughts during the negative context block, for both the high and low negative mood group. For the low negative mood group, participants were equally likely to engage in both positive (M = 0.11, SE = 0.04) and negative thoughts (M = 0.11, SE = 0.01), $t(11) = 0.14$, $p = 0.89$. For the high negative mood group however, participants were significantly more likely to entertain negative memories (M = 0.21, SE = 0.03) relative to positive memories (M = 0.07, SE = 0.01), $t(12) = 5.82$, $p < 0.05$.

DISCUSSION

Findings from Experiment 1a provide novel evidence to suggest that binding a context (i.e. a colour) to a negative mood-state, and then reinstating that context on a subsequent mind-wandering task, can not only generally boost mind-wandering rates, but can also act to systematically bias the retrieval of memories during episodes of off task thought in the high negative mood group.

EXPERIMENT 1B

Reinstating a global context previously bound with a negative state appears to heighten the accessibility of negative memories during mind-wandering episodes, especially for those in a negative mood. While the context-dependent findings align with expectations based on findings within the memory literature, the application of this theoretical framework to the mind-wandering paradigm is novel. These findings are also interesting because they have direct implications for understanding how information in the environment can trigger thought patterns in clinically depressed populations, considering negative cognitions are thought to perpetuate the disorder (e.g. Lyubomirsky & Nolen-Hoeksema, 1993). We were therefore curious whether a positively-toned context associated would induce positively-toned thoughts in participants with high negative mood. We aim to answer this question in Experiment 1b. We gave participants the same paradigm as in Experiment 1a, but instead of reinstating the negative context during the mind-wandering task, we reinstated a positive one. We predict that reinstating the positive context will (i) generally induce higher mind-wandering rates versus a neutral context (see Seibert & Ellis, 1991) and (ii) facilitate the retrieval of positive memories (Schlagman & Kvavilashvili, 2008), thus (iii) removing the bias toward negative thoughts observed in the high negative mood group in Experiment 1a.

METHOD

Participants

Participants (n = 28; 14 Females) were undergraduate students from McMaster University. Participants were recruited using the University's online experiment scheduling system and received partial course credit in exchange for their participation. Sample size was dependent on participant availability, and sample sizes reported in referenced work.

Procedure

The procedure was replicated from Experiment 1a, with one exception. As per Experiment 1a, participants were again asked to rate a series of images on a scale from negative (1) to positive (5), with the mid-point defined as neutral (3), with each picture bordered by a particular colour. The images were again presented in blocks of five, with each block consisting of either positive (bordered by purple), negative (bordered by blue) or neutral images (bordered by yellow) (IAPS; Lang, Bradley, & Cuthbert, 1999). Participants were then required to complete the SART, where they were presented with a purple block (for the positive context), which acts to substitute the negative context presented during Experiment 1a, a yellow block (for the neutral context), a red block (as a control block). Response variability on non-target trials (RTCV), the proportion of times participants failed to withhold their response on target trials (error rate), and self-report probes were used as behavioural measures of mind-wandering behaviour.

RESULTS

As per Experiment 1a, the behavioural and experience sampling data were analysed using a repeated measures Analysis of Variance (ANOVA) with a within subjects factor of *Context* (positive, neutral) and a between subjects factor of *Negative Mood* (low, high). Participants were classified into either the low (M = 14.54, SD = 2.03) or high (M = 23.93, SE = 4.80) negative mood group using a median-split technique on the negative mood subscale scores ($\tilde{X}$= 18). One participant scored the median value on the subscale, and was therefore removed from the analysis.

Response Time Variability (RTCV)

A main effect of context was observed on the RTCV, $F(1, 25)$ =9.71, $p <$ 0.01, η_p^2 = 0.28, with participants in the positive block (M = 0.34, SE = 0.02) more likely to engage in a variable response behaviour relative to the neutral block (M = 0.27, SE = 0.02). The main effect of mood, $F(1, 25)$ = 2.02, p = 0.17, η_p^2 = 0.08, and the interaction between mood and context failed to reach significance, $F(1, 25)$ = 0.30, p = 0.59, η_p^2 = 0.01.

Error Rate

A main effect of context was observed for error rate, $F(1, 25)$ = 19.42, $p <$ 0.01, η_p^2 = 0.44, with participants more likely to make errors during the positive block (M = 0.19, SE = 0.02) relative to the neutral block (M = 0.09, SE = 0.02). The main effect of mood, $F(1, 25)$ = 2.21, p = 0.15, η_p^2 = 0.08, and the interaction between context and mood failed to reach significance, $F(1, 25) = 0.00$, $p = 0.94$, $\eta_p^2 = 0.00$.

Self-Report of Mind-wandering

A main effect of context failed to reach significance (Positive: $M = 0.33$, $SE = 0.04$; Neutral: $M = 0.28$, $SE = 0.03$), $F(1, 25) = 2.07$, $p = 0.16$, $\eta_p^2 = 0.07$. The main effect of mood, $F(1, 25) = 1.93$, $p = 0.18$, $\eta_p^2 = 0.07$, and the interaction between context and mood failed to reach significance $F(1, 25) = 0.00$, $p = 0.97$, $\eta_p^2 = 0.00$.

Relative Frequency of Positive and Negative Thoughts

As per Experiment 1a, participants were generally more likely to engage in mind-wandering behaviour (as indicated by RTCV and error rate) during the positive block relative to the neutral block. This result is not entirely surprising, considering the fact that Seibert and Ellis (1991) found a boost in task-irrelevant thought following both positive and negative mood induction. To test our prediction that reinstating a positive context would facilitate positive memory retrieval, even in the high negative mood group, we ran paired t-tests between the frequency of positive and negative thoughts during the positive context, for both the low and high mood group. Results reveal that for both the low (Positive: $M = 0.11$, $SE = 0.05$; Negative: $M = 0.12$, $SE = 0.05$) and high (Positive: $M = 0.13$, $SE = 0.03$; Negative: $M = 0.15$, $SE = 0.02$) negative mood group, participants were equally likely to entertain positive and negative thoughts during the positive context, $t(12) = 0.11$, $p = 0.92$, $t(13) = 0.62$, $p = 0.55$, respectively (see Figure 7, pg. 148).

DISCUSSION

While introducing a positively-toned context during the mind wandering task bolstered higher mind-wandering rates for all participants, we failed to observe a bias toward positive thoughts in the high negative mood group. This finding suggests context-dependent retrieval for those in a negative mood is specific to a negative context.

GENERAL DISCUSSION

The ebb and flow of thought, a seemingly unconstrained and personal experience, has remained one of the largest hurdles in developing instruments that measure and predict mind-wandering behaviour. Thus, the concept of systematically cuing the retrieval of memories as the mind wanders is an especially intriguing one. In the current paper, we aimed to build on this relatively new route of thinking by using methods for context-dependent retrieval in conjunction with the traditional mind-wandering paradigm. With previous work primarily focused on the influence of emotional states on mind-wandering rates (Smallwood et al., 2007), we were especially interested in the effects an emotionally-toned context would have on the content of mind-wandering episodes.

We had participants bind an emotional state with a specific colour, and then reinstated that colour during a mind-wandering task. Throughout the task we asked participants to tell us whether they were mind-wandering and if they were, to tell us the valance of those thoughts. As predicted, participants were more likely to engage in mind-wandering behaviour (as indicated by a boost in both response variability and error rate) when they were exposed to the colour previously associated with either a negative (Experiment 1a) or positive (Experiment 1b) context. Further, those that report a high degree of negative mood were more likely to entertain negative thoughts when exposed to the colour previously bound with a negative context, suggesting that the context-dependent retrieval process was effectively engaged during the mind-wandering task for this particular population. This set of findings successfully supports the integration of context-dependent retrieval of memories during mind-wandering episodes, and provides a novel paradigm to study such effects. More importantly, this data provides an interesting possibility that the organic flow of thought can be systematically directed by indirect cues in the environment, bringing us one step closer to developing the tools that predict retrieval mechanisms during mind-wandering behaviour.

A second piece of evidence arising from the current set of experiments is that participants in a negative mood were more likely to entertain negative thoughts when the negative context was reinstated during the task, yet were equally likely to engage in mind-wandering behaviour relative to the low mood group. This finding is congruent with previous research showing that in dysphoric populations; negatively toned stimuli can influence the content of mind-wandering episodes but not the frequency with which they occur (Vinski, Smallwood & Watter, in review). One possible explanation for this selective cuing-effect could be the heightened accessibility of negative thoughts (Blaney, 1986) and the inability to inhibit emotional processing typical of depressive populations (Joormann & Gotlib, 2008). So, perhaps the degree to which the cues are personally-relevant is a primary factor in generally eliciting mind-wandering behaviour (McVay & Kane, 2013), but the ease with which negatively-toned memories can be retrieved during mind-wandering episodes is a relevant factor for those in a negative mood.

A third piece of evidence from the current work builds on a series of recent explorations of cueing effects on mind-wandering rates (McVay & Kane, 2013) and thought content during mind-wandering episodes (Stawarczyk et al., 2013; Vinski, Watter, & Smallwood, in review), which call into question the current conceptualization of mind-wandering as stimulus-independent cognition (e.g. Smallwood, 2013; Smallwood & Schooler, 2006). This line of inquiry is becoming increasingly important as we strive to understanding the mechanisms that initiate and maintain mind-wandering episodes (Smallwood, 2013). One caveat in our interpretations of the current data is the failure to observe any effects on self-report measures of mind-wandering. While there have been a number of criticisms of self-report measures generally (e.g. Jack & Shallice, 2001), and specifically within the mind-wandering literature (Schooler & Schreiber, 2004; Vinski & Watter, 2012), finding reliable self-report differences is still useful data. That said, we suggest that behavioural measures, when they occur together in a sensible pattern that is proposed to reflect task inattention, may be a more sensitive measure of mind-wandering relative to self-report probes. Indeed, bivariate correlations between the self-report and behavioural measures in the current work shows that while behavioural measures were significantly correlated with one another (r = 0.71, $p < 0.05$), self-report probes failed to correlate with either RTCV(r = 0.16, $p = 0.25$) or error rate (r = 0.13, $p = 0.34$). It is therefore possible that in the current set of experiments, self-report probes may not be a valid indicator of mind-wandering occurrence. We do however, see a trend indicative of task inattention with the behavioural measures, which correlate together as we might expect when participants' engage in mind-wandering behaviour during task performance.

Providing a novel method to explore how information in the environment can influence the ebb and flow of our conscious experience, the current set of experiments successfully integrates theories of context-dependent memory retrieval within the current mind-wandering paradigm. The work by Kane and McVay (2013) was important because they showed that presenting personally-relevant words could trigger mind-wandering episodes. These experiments, while not designed to measure thought content, provided evidence for environmental influences on mind-wandering frequency. Our work takes a less demanding or personalized approach, by simply using a colour previously associated with a negative state to not only boost mind-wandering rates, but also systematically cue the retrieval of negatively-toned memories during episodes of off task thought. This effect was especially pronounced for those reporting a high degree of negative mood. These findings may therefore have direct implications for research aiming to understand how environmental triggers can perpetuate negative thought patterns in depressive populations (e.g. Lyubomirsky & Nolen-Hoeksema, 1993), and stimulate the question for future research of whether binding an emotional state with other types of information can more generally influence the content of mind-wandering episodes.

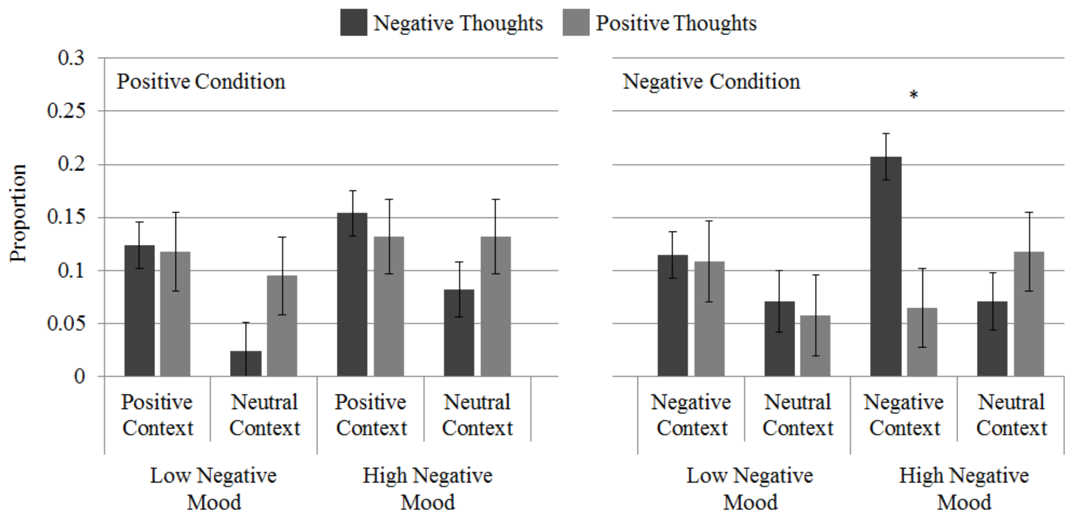

Figure 7 | The average proportion of negative and positive thoughts during probe trials across the negative context (panel A), positive context (panel B) and neutral context for both the low and high negative mood groups. Error bars reflect standard error of the mean.

* indicates significance at a $\alpha = 0.05$ criterion

CHAPTER 6: ON THE (NOT SO) HONEST MEASURES OF CONSCIOUS EXPERIENCE

Vinski, M. T., & Watter, S. (2012). Priming honesty influences self-report accuracy of mind wandering. Consciousness and Cognition, 21, 1, 451 – 455.

The findings reported in data chapters up to this point in the dissertation rely on both behavioural and self-report measures of off task thought. However, these self-report measures can be inconsistent (see discussion in Chapter 3). In Chapter 6, I presented participants with an honesty prime task prior to a mind wandering task to see whether activating "honest" goal states would influence self-report. My findings suggest that experience sampling measures may be vulnerable to the experimental context.

The work in this chapter data was published in the journal Consciousness and Cognition in 2012.

Chapter 6: On the (not so) Honest Measures of Conscious Experience

Self-report measures are a useful tool to tap conscious experience and empirically measure cognitively relevant constructs. Self-report of sensitive information however, remains vulnerable to social influences that impede response honesty and threaten data quality (Rasinski, Visser, Zagatsky & Rickett, 2005). Previous research suggests that exposure to goal-related words implicitly activates goal states that produce behaviour similar to conscious goal pursuit (Chartrand & Bargh, 1996), that priming individuals with words conceptually related to achievement enhances persistence on boring tasks (Bargh, Gallowitzer, Lee-Chai, Barndollar & Troetschel, 2001), and that priming individuals with words conceptually related to honesty enhances disclosure of sensitive information (Rasinski et al., 2005).

Mind wandering has become an emerging topic in cognitive psychology research over the past decade. Mind wandering episodes are described as thoughts that spontaneously emerge separate from the current context, resulting in decoupled information processing between the internal and external environment and a degraded representation of the current external context (Smallwood, Baracaia, Lowe & Obonsawin, 2003; Smallwood, Obonsawin & Hiem, 2003). Unlike most cognitive paradigms, mind wandering tendency is inferred from both behavioural and self-report measures (Smallwood & Schooler, 2006). The Sustained Attention Response Task (SART; Robertson, Manly, Andrade, Baddeley & Yiend, 1997) is a continuous go/nogo paradigm typically used to measure mind wandering propensity (Smallwood, Beach, Schooler & Handy, 2008; Smallwood, Davies, Heim, Finnigan, Sudberry, O'Connor & Obonsawin, 2004). On the majority of trials participants are presented with non-target stimuli (go trials) to which they must respond. On a minority of trials participants are presented with the target stimulus (nogo trials) to which they must withhold their response. To perform well on the task, participants must maintain enough top-down supervision over task performance to substitute an antagonistic response on nogo trials (Robertson et al. 1997; Smallwood & Schooler, 2006). Failure to withhold responses on nogo trials (nogo errors) and speeded reaction times (RTs) prior to nogo errors are interpreted as evidence for off task thought, and are the two primary behavioural indicators of mind wandering (Cheyne, Solman, Carriere & Smilek, 2009; Manley, Robertson, Galloway & Hawkins, 1999; Robertson et al., 1997; Smallwood, Davies et al., 2004; Smallwood & Schooler, 2006;). The subjective experience of mind wandering is measured using an intermittent probe, whereby participants must indicate whether their attention was off task prior to the probe (Smallwood & Schooler, 2006). Accuracy of response on probe trials is validated by the degree of congruence between behavioural indicators of off-task thought and participants' self-report of attentional focus prior to the probe (Schooler & Schreiber, 2004). Indeed, previous work using online thought sampling has shown a relationship between off task thought and nogo error rates using traditional designs (for a review, see Smallwood and Schooler, 2006) and ERP components (Smallwood et al., 2008).

Empirically measuring the subjective experience of mind wandering requires that participants be consciously aware of, and understand the content of, their thought processes during task performance (Nisbett & Wilson, 1977; Smallwood & Schooler, 2006). Cautious interpretation of self-report measures in the mind wandering paradigm has been openly acknowledged (Schooler & Schreiber, 2004), and previous research has offered compelling arguments that question the credibility of self-report data (Jack & Roepstord, 2002; Jack & Shallice 2001; Lambie & Marcel, 2002). As such, the debate over introspective validity in the mind wandering paradigm remains in contention (for a review, see Schooler & Schreiber, 2004). Validity of self-report however, is not only hindered by the limits of introspection. Self-report can also be vulnerable to social desirability and demand characteristics inherent in an experimental setting (Orne, 1962).

The current mind wandering paradigm assumes static disclosure of off task thought independent of experimental artifacts. As a result, introspective validity has been the prominent point of contention regarding the credibility of self-report in the mind wandering paradigm. The current research introduces an honesty prime task in order to investigate the role of goal states and social factors on self-report accuracy. Accuracy is measured by the degree of congruence between the behavioural indicators of off task thought and self-report. Participants completed either an honesty prime or control prime task prior to completing the SART. Assuming equal task performance between conditions (nogo error rate and mean reaction time), a greater congruence between behavioural and subjective measures of mind wandering was predicted for participants who receive the honesty prime in comparison to the control prime.

METHOD

Participants

Participants (n = 52, 38 female) were undergraduate psychology students from McMaster University, and received partial course credit in exchange for their participation. Participants were recruited using online registration, where they signed up for pre-determined time slots using the University's experiment participation recruitment program.

Procedure

Participants spent approximately 1 hour in the laboratory. After providing their written informed consent, participants completed a priming task where they were presented with a target word followed by three synonyms of the target word. Participants were instructed to read the target word and indicate which of the three synonyms was most conceptually similar to the target word.. In the honesty prime condition participants were shown six target words that were related to the goal of being honest. For example, participants were presented with the target word "honest" and the three synonym words "candid", "authentic" and "sincere". In the control condition participants were presented with six target words that were not related to the goals of being honest, for example “jump” or “blend” (as per Rasinski et al., 2005). Participants completed the Sustained Attention Response Task (SART; Robertson et al., 1997) following the prime task. Participants were presented with non-target stimuli (go trials) and on 10% of trials were presented with non-target stimuli (nogo trials). On go trials participants were instructed to respond as quickly and accurately as possible, and on nogo trials were instructed to withhold their response. Failure to withhold response on nogo trials was classified as a nogo error. Non-target stimuli were the numbers 0 to 2 and 4 to 9, and the target stimulus was the number 3. All stimuli were presented in black font on a white background. Participants were shown two blocks of 162 stimuli. The inter-trial interval was 1000msec and all stimuli were presented for 300ms regardless of response. A short practice session with 12 stimuli (including one nogo target) was given prior to the first experimental block.

The critical task component for the current study was the self-report of mind wandering on probe trials. The probe read “Stop! Where was your attention focused immediately before this question?” where participants were given an alternative forced choice between 1 (their attention was on task) and 2 (their attention was off task), as per the procedure in Christoff, Gordon, Smallwood, Smith & Schooler (2009), Smallwood and Schooler (2006), Smith, Keramatian, Smallwood, Schooler, Luus & Christoff (2006), and Teasdale, Dritschel, Taylor, Proctor, Lloyd and Nimmo-Smith (1995). All questionnaires and experiments were presented using E-prime software (Schneider, Eschmann & Zuccolotto, 2002).

The experiment was a between-subjects design, with the independent variable Prime (honesty vs. control). The dependent variables were mean reaction time to non-target trials as a measure of automatic responding, the proportion of times participants accurately withheld their responses to target stimuli as a measure of task supervision (nogo error rate), and the proportion of probe trials on which participants reported their attention was focused off task as a subjective measure of mind wandering frequency.

RESULTS

Separate one-way ANOVAs were performed to investigate group differences in mean reaction time on go trials, proportion of nogo errors on no-go trials, and proportion of times participants indicate their attention is off task on probe trials (self-report of off task thought). The independent variable was *Prime* (honesty prime vs control prime). A significant difference was found between the honesty prime ($M = 0.710$, $SE = 0.050$) and control prime ($M = 0.560$, $SE = 0.053$) conditions for on task thought probes, $F(1, 53) = 5.57$, $p < 0.05$, whereby individuals in the control group were less likely to indicate their attention as having been on task in comparison to the honesty prime group. No significant differences were observed for mean reaction time for the honesty prime ($M = 241.79$, $SE = 13.23$) and control prime ($M = 248.50$, $SE = 5.60$), $F(1, 53) = 0.18$, p

= ns, or nogo error rate for the honesty prime (M = 0.560, SE = 0.041) and control prime (M = 0.650, SE = 0.051), F(1, 53) = 2.35, p = ns.

A repeated-measures ANOVA was performed to investigate systematic differences in response time behaviour for the 5 trials prior to an on task vs. off task probe, for both the honesty and control prime condition. These data are shown in Figure 8 (pg. 165). The independent variables were *Trial* (n-1 through n-5 trials prior to the probe) and *Attention* (on task vs. off task probe). An on task probe was defined as when a participant indicated their attention was on task, and an off task probe when participants indicated their attention was off task. In the honesty prime group, the main effect of Trial (n-1 through n-5) was not significant, F(4, 96) = 1.04, p = ns. The main effect of Attention (on task, off task) was significant, F(1, 24) = 4.26, $p < 0.05$, with participants responding quicker prior to off task probes in comparison to on task probes. This finding replicates response behaviours previously observed during off task thought by Smallwood and colleagues (2004). A marginal interaction was found between Trial and Attention, F(4, 96) = 2.36, p = 0.05, suggesting that the difference between reaction times prior to on task and off task probes may be dependent on the number of trials prior to the probe trial. In the control prime group, the main effect of Trial (n-1 through n-5), F(4, 96) = 2.06, p = ns, Attention (on task, off task), F(1, 24) = 0.33, p = ns, and the interaction between Trial and Attention were not significant, F(4, 96) = 0.93, p = ns.

A Chi-Square analysis was performed to analyse congruency between probe responses and frequency of nogo errors prior to the probe trial, with the factors *Prime* (honesty prime vs. control prime) and *Congruency* (congruent vs. incongruent). When participants make a nogo error and then subsequently report off-task thought on a probe it is considered a congruent behaviour, whereas participants making a nogo error and reporting on-task thought is considered an incongruent behaviour. Conversely, when participants successfully withhold a response on a nogo trial and then subsequently report on-task thought it is classified as congruent behaviour, whereas participants successfully withholding a response and reporting off-task thought is considered incongruent behaviour. We investigated two trial durations between nogo trials and probe trials. One trial duration was when the nogo trial occurred within 10 trials prior to a probe trial (Bin 1), and the second trial duration was when nogo trials occurred between 11 to 20 trials prior to a probe trial (Bin 2). Bins were created to investigate whether duration of time between the nogo trial and the probe trial influenced congruence between self-report and nogo errors. We expected a correlation between time elapsed and self-report congruency, whereby congruence between self-report and nogo errors would be greater when the nogo trial occurred within 10 trials prior to the probe in comparison to more than 10 trials prior to the probe.

In Bin 1, Prime and Congruency were significantly related, $X^2(1) = 5.12$, $p < 0.05$, $V = 0.323$, suggesting that whether participants completed the honesty or control prime has a medium sized effect on the congruency of self-report and nogo error rate prior to probe trials. In Bin 2, Prime and Congruency were not significantly related, $X^2(1) = 0.24$, $p = ns$, $V = -0.118$, suggesting that the type of prime participants completed has no effect on the congruency of self-report and nogo error rate prior to probe trials.

DISCUSSION

Debate surrounding self-report validity in the mind wandering paradigm has traditionally focused on introspective validity (Schooler & Schreiber, 2004). The current work investigates the validity of self-report as a function of goal-state activation and the social context inherent in the empirical study of conscious experience. To investigate these potential confounds, participants' goal states were manipulated by a prime task prior to task completion and the congruency between self-report and behavioural indicators of off task thought were compared between groups. Discrepancy between groups provides evidence for the role of goal states in self-report accuracy and, by extension, the level of self-report accuracy to be expected when using the traditional paradigm and the influence of social context on this expected accuracy.

Congruency was greater between self-report and behavioural indicators of off-task thought when participants completed the honesty prime task prior to the experiment in comparison to the control prime. Specifically, if participants were exhibiting behavioural indicators of off task thought (increased nogo errors and faster non-target reaction times) prior to a probe trial, participants were more likely to indicate their attention as having been off task if they had completed the honesty prime.

Activation of honesty-based goal states may alternatively facilitate meta-cognitive awareness of task performance. The superior congruency between nogo errors and self-report observed in the honesty prime condition diminished when the target trial occurred more than 10 trials prior to the probe. This finding provides evidence that activating honesty-based goal states facilitates conscious awareness of task performance. While accuracy does not necessarily constitute honesty, this finding suggests that activation of honesty-based goal states lead to more accurate report of off-task thought in compliance with the task instructions.

Group differences in self-report illuminate base-rate accuracy in the current paradigm. Specifically, individuals in the honesty prime condition were significantly less likely to indicate their attention as having wandered off task in comparison to individuals in the control prime condition. In conjunction with reduced self-report accuracy in the control prime group, this finding suggests base-rate inflation in the self-report of mind wandering during task performance. This over-estimation effect observed in the control group raises questions about the validity of self-report measures currently used in the mind wandering paradigm and may reflect compliance with demand characteristics implicit in the experimenter-participant relationship. Demand characteristics are behaviours that emerge when participants interpret the purpose of the experiment and unconsciously modify their behaviour in accordance with the interpretation (Orne, 1962). During both recruitment and task instruction, participants were explicitly made aware that the experiment investigated individual differences in mind wandering tendency and were provided with a definition of mind wandering prior to task completion. Providing such information may modify participants' interpretation of the experiment purpose, making demand characteristics a substantial confound for self-report measures in the current mind wandering paradigm.

Comparable mean reaction times and error rates between priming conditions implies that implicit goal activation selectively influences self-report measures of the SART. One reason for this selective influence could be participants' awareness of how performance measures converge as evidence of mind wandering episodes. The self-report probe is explicit in intention and is the sole dependent measure that provides participants with the opportunity to manipulate perceived frequency of mind wandering. Reaction time and error rate on the other hand, are defined in task instruction but remain ambiguous in contribution to inference. Participants are not explicitly informed about how their response behaviours are collated as evidence of mind wandering. It is therefore reasonable to suggest that behavioural measures are free of volitional control in service of demand characteristics while self-report remains susceptible to either conscious or unconscious modification.

Susceptibility to demand characteristics in the control group may additionally be facilitated by limitations in meta-cognitive awareness of task performance and probe trial format. In the current paradigm, participants were offered fixed alternatives to describe the contents of their conscious experience on probe trials. Recent work shows that individuals are unlikely to report mind wandering episodes unless probed (Schooler & Schreiber, 2004), suggesting a general deficit in metacognitive awareness of off task thought. In the honesty prime condition, unconscious compliance with demand characteristics may be usurped by goal states activated by the honesty prime, enhancing self-report accuracy and diluting unconscious pursuit to satisfy the purpose of the experiment. Future research should investigate the interaction between social and introspective threats to self-report validity in order to develop a subjective measure conducive to vulnerabilities.

An alternative interpretation of the current findings is that demand characteristics are responsible for manufacturing the tight correlation observed between performance errors and off task thought probes in the honesty prime group. Inherent in this interpretation is the assumption that the weak correlation observed between behavioural and self-report measures in the control group reflects the true cognitive nature of mind wandering. This interpretation seems unlikely however, given that previous work provides evidence for a coupling between errors and off task thought using probe-free methods (Barron, Riby, Greer & Smallwood, 2011; Smallwood et al., 2008). It would seem much more likely to suggest that activating honesty-based goal states through a priming procedure augments the underlying relationship between behavioural and subjective measures, while the control condition remains susceptible to issues of demand bias in self-report. An additional concern is that the over-estimation effect observed in the control condition is problematic when attempting to compare response behaviours between on task and off task probes. The current analyses were conducted using Type III sum of squares to control for the unbalanced design, alleviating the empirical concern (Cohen, 2002).

The current work suggests that self-report and behavioural indicators of off task thought are differentially susceptible to implicit activation of goal states. Group differences suggest inflation of base-rate self-report of mind wandering and incongruence between behavioural and subjective indicators of off task thought for control participants compared to those receiving an honesty prime. Our findings suggest that self-report validity is a methodological issue in the current mind wandering paradigm, and that beyond introspective ability, validity of self-report may be confounded by unconscious compliance with demand characteristics.

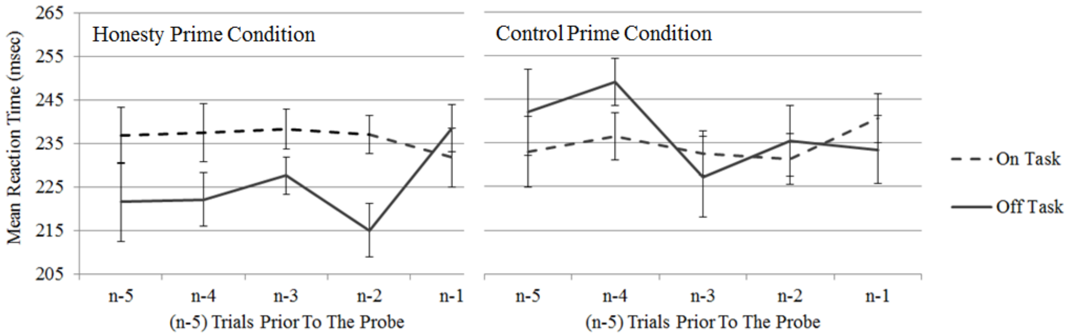

Figure 8 | Mean reaction time for n-5 trials prior to on-task (“On”), represented by the dotted line, and off-task (“Off”) probe trials, represented by the solid line, for both the honesty prime condition (left) and the control prime condition (right).

Condition	Congruency Between Behavioural Response on Target Trial and Probe Response: Congruent	Congruency Between Behavioural Response on Target Trial and Probe Response: Incongruent
Honesty Prime	87.0%	13.0%
Control Prime	57.7%	42.3%

Table 8 | Percentage of probe responses that were congruent or incongruent with performance on target trials for both the honesty prime and the control prime condition. This table provides additional information to support the findings in Chapter 6, but were not included in the original publication.

CHAPTER 7: THE FINAL DISCUSSION

> Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought.
> – William James, 1890

While the stream of consciousness has long been pondered by the philosophical greats (Descartes, 1644), empirical investigation of the wandering mind has emerged as a prominent topic in cognitive science over the last fifty years (Antrobus, Singer, Goldstein, & Fortgang, 1970; Antrobus et al., 1966; Klinger, 1971; Klinger & McNelly, 1969; Mason et al., 2007; Singer & Antrobus, 1963; Smallwood & Schooler, 2006). Since its occurrence is controlled by the omnibus executive control system (Thomson et al., in press), arguably one of the most dominant architectures in cognition, the study of mind wandering offers a unique window into how, why and for whom these control mechanisms tend to fail (or not fail, depending on how you view the functional quality of mind wandering).

There are two contexts in which to study mind wandering. One involves measuring the occurrence of off task episodes during complex tasks, and the other involves measuring the occurrence during simple tasks. In both of these contexts the nature of mind wandering is conceptualized differently (Smallwood & Andrews-Hanna, 2013), with the former labelling mind wandering as a disruptive force and the latter applauding its creative potential. The current set of experiments capitalizes on the latter paradigm. I encouraged individuals' attention to wax and wane over the duration of the experiments, in an effort to understand the mechanisms that drive the natural ebb and flow of conscious thought.

The decoupling hypothesis (Smallwood, 2013) argues that internally and externally-oriented focus share (and compete for) a pool of limited, yet global cognitive resources. This theory is supported by a co-activation between the executive and default mode networks during mind wandering behaviour (Christoff et al., 2009), with the former typically associated with externally-oriented cognition (Posner & Rothbard, 1998) and the latter typically associated with internally-oriented cognition (e.g. Mason et al., 2007). The executive network is therefore either coupled with the perceptual system to guide attention to external stimuli or with the default mode network to guide attention internally (Smallwood, Brown, Baird, & Schooler, 2012). This framework provides support for the adaptive quality of mind wandering episodes as a focused attentional state that aids problem solving (Baird et al., 2012), future planning (Baird et al., 2011), and self-reflection (Smallwood et al., 2011) in scenarios where we can disengage from the external world.

The resource-control account of mind wandering suggests that there is a point of optimal distribution between internally and externally-oriented processing that ensures successful task performance (see Figure 2, pg. 40) (Thomson et al., in press). When an individual has a high degree of executive control, they are able to maintain this optimal distribution point and therefore perform the task well. When an individual has a low degree of executive control they are unable to maintain optimal distribution and are therefore more likely to show deficits in concurrent task performance. While there are individual differences in general capacity (Kane & Engle, 2002), exogenous factors can also play a role. The prominent example used in the current dissertation is time on task. Specifically, executive control declines over the duration of a task which in turn results in a redistribution of resources toward internally-oriented cognition (the default cognitive state) and a decline in task performance (see Thomson et al., in press).

I was particularly interested in the conscious experience of a population that tends to focus on the internal world. This population includes those with higher levels of state negative affect. These individuals, who tend to have a heightened perception of problems in daily life (Smallwood, Obonsawin, Baracaia et al., 2003), are more likely to mind wander in an attempt to resolve said problems (e.g. Smallwood & O’Connor, 2011). Experiments were therefore designed to create a context in which the risk of this group letting their attention drift from the task was relatively low, thus indirectly encouraging them to slip into a mind wandering state and at least potentially, ponder life’s problems (Giambra, 1995; Smallwood et al., 2007). Stated another way, the experiments in the current dissertation offered a scenario where the personal relevance of the task is low, and therefore over the duration of the task, participants in a negative mood would be more likely to disengage from the task. This behavioural trend effectively parallels the traditional decline in executive control observed as a function of task duration (See Figure 2, pg. 40). Research with this population is relevant not only because it helps us develop models for predicting mind wandering rates in the general population (Gross, 1998), but also due to its relevance in understanding clinical disorders such as depression and anxiety (Nolen-Hoeksema, 2000).

A closer look at the resource distribution process

The distribution of resources between internal and external processing is dependent on the executive control system (Thomson et al., in press). The executive control system is proposed to serve a number of operations, including the ability to update current goals, adapt strategies, and inhibit the processing of irrelevant information or behaviour (Damasio, 1995; Miyake et al., 2000). What aspect of executive control acts to maintain the focus of attention, or buffer the optimal distribution point? In Chapter 2, I aimed to answer this question by isolating the control component that may be important in this "buffer" operation: inhibition. Specifically, I looked at the role of access and deletion inhibition (Hasher & Zacks, 1988) in predicting an individual's tendency to mind wander over the duration of a task. Indeed, findings suggest that individual differences in deletion inhibition, or the ability to down regulate the activation of task-irrelevant thought (Hasher & Zacks, 1988), predict the tendency to mind wander. This effect emerged only during the second half of the task, and was observed for the indicators of transient states of inattention only. I interpreted these data as evidence for deletion inhibition as a control mechanism that prevents the progression of transient lapses of attention into full-blown mind wandering episodes (Barnard & Teasdale, 1991; Teasdale et al., 1995). Deletion inhibition therefore operates to buffer or maintain the distribution of resources toward the current focus of attention. I argued that this operation may effectively protect against the rise in mind wandering rates typically observed over the duration of a task, and therefore, this operation may account for the executive operation that tends to fail with time on task.

Throughout this dissertation, the current concerns framework has been used to argue that the degree to which a task is relevant to personal concerns will determine the likelihood of an individual maintaining an attentive focus on that task (see Smallwood & Schooler, 2006). This framework has been used as evidence to argue that the positive relation between negative mood and mind wandering is primarily due to an enhanced perception of current concerns in daily life (Smallwood, Obonsawin, Baracaia, et al., 2003). In Chapter 3, I tested this hypothesis by exploring whether a psychosocially stressful situation, presumed to elicit a certain degree of personally-relevant concern, biases the distribution of resources toward the internal world on a subsequent mind wandering task. Findings were interpreted within a transactional framework (Lazarus & Folkman, 1984), which provides a state-stressor algorithm to characterize the stress response. In this framework, the stress response is initiated by an appraisal of the situation. This appraisal mechanism determines the degree to which the stressful context is relevant to the individual. If relevant, the distribution of resources is determined by individuals' coping strategies, which can either be either task-focused or internally-focused (Matthews & Desmond, 2002).

The data from Chapter 3 demonstrate that experiencing a social stressor can activate a stressor-oriented thought pattern, which aligns with deficits in task performance and a reduction in available cognitive resources (indicated by increased pupil diameter). Within the resource control framework, I would interpret this series of findings as evidence that stress induces a biased distribution of resources to serve internally-oriented cognition at the sacrifice of task performance. However, this behaviour was prevalent only in those with a negative mood. This finding aligns with previous work showing that depressive populations tend to engage in internally-focused coping strategies in stressful situations (Coyne et al., 1981; Parker & Brown, 1982). More important however, depressive states have also been associated with a heightened perception of what is at stake in a stressful situation (for example, self-esteem and well-being) (Lazarus & Folkman, 1984). These data therefore provide preliminary evidence for the integration of the current concerns theory within the resource-control account of mind wandering. Specifically, findings from Chapter 3 suggest that in situations of psychosocial stress, dysphoric populations have a heightened sensitivity to the potential social threat of the stressor, which in turn activates a representation of the event as a "current concern". This activation operates to encourage the co-activation of the executive and default mode networks

(Smallwood et al., 2012) in an effort to redistribute attentional resources toward stressor-oriented processing in the resolution of stressor-related concern. Performance on a concurrent task declines as a result. This type of post-event processing would also be expected in a scenario where a stressor is expected to occur in the near future. A recent study by Stawarczyk et al. (2013) explored this scenario, and demonstrated a boost in mind wandering rates (and decline in task performance) when participants were informed about an impending stressful situation after completing the experiment. Using the findings from Chapter 3 to interpret the findings reported by Stawarczyk and colleagues (2013), it is likely that in the face of a low demand task of low personal relevance, being informed about the upcoming stressor activated an internally-oriented cognition that permits the participants to process (and potentially prepare) for the upcoming event.

Let's revisit the PhD candidate who is hunkering down to write her dissertation. Data from Chapter 2 and 3 suggest that if she has efficient deletion regulation, she will likely be able to maintain her focus on the writing task. In this scenario, the "winner" of the battle for limited resources should therefore reflect the cognitive processes required to write the thesis, with deletion regulation moderating her ability to maintain task focus. If she has poor deletion regulation she will maintain the task-oriented focus for a while, only to eventually succumb to thoughts of other current concerns as the control process diminishes over time. These intruding thoughts would increase in frequency over the duration of the writing session. Findings also suggest that if she is stressed by a psychosocial stressor (for example, a disagreement with her partner) and she is in a particularly bad mood, the mental cost of maintaining a focus on writing the thesis becomes too high relative to said concerns, and therefore she is more likely to succumb to task-irrelevant thoughts.

A closer look at the retrieval process

My work, along with the work of several other researchers (see McVay & Kane, 2013; Smallwood, Fitzgerald, et al., 2009), supports the current concerns theory of mind wandering (Klinger, 1971). However, in his original proposal of the theory Klinger (1971; 1999; 2009) argued that personally-relevant cues in the environment can trigger thought patterns related to that cue. This aspect of the current concerns theory is not congruent with the current conceptualization of mind wandering episodes as independent of perceptual input (Smallwood, 2013), or "stimulus-independent" (Mason et al., 2007; Teasdale et al., 1995).

Evidence for the cue-based component of Klinger's theory has been provided primarily by research in the memory literature. For example, previous work has shown that memories can be involuntarily retrieved by cues that are congruent with an individual's concerns (Kvavilashvili and Mandler, 2004; Kvavilashvili & Schlagman, 2011; Schlagman & Kvavilashvili, 2008). This cueing effect is especially pronounced for negative cues, which appear to systematically facilitate the retrieval of negatively-toned and personally relevant memories (Schlagman & Kvavilashvili, 2008). Valence-dependent retrieval has also been replicated with mood state, where mood appears to make mood-congruent memories more accessible (Holland & Kensinger, 2010; Isen, Shalker, Clark, & Karp, 1978). If the content of mind wandering episodes arises from the episodic memory system (Schacter & Addis, 2007), is it possible to cue the retrieval of specific memories during a mind wandering episode? I explored this question in Chapter 4 and Chapter 5.

The investigation of how the environment influences mind wandering initially emerged as a topic of discussion in the 1960s (see Antrobus et al., 1966; Horowitz et al., 1971). This line of inquiry has recently emerged again, with the intent of building models to understand, and more importantly predict, when the mind will wander. For example, McVay and Kane (2013) found that showing participants words that align with their personal concerns increased global mind wandering rates. Up to this point in the dissertation, the primary predictors of mind wandering frequency have been individuals' ability to inhibit the activation of task-irrelevant thought (Chapter 2) and individuals' mood (Chapter 3). These factors are endogenous. What makes the work by Antrobus et al. (1996), Horowitz et al. (1971) and McVay and Kane (2013) so important is that they provide evidence to suggest that information in the external environment can influence the likelihood that the mind will wander, independent of cognitive load. These studies do not however, directly measure whether the environment can trigger the retrieval of specific memories when the mind wanders off task. It is in this particular aspect of environmental influence that I was most interested.

The cue-dependent effects mentioned above (Antrobus et al., 1966; Horowitz et al., 1971; McVay & Kane, 2013) all used either personally-relevant or highly arousing cues to elicit episodes of off-task thought. In Chapter 4, I wanted to explore whether ambiguous yet emotionally-toned information could not only boost mind wandering rates similar to relevant or arousing cues, but also act to trigger certain thought patterns during mind wandering episodes. Indeed, we found that presenting a string of either relevant (Experiment 1) or irrelevant (Experiment 2) negative words during a mind wandering task activated a retrospective thought pattern. This set of findings suggests that ambiguous information can systematically bias the retrieval of memories much like personally-relevant cues (Bernsten & Hall, 2004; Kvavilashvili & Mandler, 2004), even when participants' attention has wandered from the task.

Not surprisingly, this effect was especially pronounced for those in a negative mood. The findings therefore also provide evidence to suggest that when an individual is in a bad mood, negatively-toned stimuli can potentiate the typical retrospective thought pattern associated with a negative mood state (Smallwood & O'Connor, 2011). Interestingly, Ruby, Smallwood, Engen, and Singer (2013) have recently shown that the temporal focus of a mind wandering episode mediates the relationship between participants' thought content and subsequent mood. The authors showed that retrospective thoughts can subsequently induce a negative mood even if the thoughts were positively-toned. It is therefore plausible that for the data presented in Chapter 4, the presentation of negatively-toned words initially induced a retrospective thought pattern, which in turn amplified participants' negative mood. The inflated negative mood would then be expected to increase the likelihood of a retrospective thought pattern (Smallwood & O'Connor, 2011). The data could therefore represent the accrued effects of the temporal focus-mood effect reported by Ruby and colleagues (2013).

The experiment design in Chapter 5 went a few steps further. In Chapter 4, participants were shown negatively-toned words during a mind wandering task and were asked to report the frequency and temporal focus of off task thought. In Chapter 5, participants were encouraged to bind either a negative or a positive emotional state with a colour, and were reintroduced to that colour during a mind wandering task. I wanted to explore whether presenting a global context that has been previously associated with a negative state would have the same effect as a directly negative context (i.e. negative words) on the content and frequency of mind wandering episodes. Findings showed a boost in task inattention when participants were exposed to the colour previously bound to either a negative or a positive context, with the negative context selectively biasing the retrieval of negatively-toned thoughts for participants in a negative mood. These data suggest that if you are in a negative mood and are exposed to a negative context, you are more likely to mind wander and entertain negative thoughts. This finding mirrors the effects observed immediately following stress induction in Chapter 3. It is therefore plausible that psychosocially stressful situations and contexts associated with a negative state are functionally comparable in dysphoric populations. Both scenarios facilitate the redistribution of resources toward internally-oriented cognition in the service of negative thoughts (with the stress induction leading to a stressor-oriented focus specifically). It is therefore also plausible that the base requirement to stimulate this type of negative cognition is a generally negative context, and that the negatively-toned thoughts observed in Chapter 3 were not necessarily due to the stressor itself but more the negative context associated with the stressful event.

For those participants who did report being in a negative mood, exposure to a negative context cued the retrieval of negative memories. This finding is not surprising given the mood-specific findings reported consistently throughout this dissertation, and theories of mood-congruent memory retrieval in the memory literature (Holland & Kensinger, 2010; Seibert & Ellis, 1991; Siemer, 2005). This finding may also, however, provide a potential framework for interpreting the findings in Chapter 4. As previously mentioned, participants in a negative mood were more likely to entertain retrospective thoughts when perceiving negative words. Our primary interpretation of the findings in Chapter 5 was that reinstating the negative context during the mind wandering task potentiated the negative mood for the high negative mood participants, which lead to the systematic retrieval of negative thoughts. It is therefore possible that the negative words presented during the semantic SART also potentiated the negative state in the high negative mood group, which in turn activated a retrospective thought process typical of those with a negative disposition (Smallwood & O’Connor, 2011). This interpretation aligns with previous work by Killingsworth and Gilbert (2010) showing that if participants were in a bad mood when their mind wandered, they were more likely to experience unpleasant memory retrieval during off task thought. With this interpretation, the implications of the retrospective thought-mood effect reported by Ruby and colleagues (2013) is still relevant and may explain the perpetuation of a retrospective thought pattern for high negative mood participants.

These findings provide evidence to suggest that the content of our conscious experience is dependent on an interaction between the emotional context of both the internal and external world. When reflecting on the conscious experience of daily life, this statement may not be surprising. However, the experiments in the current dissertation provide a mechanistic explanation for the trade-off of attentional resources between the information of value in the internal and external world. The experiments offer a mechanistic account of the everyday experience. Thinking again about the PhD candidate who is trying to write her dissertation, data from Chapter 5 suggest that if she attempts to write in a context (for example, an office or a café) that has previously been associated with a negative state, then she will be less able to maintain her focus on the writing task. If she is having a particularly bad day, she will not only have trouble maintaining focus on her dissertation, but will also be more likely to suffer from negative thoughts when her mind does wander. In this latter scenario, resources will be distributed to maintain an internal stream of thought, with the activated content from the episodic memory system likely to be negative. Unlike the application of our Chapter 2 and 3 findings in predicting the PhD candidate's writing success, we are unable to predict how the contextual bias would occur over the duration of a writing session. However I could make a few predictions. If she has an inefficient deletion filter, the negative context should be more likely to influence mind wandering behaviour as her writing session progresses. This would likely be due to a fatigued executive control system (Thomson et al., in press). If she has an efficient deletion filter on the other hand, she should be able to down-regulate the activation of negatively toned, task irrelevant thoughts and maintain a stable mind wandering frequency throughout the writing session. We could also predict that if she were exposed to psychosocial stress immediately before entering the office or cafe, she would be more vulnerable to the intrusion of negative thoughts during the beginning of the writing session, and that these thoughts would likely focus on the stressor. These scenarios are of course speculative. If only the duration of a doctoral degree were longer than four years, then the PhD candidate in question would be able to investigate the interaction between inhibitory control, stress, and context on mind wandering frequency.

A closer look at negative mood

The findings in this dissertation provide preliminary evidence to suggest that psychosocially stressful situations (Chapter 3), as well as direct (Chapter 4, Experiment 1), subtle (Chapter 4, Experiment 2), and even associative (Chapter 5) environmental triggers may cue disruptive thought patterns in those with a negative mood. In a healthy population, the effect of negative mood on mood-congruent cognitions is typically repaired through the activation of constructive thought patterns (Erber & Erber, 1994; Rusting & DeHart, 2000). This restorative exercise is not typical for those affected by depression. The findings in Chapters 3, 4, and 5 may therefore illuminate some of the mechanisms that underlie negative thought patterns presumed to derail task performance in depression (Ingram & Smith, 1984; Larsen & Cowan, 1988; Wood, Saltzberg, Neale, Stone, & Rachmiel, 1990), as well as other mood disorders associated with intrusive thoughts such as anxiety (Mellings & Alden, 2000), or Post Traumatic Stress Disorder (PTSD; e.g. Ehlers et al., 2002). Understanding these mechanisms may help refine the cognitively-based treatment options that are currently used to help these clinical populations.

One question that remains is whether higher mind wandering rates for those in a negative mood are associated with a lack of executive control to impede the activation of spontaneous thought (a resource control hypothesis), or whether they actively prioritize personal problems over most other activities and therefore mind wander more (a current concerns hypothesis). Previous work provides evidence for a weakened executive control system in depressed populations (see Burt et al., 1995; Hartlage et al., 1993), including impaired performance on both the Wisconsin Card Sorting Test (Merriam, Thase, Haas, Keshavan, & Sweeney, 1999) and the Stroop test (Trichard et al., 1995). Neural evidence supports the behavioural accounts of executive dysfunction, including hypofrontality (Dolan, Bench, Brown, Scott, & Frackowiak, 1994) and impairments in anterior cingulate functioning (Elliott, Sahakian, Michael, Paykel, & Dolan, 1998; George et al., 1997). But which component of executive control is impaired in this population?

Joormann and Gotlib (2008) argue that cognitive impairments in depressed patients arise from an inability to remove or expel previously relevant negative material from working memory. The authors support their claim with findings demonstrating higher intrusion effects (Joormann, 2006) and reduced negative priming (Joormann, 2004) for negative distractors for participants with major depressive disorder relative to healthy controls. Further, using the same directed forgetting paradigm as in Chapter 2 to measure deletion inhibition, Power, Dalgleish, Claudio, Tata, and Kentish (2000) have shown enhanced retrieval for to-be-forgotten negative words for depressed participants, suggesting that the dysfunction arises from inefficient deletion regulation. Other researchers have attributed cognitive deficits in depression to the direct competition between task-focused attention and internally-oriented negative thought for cognitive resources, with inhibition playing a critical role in directing the available resources (Christopher & MacDonald, 2005; Hertel, 1998). This series of findings bolster the possibility that inhibitory control (and perhaps deletion inhibition) may be the executive operation that is dysfunctional in depressed populations, leading to a suboptimal distribution of resources on cognitive tasks. This interpretation aligns with a resource control hypothesis of mind wandering rates.

Mind wandering behaviour in depressed populations may be associated with impaired inhibitory control, but what about the subclinical population in question in the current dissertation? Previous work has shown that negative mood does not influence working memory capacity (Spies, Hesse, & Hummitzsch, 1996) or general executive functioning (for a review, see Mitchell & Phillips, 2007; Shallice, 1982) and that like healthy controls, those in a negative mood are less likely to slip into an internally-oriented cognition when distracted with a demanding task relative to clinically depressed populations (Van Dillen & Koole, 2007). In addition, Joorman (2006) did not observe any evidence for intrusion effects of negative words for sad participants relative to participants with major depressive disorder, and no significant correlations were observed between deletion inhibition and negative mood in Chapter 2 (see Appendix 2 for correlation table). This series of data suggests a preserved executive functioning for those in a negative mood. Yet this group is still more likely to mind wander (e.g. Smallwood et al., 2007; Smallwood, Obonsawin, Baracaia et al., 2003). However as mentioned several times throughout this dissertation, this group is also more likely to have a heightened perception of current concerns (Smallwood, Obonsawin, Baracaia et al., 2003), which according to the current concerns hypothesis would predict a general boost in mind wandering rates (Klinger, 1971). This dichotomy suggests that being in a negative mood does not necessarily lead to a failure of executive control, but rather that the state is associated with an inherent tendency to distribute cognitive resources toward the internal world. In other words, the (functioning) executive control system in individuals with a negative mood appears to be biased toward the internal world.

Based on the limited research reviewed above, it would appear that the origin of mind wandering behaviour in depressed populations may differ from the origin of mind wandering behaviour in those who have high levels of negative affect. Where the former arises from a faulty executive control system, the latter arises from a need to temporarily resolve current concerns. This avenue of investigation seems fruitful for researchers interested in understanding the differences between and the implications of negative cognition for the clinically depressed versus the dysphoric.

A closer look at the task

Experiments in Chapter 2, 3, 4, and 5 all investigate factors that predict the frequency and content of mind wandering episodes. The experiment in Chapter 6 was of a slightly different focus. In this experiment, I decided to test the degree to which the self-report measures of off task focus were veridical. Participants completed an honesty prime task to activate the goal state of being honest, and then completed a mind wandering task. Surprisingly, behavioural measures were more congruent with the probe responses if participants had completed the priming task.

This type of effect is important. Mind wandering research has exploded over the past twelve years, and as such, researchers from various domains of cognitive science are tackling the phenomenon from their own perspective using their own tools. This collective effort propels our understanding of how the mind wanders, but with one limitation. Most of these studies employ general cognitive tasks, with the inclusion of intrusive self-report probes as the sole measure of mind wandering frequency. As must be evident having read through (almost) my entire dissertation by this point, the failure to find effects for self-report probes was a consistent issue. This issue was pervasive in the review process of my work, often impeding my ability to publish. A considerable amount of research is still required to validate probes as a measure of mind wandering frequency, and to develop new methods for investigating mind wandering behaviour without a reliance on experience sampling measures.

A closer look at some limitations

In addition to the use of self-report probes as a measure of mind wandering frequency, a second major limitation of the current work is the failure to control for individual differences in rumination. In the current work we show that negative mood biases the distribution of resources toward the internal world, and argue that this may be due to the heightened perception of current concerns. This heightened concern facilitates a distribution of resources toward the internal world, resulting in deficits in concurrent task performance. Is this type of internal processing the same as rumination? Rumination is characterized by a persistent thought pattern focused on the causes and implications of an individual's depressed state (Morrow & Nolen-Hoeksema, 1990), and indeed has also been shown to be an effortful, resource consuming process that causes poor performance on concurrent tasks (Watkins & Brown, 2002). Although mind wandering is theoretically similar to rumination (Watkins & Baracaia, 2002), there has yet to be any evidence that the two constructs are related (Lyubomirsky et al., 2003; Smallwood, O'Connor, et al., 2006; Smallwood, Obonsawin, Baracaia, et al., 2003). It would have been useful to include measures of rumination in the current studies to ascertain whether the mind wandering frequency in negative mood groups is mediated by the degree to which this population engages in rumination in their daily lives.

Concluding remarks

The study of the wandering mind offers a unique window into how, why and for whom the dominant control mechanisms within our brain tend to fail (or not to fail). Smallwood (2013) argues that understanding the answers to these particular questions remain the most important in mind wandering research. In the current dissertation, I explored the degree to which the emotional quality of the internal and external world shapes our conscious experience, and the control mechanisms that give us stability in focus.

I argue that the vacillation between internal and external processing operates at the nexus of two primary theories: the resource control theory (Thomson et al., in press) and the current concerns theory (Klinger, 1971; 1999; 2009). While the former offers a framework for understanding *how* the mind may wander, the latter provides a framework to understand *why* and *for whom*. The result is the conceptualization of an executive control system that operates to coordinate the activation between various neural networks, which when activated, operate to distribute cognitive resources toward the information most relevant at that moment in time. Driven by the emotional quality of our internal state and contextual cues in our external environment, relevance is determined by our current concerns and most personal of goals. I believe the experiments in the current dissertation provide some granularity to this theoretical integration.

When I first decided to apply for a doctoral research program in cognitive science, my undergraduate supervisor gave me one piece of advice. He said "study a facet of cognition for which you are particularly gifted. Not only will your personal experience give you an advantageous insight into the mechanisms that could drive that particular behaviour, but you will be less likely to give up on your exploration during the hard times." The answer was simple for an incessant mind wanderer like me. And he was (partially) right. Perhaps being an avid mind wanderer did give me some insight into its occurrence but more importantly, it kept me in a perpetual state of curiosity. It was the perfect way for me to learn how the brain works. When you take the time to consider the fantastic world we are able to conjure within our minds, to be limited only by the boundaries of the imagination, I've realized that being a cognitive scientist is truly one of the most captivating and embodied pursuits.

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