Preliminary thesis report

Exploring the Relative Impact of Mindfulness and Mind-Wandering on Task Performance: What are the Mediating Mechanisms of Arousal and Cognitive Processing?

Hand-in date:
15.01.2018

Campus:
BI Oslo

Examination code and name:
GRA 19502 Master Thesis

Programme:
Master of Science in Leadership and Organizational Psychology

Table of Contents

Summary

In the present preliminary thesis report, we propose a study examining the relative impact of dispositional mindfulness and mind-wandering on performance in the Iowa Gambling Task (IGT). Adopting a competing hypothesis design, we hypothesize a sequence of multiple mediating relationships starting from mindfulness/mind-wandering and moving onto arousal, cognitive processing, and IGT performance. Specifically, we want to explore whether mindfulness reduces IGT performance by a) reducing arousal, b) triggering analytical cognitive processing, and c) whether the triggered analytical processing will impair IGT performance. Since IGT performance is largely guided by emotions, and since mindfulness, as opposed to mind-wandering, attenuates emotional signals, we believe that mindfulness may reduce IGT performance. To answer our research question, we intend to employ an experimental between-subject research design.

1. Introduction

Mindfulness has gained wide attraction from both the academic and public domain. The popularity of this construct owes to the extant literature on the positive effects of mindfulness on psychological and cognitive outcomes (Brown & Ryan, 2003; MacKillop & Anderson, 2007). However, less is known about the relative impact of mindfulness and mind-wandering on cognitive tasks. Only recently has mindfulness become recognized as an important independent variable in the field of judgement and decision making (JDM). Studies have related mindfulness to improved performance on cognitive tasks (Mrazek, Smallwood, & Schooler, 2012; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013) that measure executive functions, such as working memory (Jha, Krompinger, & Baime, 2007), attention (Jha et al., 2007) and inhibitory control (Allen, Dietz, Blair, van Beek, Rees, & Vestergaard-Poulsen, 2012). A common explanation behind these positive effects of mindfulness include increased analytical thinking and reduced stress. On the other hand, low levels of mindfulness have been associated with increased stress and automatic processing. Nevertheless, more recent findings suggest that mindfulness may not produce such salutary effects in certain task domains. Several studies have found that mindfulness impairs learning in implicit cognitive tasks (Stillman, Feldman, Wambach, Howard, & Howard, 2014; Whitmarsh, Uddén, Barendregt, & Petersson, 2013) and creativity (Zedelius & Schooler, 2015). Thus, suggesting that mindlessness, or mind-wandering, can improve learning in tasks that rely more on automatic processing. Additionally, since arousal (physiological responses to certain stimuli) is known to trigger automatic processing, then a plausible assumption is that mindlessness, or mind-wandering, may in fact improve task performance. Our hypothesized relationship is backed by several well-established theories, most notably the idea of fast and frugal heuristics (Gigerenzer, 2004) and their validity across many decision-making contexts. This leads us to the following research question: *What is the relative impact of mindfulness and mind-wandering on task performance? And to what extent do arousal and cognitive processing mediate the relationship between mindfulness and task performance?*

2. Key Concepts & Conceptual Model

For ease of reading and clarification we begin by giving a short synopsis of the key concepts which will later be discussed in the literature review, where the relationships between the main concepts will be explored in depth.

Mindfulness is the ability of remaining focused and attentive on an experience or event taking place in the immediate and present environment. Mindfulness induces the ability to stay undistracted from the task at hand (Mrazek et al., 2012; Brown & Ryan, 2003; MacKillop & Anderson, 2007).

Mind wandering is a mental process which does not focus attention on the task at hand, but rather causes sporadic shifts in attention away from the task. This causes an individual to lose focus on the task by the experience of task-unrelated thoughts (TUT), which can be very disruptive. A simple example of this is when one becomes unfocused by mind-wandering when reading and does not absorb the information in the text, however the eye-movement continues as if one were focused on the reading (Mrazek et al., 2012).

Cognitive processing. Dual system models (DSM) are well established and have become the prevailing approach to cognitive processing; intuitive and analytical. Intuitive processing mode, is also known as; System 1, emotionally driven system, primary process (Frankish, 2010). This mode is described as a quick, automatic, reflexive way of judging and making decisions with low cognitive demands since it is most often unconscious and the go-to mode in daily life (Epstein, 1994; Frankish, 2010). High cognitive demand can be draining and difficult and the change to analytic mode is mostly context driven. The analytical processing mode is more explicit and controlled, requires high cognitive demands (Mukherjee, 2010; Frankish, 2010; Epstein, 1994).

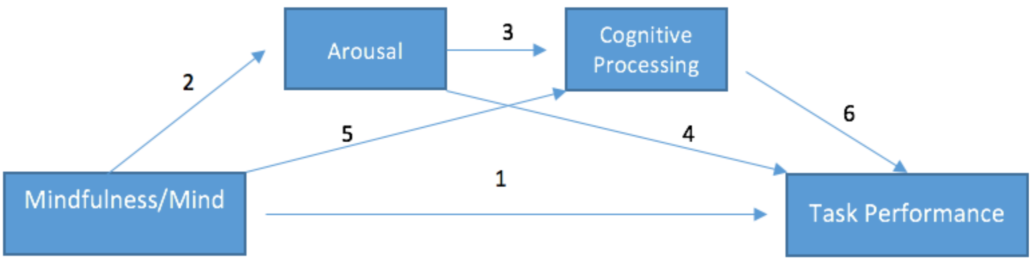

Figure 1: conceptual model

3. Literature Review & Hypotheses

3.1 Mindfulness, Mind-Wandering, & Task Performance

Although mindfulness is a relatively new independent variable in JDM research, studies have related mindfulness to increased cognitive functioning. However, more recent findings suggest that mindfulness may not always produce salutary effects. Stillman et al. (2014) found that dispositional mindfulness was negatively related with performance on an implicit sequential learning task called the Alternating Serial Response Time Task (ASRT) (Howard & Howard, 1997). In this task, participants responded to the location of sequentially presented targets using response buttons that corresponded to the target's location. However, the participants were unaware that the location of the target on every other trial was determined by a repeating sequence. In other words, hidden in the task is a pattern that participants are expected to learn. Thus, mindlessness, or mind-wandering, was associated with improved implicit learning. Similar results were found in another article by Whitmarsh et al. (2013), where the authors found that dispositional mindfulness was associated with reduced learning of artificial grammar (Reber, 1967). This cognitive task is reliant on the subcortical region (which is associated with automatic processing) and weakened by explicit task instructions (Reber, 1976). Whitmarsh and colleagues (2013) posit that higher levels of mindfulness inhibits the acquisition of implicit knowledge inherent in the task. Indeed, as the authors note, the acquisition of such knowledge relies on the use of intuitive cognitive processing, or 'gut feeling'. Other studies have similarly shown how intuitive cognitive processing improves performance on various decision making tasks. Zedelius and Schooler (2015) examined the differing effects of mindfulness and mind-wandering on creative problem-solving. The authors found a negative relationship between mindfulness and creative performance, and found that more mindful participants performed better when adopting an analytical approach to problem-solving, as opposed to an intuitive one. A study by Bierman, Destrebecqz, and Cleeremans (2005) examined how somatic markers influenced implicit learning performance on the previously mentioned artificial grammar task. The Somatic Marker Hypothesis (SMH) is a well-known neural framework that describes how emotions guide decisions (Damasio, Everitt, & Bishop, 1996; Bechara, Damasio, & Damasio, 2003).

Findings indicated that task performance increased long before subjects could verbally explain their choices. "Even though we may not be consciously aware of learning, our bodies may be subtly influencing our responses to patterns in environmental stimuli'' (Forman-Alberti & Hinnant, 2016, p. 1). As implicit learning is a large component of the IGT task, then one might expect a negative relationship between mindfulness and IGT performance. To elaborate, the IGT captures the affective cognitive processes involved in decision-making whereby good IGT performance is contingent upon emotions. And mindfulness is known to attenuate emotional arousal (Follette, Palm, & Pearson, 2006).

This is not to neglect findings demonstrating negative effects of mind-wandering on task performance. Mind-wandering generates thoughts unrelated to the primary task, and such thoughts are believed to interfere with one's consciousness and ability to perform cognitive tasks (Kane, Brown, McVay, Silvia, Myin-Germeys, & Kwapil, 2007). Kane et al. (2007) found that the relationship between mind-wandering and cognitive activities was moderated by working memory capacity (WMC). Specifically, those higher in WMC were better able to maintain on-task thoughts during cognitive activities and, therefore, performed better. However, per Bechara, Damasio, Damasio, and Lee (1999), IGT performance is independent from working memory. Bechara and colleagues found that patients with working memory disorders performed well on the IGT. These findings have been replicated by numerous studies (e.g., Turnbull et al., 2005). Based on these findings, we hypothesize that:

H1a: Mindfulness will reduce task performance, whereas mind-wandering will improve task performance.

However, the relationship between mindlessness and implicit learning is still debated among researchers. For instance, Franklin, Smallwood, Zedelius, Broadway, and Schooler, (2016) challenged the aforementioned findings of Stillman et al. (2014) regarding the positive relationship between mindlessness and implicit learning. In attempts to probe participants' awareness, Franklin and colleagues used experience-sampling as an alternative to the common dual-task approach, a method that has been questioned by some researchers. The idea behind this method derives from the literature on mind-wandering, where researchers have used the method to assess the frequency of task-unrelated thoughts (Teasdale, Dritschel, Taylor, Proctor, Lloyd, Nimmo-Smith, & Baddeley, 1995). Apparently, the largest portion of current literature studies suggest detrimental effects of mind-wandering on cognitive performance (for reviews see Smallwood & Schooler, 2006; Smallwood, Fishman, & Schooler, 2007), as well as well-being (Killingsworth & Gilbert, 2010). Franklin and colleagues found that mind-wandering impeded implicit learning: greater task focus was linked with better task performance. Desbordes, Negi, Pace, Wallace, Raison, & Schwartz (2012) found that mindful participants did not respond to stimuli with their emotions as much as the mindless participants in the IGT. The authors concluded that since stress reduced IGT performance by impeding reflective thinking, analytical processing proved to be critical for good IGT performance. Moreover, studies have similarly expressed critical views in terms of the implicitness of learning in the IGT. Bechara et al.'s (1999) results were replicated in a more recent study by Maia and McClelland (2004). Rather than probing participants' awareness using open-ended questions, as in the original study, Maia and McClelland used more detailed and direct, including questions about the expected gains and losses of each trial as well as the participants' evaluation of their own knowledge. By using such elaborate questioning, the authors found that participants did in fact possess explicit knowledge of the advantageous and disadvantageous decks as well the optimal strategies to deploy in the IGT. The authors thus concluded that there was little support for the notion that the IGT involved unconscious knowledge. In a similar view, a recent critical review by Newell and Shanks (2014) demonstrated that several studies have found that participants in fact do consciously form explicit knowledge about the good and bad decks. Other researchers have similarly argued that learning in the IGT task is not implicit (Simonovic, Stupple, Gale, and Sheffield, 2017), revealing findings that challenge the notion that attention is not necessary for learning in the IGT (Simonovic et al., 2017). Furthermore, studies have demonstrated that emotion may not be the key predictor of IGT performance as previously thought. For example, Webb, DelDonno, and Killgore (2014) found that after controlling for IQ, emotional intelligence was no longer significantly associated with IGT scores. Thus, from this we formulate a contrasting hypothesis:

H1b: Mindfulness will improve task performance, Mind-wandering will reduce task performance.

3.2 Mindfulness & Arousal

A great deal of research has demonstrated the attenuation of mindfulness on arousal. Ortner, Kilner, and Zelazo (2007) found that mindfulness meditation was related to a decrease in skin conductance response (SCR). Specifically, mindfulness meditation decreased self-reported intensity ratings after viewing unpleasant images. The authors interpreted their findings as support for the notion that mindfulness meditation reduces the processing of negative stimuli. They further explain that by increasing one's attention to the "here and now'', mindfulness meditation reduces redundant processing of negative stimuli. Consequently, this reduces the detrimental effects of negative emotions. Similarly, Tang, Yang, Leve, and Harold (2012) tested a specific mindfulness-based therapy where the mindful participants exhibited significantly better physiological reactions, including SCR. Several neurobiological mechanisms are highlighted that are thought to be responsible for these effects. The mindfulness-based therapy influences brain states by increasing the connection between the brain and the body. Brain states are defined as "reliable patterns of brain activity that involve the activation or connectivity of multiple large-scale brain networks that are present even when doing no specific task'' (Tang et al., 2012, p. 1). Modifications in brain states refers to the shift between different kinds of experience, such as sleepiness or wakefulness. Such experiences are believed to share a modified state of mind and body (Tang et al., 2012). These changed brain states involving both mind and body consequently lead to improvement in attention and self-regulation. Brain state changes are signalled by increased activity in the prefrontal cortex (PFC) as well as changes in heart rate. Activation of the PFC has been linked with improvements in attentional control, attention shifting, cognitive flexibility, self-monitoring, planning, inhibitory control of prepotent responses, and working memory (Roth, Randolph, Koven, & Isquith, 2006). Notably, this lends credibility to our proposed dual mediating mechanism (arousal and cognitive processing), which will be returned to later.

Similar effects have been found for dispositional/trait mindfulness. Trait mindfulness, particularly the labeling dimension of a mindfulness scale (e.g., “I’m good at finding the words to describe my feelings’’), has been shown to improve emotion regulation (Creswell, Way, Eisenberger, & Lieberman, 2007). Findings in the neuroscience literature demonstrate that verbally labeling affective stimuli triggers the right ventrolateral prefrontal cortex (VLPFC) and reduces responses in the amygdala (a region in the brain believed to be linked with negative affective states. Previous studies have linked such emotion regulation with reduced anxiety and negative affect (Kalisch, 2005; Ochsner, Bunge, Gross, & Gabrieli, 2002), as well as automatic processing (Lieberman, Eisenberger, Crockett, Tom, Pfeifer, & Way, 2007). The effects of mindfulness on cognitive process will be returned to later in this paper. In contrast to mindfulness, mind-wandering has been associated with higher levels of arousal. McVay, Kane, and Kwapil (2009) found that mind-wandering was positively related to stress, sleepiness, boredom, and chaotic environments, but negatively related to among others, concentration and happiness.

H2: Mind-wandering, as compared with mindfulness, will have a stronger positive relationship with arousal.
H3: Arousal will have a positive relationship with intuitive cognitive processing.

3.3 Arousal & Task Performance

Although the relationship between stress and learning has been widely studied, findings remain mixed (Joels et al., 2006; Starcke & Brand, 2012). Stress influences decision making through its effect on mechanisms such as strategy use, adjustment from automated responses, feedback processing, and reward and punishment sensitivity (Starcke & Brand, 2012). Whether such effects yield an advantage or disadvantage depends on contextual factors, such as the task. Some studies have shown negative effects of stress on performance (Keinan, 1987; Starcke, Wolf, Markowitsch, & Brand, 2008). Reduced attention span and executive functioning caused by stressors have been highlighted as underlying mechanisms for deploying maladaptive strategy. Limited cognitive resources has also been found to decrease adjustment under stressful conditions (Kassam, Koslow, Mendes, 2009). Notably, this reduction was only observed when stress was perceived by participants as a threat. When stress was perceived as a challenge, stress improved performance. Participants who perceive stress as threat fail to suppress their prepotent automatic response and, thus, fail to make a controlled rational adjustment. Stress is conducive to an over-reliance on automatic cognitive processing and a lower reliance on controlled cognitive processes (Masicampo & Baumeister, 2008). Naturally, increased engagement in automatic processing is likely to increase participants' sensitivity to framing effects under stressful conditions. Indeed, studies demonstrate that stress enhances risk-averse decisions in loss-domain trials, and enhances risk-seeking decisions in loss-domain trials (Porcelli & Delgado, 2009).

Despite such detrimental effects of stress, there are indeed many situations that warrant the use of automatic processing (Starcke & Brand, 2012). The automatic processing is related to the human 'fight-or-flight' stress response, an evolutionary tool that has helped humans navigate through a highly uncertain and dangerous world. Studies that employ tasks involving feedback learning and risk-taking demonstrate that participants' decisions can be explained by their stress responses. It should be noted that although we acknowledge that there are important differences between the stress and arousal, the two constructs are also highly related. As has been noted by many authors, stress is typically a symptom of high arousal (e.g., Boucsein, 2012; Gold & Chrousos, 2002). As stress is believed to be a result of arousal, then the above findings should help us understand our proposed relationship between arousal and task performance. As demonstrated in their original study, Bechara et al. (1999) assessed performance in the IGT while simultaneously measuring their skin conductance response (SCR). The participants showed greater levels of SCR just before selecting a disadvantageous deck and lower levels before selecting from disadvantageous decks. These SCR responses, or somatic markers, thus appear to signify the importance of intuitive processing in tasks like the IGT. A large number of studies have replicated these findings. van Den Bos, Claes, and Godoy (2009) found a negative linear relationship between stress and selection of disadvantageous decks in the IGT, a task in which risk-seeking reduces performance. Specifically, the authors found a linear relationship between cortisol reactions and selection of disadvantageous decks among male participants, and an inverted U-shaped relationship among female participants. The latter relationship thus indicated that while performance improved as cortisol secretion increased, performance declined at very high levels of cortisol secretion. Cortisol secretion is believed to interrupt the functioning of the ventromedial prefrontal cortex (which processes risk and fear) and the amygdala (which processes emotions and motivation) (Pruessner, Dedovic, Pruessner, Lord, Buss, Collins, & Lupien 2010). Studies have linked these two regions of the brain with positive IGT performance (reference).

Moreover, risk-seeking has in some cases been found to improve performance in the Balloon Analogue Risk Task (BART), where stress has a positive relationship with advantageous decisions (e.g., Lighthall, Mather, & Gorlick, 2009). Moreover, the stress-learning relationship also depends on whether stressors are related or unrelated to the primary task. Stress can enhance sensitivity to reward, which may improve performance in some tasks and reduce performance in other tasks. Notably, as noted by Starcke and Brand (2012), the relative impact of such effects seem to be influenced by situational factors, which is perhaps a contributing factor to the mixed findings. A factor that is of particular relevance to the present study is the task-relatedness of specific stressors. Different methods have been employed in inducing stress. For instance, Preston, Buchanan, Stansfield, and Bechara (2007) induced anticipatory stress by informing participants that, after performing a task, they would have to hold a public speech which would be recorded on video. Participants who were induced with this anticipatory stress, compared with the control participants, did not select more disadvantageous decks. However, learning was slower in the stress condition, as compared with the control condition. These findings provide a useful illustration of the Somatic Marker Hypothesis. While task-related emotions (e.g., punishment and reward) guide decision-making towards choosing more advantageous decks, task-irrelevant emotions (such as the anticipated stress of holding a public speech) disturb these somatic markers (Starcke & Brand, 2012). An important note to be drawn from this is that these somatic markers, or affect heuristics (Finucane, Alhakami, Slovic, & Johnson, 2000), are task-related (Preston et al., 2007). In the present paper, we propose the use of specific sounds to induce stress. We expect such sounds to trigger stressors that are task-related. Joel et al. (2006) explain that the effect of stress on memory performance depends on "whether stress is experienced closely linked in time to and within the context of the information to be learned (Joels et al., 2006, p. ?).

A more recent exploration is the impact of perceived time pressure on IGT performance. For instance, Cella, Dymond, Cooper, and Turnbull (2007) found that participants who were allocated less time to perform the IGT performed worse. DeDonno and Demaree (2008) built on this finding by informing participants only once, prior to the IGT, that the time allocated to perform the task was either sufficient and sufficient. The authors found that those who were informed that time was insufficient performed worse than those who were informed that time was sufficient. However, it is important to note that one might also find opposite results of time pressure on IGT performance. The perception of time being insufficient is also conducive to better IGT performance, as it nudges participants towards higher reliance on the emotional signals (DeDonno & Demaree, 2008). Indeed, such emotional signals, or somatic markers, are integral to good IGT performance (Bechara et al., 1999). Thus, we arrive at the following set of competing hypotheses:

H4a: Arousal will improve task performance.
H4b: Arousal will impair task performance.

3.4 Mindfulness, Mind-Wandering, & Cognitive Processing

Mindfulness-based training has been linked to improved psychological well-being and performance on cognitive tasks that measure executive functions, such as working memory (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Mrazek et al., 2013). In the clinical domain, mindfulness-based therapies have been linked to an attenuation of psychiatric disorders, such as depression and anxiety (Barnhofer, Crane, Hargus, Amarasinghe, Winder, & Williams, 2009; Shahar, Britton, Sbarra, Figueredo, & Bootzin, 2010) chronic pain (Kabat-Zinn, 1982; Rosenzweig, Greeson, Reibel, Green, Jasser, & Beasley, 2010), addictions (Tang, Tang, & Posner, 2013), and disordered eating (Kristeller & Hallett, 1999). Many of these disorders have been linked with abnormal functioning and structure in brain regions that are responsible for the regulation and processing of emotions. Several studies have observed the effects of these disorders in the prefrontal cortex, including the anterior cingulate and dorsolateral prefrontal cortices (Beauregard, Paquette, & Levesque, 2006; Bishop, Duncan, Brett, & Lawrence, 2004; Luerding, Weigand, Bogdahn, & Schmidt-Wilcke, 2008). As noted by Stillman et al. (2014), similar abnormalities of these prefrontal regions are seen in healthy patients with weak cognitive control and executive functioning (Cabeza & Nyberg, 2000; Miller & Cohen, 2001). As such, mindfulness is thought to produce its positive effects through its ability to reduce habitual response tendencies that is supported by subcortical neural systems, and increasing the activation of executive control functions that are processed by the frontal lobes (Teper, Segal, & Inzlicht, 2013). In a study by Tang et al. (2013), the authors found that participants who were placed in a mindful state benefited from increased self-control (in their case, smoking). This relationship was explained by a strengthening in the structure and function of frontal regions. Paraphrasing Stillman et al. (2014), these findings seem to suggest that mindfulness plays a particularly important role in triggering cognitive functioning that is mediated by frontal regions. A plausible assumption is, therefore, that while mindful individuals may be better of performing tasks that require high levels of analytical cognitive processing (as mediated by the frontal region), they may be worse off in task that warrant automatic, or implicit, cognitive processing. Support for this notion is seen in more recent articles that have explored the effects of mindfulness on implicit learning (see section 3.1). This leads us to the following hypothesis:

H5: Mindfulness will increase the propensity to engage in analytical cognitive processing, whereas mind-wandering will increase the propensity to engage in intuitive cognitive processing.

3.5 Cognitive processing and task performance

The previous section in the present paper has discussed the relationship between mindfulness/mind-wandering and cognitive processing. Section 3.1 highlighted different findings regarding the relationship between mindfulness/mind-wandering and performance in various cognitive tasks. Although apparent overlaps between the sections of the present paper are expected, here we attempt to provide a closer look into the relationship between cognitive processing (analytical vs intuitive) and task performance.

According to theories of dual-processing, reflective (analytical) processing is associated with rational decision-making, while reflexive (intuitive) processing is believed to be responsible for producing cognitive biases (Epstein, 1994: Gibbard, 1992). Consequently, it is commonly believed that analytical, or reflective, processing will lead to better task performance (e.g., Kokis, Macpherson, Toplak, West, & Stanovich, 2002; Witteman, van den Bercken, Claes & Godoy, 2009) than intuitive processing (e.g., Klaczynski, Gordon, & Fauth, 1997; Shiloh, Salton, & Sharabi, 2002). Other studies, on the other hand, have assumed contrary effects of analytical and intuitive processing. Evans and Stanovich (2013) refer to analytical thinking as a potential type of fallacy in decision-making (e.g., Macpherson & Stanovich, 2007), and consider intuitive processing as an effective tool for decisions that are complex (Dijksterhuis & Nordgren, 2006), based on past experiences (Glöckner & Betsch, 2008), or made under certain situational or contextual conditions (Payne, Bettman, & Johnson, 1993). Indeed, these findings seem to suggest varying effects of cognitive processing styles on task outcomes (Phillips, Fletcher, Marks, & Hine, 2016). For example, Sadler-Smith (2016) demonstrated the importance of intuitive affect and somatic states in assessing risk and benefits in business venturing decisions. Intuition, therefore, seems to be closely, and positively, tied to emotion-based judgement and decision-making (JDM). Moreover, much of what has been discussed in section 3.1 in the present paper supports our discussion here. Thus, we arrive at the following set of competing hypotheses:

H5a: A direct relationship will be found between cognitive processing and task performance, such that increased analytical processing will impair task performance, while increased intuitive processing will improve task performance.

H5b: A direct relationship will be found between cognitive processing and task performance, such that increased analytical processing will improve task performance, while intuitive processing will impair task performance.

4. Methodology

4.1 Measures

4.1.1 Mindful Attention and Awareness Scale (MAAS)

Mindfulness is a relatively new field of scientific study, and much of the early research has been criticised for subpar measurements of mindfulness, which has even rendered some of it unusable (MacKillop & Anderson, 2007). The Mindful Attention and Awareness Scale (MAAS), developed by Brown and Ryan (2003) is the most commonly used measure of mindfulness, which has demonstrated strong psychometric properties. It is a self-report measure which determines how well an individual can stay undistracted and attentive on an experience. (MacKillop & Anderson, 2007; Mrazek et al., 2012).

Although numerous studies have used low scores on the MAAS (MAAS; Brown & Ryan, 2003) as a proxy for mind-wandering, such an approach has recently been subject to scrutiny (Mrazek, Phillips, Franklin, Broadway, & Schooler, 2013; Grossman & Van Dam, 2013). The MAAS seeks to capture the extent to which one is aware and attentive of events occuring in the present. At first glance, it may seem plausible to treat a low level of mindfulness as an indicator of mind-wandering. Indeed, studies have found that those who report high levels of mindfulness on the MAAS are less prone to mind-wandering when working with tasks (Mrazek et al., 2012). However, the use of the MAAS in capturing mind-wandering entails several limitations. The MAAS probes attention without a clearly defined primary task (e.g., "I find myself preoccupied with the future or the past.''). Paraphrasing Mrazek et al. (2013), such preoccupation cannot be defined as mind-wandering if it occurs in the absence of a primary task. In addition to measuring attention, the MAAS also seeks to measure awareness (e.g., "I do jobs or tasks automatically, without being aware of what I'm doing''). Yet, one can effectively perform a task while highly attentive, without meta-awareness (Mrazek et al., 2013). In response to this, Mrazek et al. (2013) developed a questionnaire that specifically taps into mind-wandering, called the Mind-Wandering Questionnaire (MWQ).

4.1.2 Skin conductance response (SCR)

Before the experiment begins the participants will be attached to measure skin conductance response, is a well-known method of assessing arousal (Bechara et al., 1999), measurements start before the task as to create a baseline and then continue throughout the experiment.

4.2 Task

The Iowa Gambling Task (IGT) is one of the most popular tools in the investigation of decision-making in uncertain conditions. Good performance on the IGT requires learning which decks are advantageous and which are disadvantageous. The decks that yield high gains initially, also yield high loss in the in the long run. To assess awareness, after a set of trials, participants are probed on their awareness of their choices. Participants have been shown to select advantageous decks before they can verbally explain their selection of decks, thus indicating implicit learning (Bechara et al., 1999).

4.3 Manipulation and Procedure

We intend to use a 2 (mindfulness, mind-wandering) x 3 (arousal, cognitive processing, task performance) between-subject factorial design. Participants will be randomly assigned across 4 cells. Specifically, the independent variables (mindfulness and mind-wandering) will be separated across these groups as to reduce participant fatigue. Moreover, we intend to use a sample consisting of Norwegian undergraduate students (N = 200). The choice of sample size is based on our aim to increase statistical power. The auditory stimuli will be introduced during the administration of the experiment task.

References

Allen, M., Dietz, M., Blair, K., van Beek, M., Rees, G., & Vestergaard-Poulsen, P. et al. (2012). Cognitive-Affective Neural Plasticity following Active-Controlled Mindfulness Intervention. *Journal Of Neuroscience*, *32*(44), 15601-15610. http://dx.doi.org/10.1523/jneurosci.2957-12.2012

Barnhofer, T., Crane, C., Hargus, E., Amarasinghe, M., Winder, R., & Williams, J. M. G. (2009). Mindfulness-based cognitive therapy as a treatment for chronic depression: A preliminary study. *Behaviour Research and Therapy*, 47(5), 366-373.

Beauregard, M., Paquette, V., & Levesque, J. (2006). Dysfunction in the neural circuitry of emotional self-regulation in major depressive disorder. *Neuroreport*, 17(8), 843-846.

Bechara, A., Damasio, H., & Damasio, A. R. (2003). Role of the amygdala in decision-making. *Annals of the New York Academy of Sciences*, 985(1), 356-369.

Bechara, A., Damasio, H., Damasio, A. R., & Lee, G. P. (1999). Different contributions of the human amygdala and ventromedial prefrontal cortex to decision-making. *Journal of Neuroscience*, 19(13), 5473-5481.

Betsch, C., & Kunz, J. J. (2008). Individual strategy preferences and decisional fit. *Journal of Behavioral Decision Making*, 21(5), 532-555.

Bierman, D. J., Destrebecqz, A., & Cleeremans, A. (2005). Intuitive decision making in complex situations: Somatic markers in an artificial grammar learning task. *Cognitive, Affective, & Behavioral Neuroscience*, 5(3), 297-305.

Bishop, S., Duncan, J., Brett, M., & Lawrence, A. D. (2004). Prefrontal cortical function and anxiety: controlling attention to threat-related stimuli. *Nature Neuroscience,* 7(2), 184-188.

Boucsein, W. (2012). *Electrodermal activity*. Springer Science & Business Media. New York: Springer.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, 84(4), 822.

Cabeza, R., & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience*, 12(1), 1-47.

Cella, M., Dymond, S., Cooper, A., & Turnbull, O. (2007). Effects of decision-phase time constraints on emotion-based learning in the Iowa Gambling Task. *Brain and Cognition*, 64(2), 164-169.

Creswell, J. D., Way, B. M., Eisenberger, N. I., & Lieberman, M. D. (2007). Neural correlates of dispositional mindfulness during affect labeling. *Psychosomatic Medicine*, 69(6), 560-565.

Damasio, A., Everitt, B., & Bishop, D. (1996). The Somatic Marker Hypothesis and the Possible Functions of the Prefrontal Cortex [and Discussion].

Philosophical Transactions Of The Royal Society B: Biological Sciences, *351*(1346), 1413-1420. http://dx.doi.org/10.1098/rstb.1996.0125

DeDonno, M. A., & Demaree, H. A. (2008). Perceived time pressure and the Iowa Gambling Task. *Judgment and Decision Making*, 3(8), 636.

Desbordes, G., Negi, L. T., Pace, T. W., Wallace, B. A., Raison, C. L., & Schwartz, E. L. (2012). Effects of mindful-attention and compassion meditation training on amygdala response to emotional stimuli in an ordinary, non-meditative state. *Frontiers in Human Neuroscience*, 6.

Dijksterhuis, A., & Nordgren, L. F. (2006). A theory of unconscious thought. *Perspectives on Psychological Science*, 1(2), 95-109.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, 49(8), 709.

Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science*, 8(3), 223-241.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000). The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making*, 13(1), 1.

Follette, V., Palm, K., & Pearson, A. (2006). Mindfulness and trauma: implications for treatment. *Journal Of Rational-Emotive & Cognitive-Behavior Therapy*, *24*(1), 45-61. http://dx.doi.org/10.1007/s10942-006-0025-2

Forman-Alberti, A. B., & Hinnant, J. B. (2016). Links between autonomic activity and implicit learning. *International Journal of Psychophysiology*, 110, 75-80.

Frankish, K. (2010). Dual-Process and Dual-System Theories of Reasoning. *Philosophy Compass*, *5*(10), 914-926. http://dx.doi.org/10.1111/j.1747-9991.2010.00330.x

Franklin, M. S., Smallwood, J., Zedelius, C. M., Broadway, J. M., & Schooler, J. W. (2016). Unaware yet reliant on attention: Experience sampling reveals that mind-wandering impedes implicit learning. *Psychonomic Bulletin & Review*, 23(1), 223-229.

Gibbard, A. (1992). *Wise choices, apt feelings*. Oxford: Clarendon Press.

Gigerenzer, G. (2004). Fast and frugal heuristics: The tools of bounded rationality. *Blackwell handbook of judgment and decision making*, 62, 88.

Glöckner, A., & Betsch, T. (2008). Multiple-reason decision making based on automatic processing. Journal of experimental psychology: *Learning, Memory, and Cognition*, 34(5), 1055.

Gold, P. W., & Chrousos, G. P. (2002). Organization of the stress system and its dysregulation in melancholic and atypical depression: high vs low CRH/NE states. *Molecular psychiatry*, 7(3), 254.

Howard Jr, J. H., & Howard, D. V. (1997). Age differences in implicit learning of higher order dependencies in serial patterns. *Psychology and Aging,* 12(4), 634.

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience,* 7(2), 109-119.

Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion*, 10(1), 54.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, 4(1), 33-47.

Kalisch, R., Wiech, K., Critchley, H. D., Seymour, B., O'doherty, J. P., Oakley, D. A., ... & Dolan, R. J. (2005). Anxiety reduction through detachment: subjective, physiological, and neural effects. *Journal of Cognitive Neuroscience*, 17(6), 874-883.

Kane, M. J., Brown, L. H., McVay, J. C., Silvia, P. J., Myin-Germeys, I., & Kwapil, T. R. (2007). For whom the mind wanders, and when: An experience-sampling study of working memory and executive control in daily life. *Psychological Science*, 18(7), 614-621.

Kassam, K. S., Koslov, K., & Mendes, W. B. (2009). Decisions under distress: Stress profiles influence anchoring and adjustment. *Psychological Science,* 20(11), 1394-1399.

Keinan, G. (1987). Decision making under stress: Scanning of alternatives under controllable and uncontrollable threats. *Journal of Personality and Social Psychology*, 52(3), 639.

Klaczynski, P. A., Gordon, D. H., & Fauth, J. (1997). Goal-oriented critical reasoning and individual differences in critical reasoning biases. *Journal of Educational Psychology,* 89(3), 470.

Kokis, J. V., Macpherson, R., Toplak, M. E., West, R. F., & Stanovich, K. E. (2002). Heuristic and analytic processing: Age trends and associations with cognitive ability and cognitive styles. *Journal of Experimental Child Psychology*, 83(1), 26-52.

Kristeller, J. L., & Hallett, C. B. (1999). An exploratory study of a meditation-based intervention for binge eating disorder. *Journal of Health Psychology*, 4(3), 357-363.

Lieberman, M. D., Eisenberger, N. I., Crockett, M. J., Tom, S. M., Pfeifer, J. H., & Way, B. M. (2007). Putting feelings into words. *Psychological Science*, 18(5), 421-428.

Lighthall, N., Mather, M., & Gorlick, M. (2009). Acute Stress Increases Sex Differences in Risk Seeking in the Balloon Analogue Risk Task. *Plos ONE*, *4*(7), e6002. http://dx.doi.org/10.1371/journal.pone.0006002

Luerding, R., Weigand, T., Bogdahn, U., & Schmidt-Wilcke, T. (2008). Working memory performance is correlated with local brain morphology in the medial frontal and anterior cingulate cortex in fibromyalgia patients: structural correlates of pain–cognition interaction. *Brain*, 131(12), 3222-3231.

MacKillop, J., & Anderson, E. (2007). Further Psychometric Validation of the Mindful Attention Awareness Scale (MAAS). *Journal Of Psychopathology And Behavioral Assessment*, *29*(4), 289-293. http://dx.doi.org/10.1007/s10862-007-9045-1

Macpherson, R., & Stanovich, K. E. (2007). Cognitive ability, thinking dispositions, and instructional set as predictors of critical thinking. *Learning and Individual Difference*s, 17(2), 115-127.

Masicampo, E. J., & Baumeister, R. F. (2008). Toward a physiology of dual-process reasoning and judgment: Lemonade, willpower, and expensive rule-based analysis. *Psychological Science*, 19(3), 255-260.

McVay, J. C., Kane, M. J., & Kwapil, T. R. (2009). Tracking the train of thought from the laboratory into everyday life: An experience-sampling study of mind wandering across controlled and ecological contexts. *Psychonomic Bulletin & Review*, 16(5), 857-863.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, 24(1), 167-202.

Mrazek, M. D., Phillips, D. T., Franklin, M. S., Broadway, J. M., & Schooler, J. W. (2013). Young and restless: validation of the Mind-Wandering Questionnaire (MWQ) reveals disruptive impact of mind-wandering for youth. *Frontiers in Psychology*, 4.

Mrazek, M. D., Smallwood, J., & Schooler, J. W. (2012). Mindfulness and mind-wandering: finding convergence through opposing constructs. *Emotion*, 12(3), 442.

Mrazek, M., Franklin, M., Phillips, D., Baird, B., & Schooler, J. (2013). Mindfulness Training Improves Working Memory Capacity and GRE Performance While Reducing Mind Wandering. *Psychological Science*, *24*(5), 776-781. http://dx.doi.org/10.1177/0956797612459659

Mukherjee, K. (2010). A dual system model of preferences under risk. *Psychological Review*, *117*(1), 243-255. http://dx.doi.org/10.1037/a0017884

Newell, B. R., & Shanks, D. R. (2014). Unconscious influences on decision making: A critical review. *Behavioral and Brain Sciences*, 37(1), 1-19.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. (2002). Rethinking feelings: an FMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience*, 14(8), 1215-1229.

Ortner, C. N., Kilner, S. J., & Zelazo, P. D. (2007). Mindfulness meditation and reduced emotional interference on a cognitive task. *Motivation and Emotion*, 31(4), 271-283.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker.* Cambridge University Press.

Phillips, W. J., Fletcher, J. M., Marks, A. D., & Hine, D. W. (2016). *Thinking styles and decision making*: A meta-analysis.

Porcelli, A. J., & Delgado, M. R. (2009). Acute stress modulates risk taking in financial decision making. *Psychological Science*, 20(3), 278-283.

Preston, S. D., Buchanan, T. W., Stansfield, R. B., & Bechara, A. (2007). Effects of anticipatory stress on decision making in a gambling task. *Behavioral Neuroscience*, 121(2), 257.

Pruessner, J. C., Dedovic, K., Pruessner, M., Lord, C., Buss, C., Collins, L., & Lupien, S. J. (2010). Stress regulation in the central nervous system: evidence from structural and functional neuroimaging studies in human populations-2008 Curt Richter Award Winner. *Psychoneuroendocrinology*, 35(1), 179-191.

Reber, A. S. (1967). Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior*, 6(6), 855-863.

Reber, A. S. (1976). Implicit Learning of artificial languages: The role of instructional. Journal of Experimental Psychology: *Human Learning and Memory*, 2.

Rosenzweig, S., Greeson, J. M., Reibel, D. K., Green, J. S., Jasser, S. A., & Beasley, D. (2010). Mindfulness-based stress reduction for chronic pain conditions: variation in treatment outcomes and role of home meditation practice. *Journal of Psychosomatic Research*, 68(1), 29-36.

Roth, R. M., Randolph, J. J., Koven, N. S., & Isquith, P. K. (2006). Neural Substrates of Executive Functions: *Insights from Functional Neuroimaging*.

Shahar, B., Britton, W. B., Sbarra, D. A., Figueredo, A. J., & Bootzin, R. R. (2010). Mechanisms of change in mindfulness-based cognitive therapy for depression: Preliminary evidence from a randomized controlled trial. *International Journal of Cognitive Therapy*, 3(4), 402-418.

Shiloh, S., Salton, E., & Sharabi, D. (2002). Individual differences in rational and intuitive thinking styles as predictors of heuristic responses and framing effects. *Personality and Individual Differences*, 32(3), 415-429.

Simonovic, B., Stupple, E. J., Gale, M., & Sheffield, D. (2017, July). Pupil dilation and cognitive reflection as predictors of performance on the Iowa Gambling Task. *Cognitive Science Society*.

Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin,* 132(6), 946.

Smallwood, J., Fishman, D. J., & Schooler, J. W. (2007). Counting the cost of an absent mind: Mind wandering as an underrecognized influence on educational performance. *Psychonomic Bulletin & Review*, 14(2), 230-236.

Starcke, K., & Brand, M. (2012). Decision making under stress: a selective review. *Neuroscience & Biobehavioral Reviews*, 36(4), 1228-1248.

Starcke, K., Wolf, O. T., Markowitsch, H. J., & Brand, M. (2008). Anticipatory stress influences decision making under explicit risk conditions. *Behavioral Neuroscience*, 122(6), 1352.

Stillman, C. M., Feldman, H., Wambach, C. G., Howard, J. H., & Howard, D. V. (2014). Dispositional mindfulness is associated with reduced implicit learning. Consciousness and cognition, 28, 141-150.

Tang, Y. Y., Tang, R., & Posner, M. I. (2013). Brief meditation training induces smoking reduction. *Proceedings of the National Academy of Sciences,* 110(34), 13971-13975.

Tang, Y. Y., Yang, L., Leve, L. D., & Harold, G. T. (2012). Improving executive function and its neurobiological mechanisms through a mindfulness-based intervention: Advances within the field of developmental neuroscience. *Child Development Perspectives*, 6(4), 361-366.

Teasdale, J. D., Dritschel, B. H., Taylor, M. J., Proctor, L., Lloyd, C. A., Nimmo-Smith, I., & Baddeley, A. D. (1995). Stimulus-independent thought depends on central executive resources. *Memory & Cognition*, 23(5), 551-559.

Teper, R., Segal, Z. V., & Inzlicht, M. (2013). Inside the mindful mind: How mindfulness enhances emotion regulation through improvements in executive control. *Current Directions in Psychological Science*, 22(6), 449-454.

van den Bos, R., Harteveld, M., & Stoop, H. (2009). Stress and decision-making in humans: Performance is related to cortisol reactivity, albeit differently in men and women. *Psychoneuroendocrinology*, *34*(10), 1449-1458. http://dx.doi.org/10.1016/j.psyneuen.2009.04.016

Webb, C. A., DelDonno, S., & Killgore, W. D. (2014). The role of cognitive versus emotional intelligence in Iowa Gambling Task performance: What's emotion got to do with it? *Intelligence*, 44, 112-119.

Whitmarsh, S., Uddén, J., Barendregt, H., & Petersson, K. M. (2013). Mindfulness reduces habitual responding based on implicit knowledge: Evidence from artificial grammar learning. *Consciousness and Cognition*, 22(3), 833-845.

Witteman, C., van den Bercken, J., Claes, L., & Godoy, A. (2009). Assessing rational and intuitive thinking styles. *European Journal of Psychological Assessment,* 25(1), 39-47.

Zedelius, C. M., & Schooler, J. W. (2015). Mind wandering “Ahas” versus mindful reasoning: alternative routes to creative solutions. *Frontiers in Psychology*, 6.