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A multi-faceted approach to understanding individual differences in mind-wandering[★,★★,★]

Matthew K. Robison[a,*], Ashley L. Miller[b], Nash Unsworth[b]

[a] Department of Psychology, Arizona State University, United States
[b] Department of Psychology, University of Oregon, United States

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ABSTRACT

The present study examined a multi-faceted approach to individual differences in mind-wandering. Further, the influence of task demands as a moderator of inter-individual relationships and the distinction between intentional and unintentional mind-wandering was also examined. A large sample ($N = 332$) of participants completed a battery of tasks during which mind-wandering was measured with periodic thought probes. One set of tasks placed relatively high demands on attention, whereas another set of tasks placed relatively low demands on attention. We also measured individual differences in working memory capacity and attention control, along with measures of state variables like motivation, alertness, and mood. Finally, participants completed a series of questionnaires to measure various personality traits. Overall, the results reinforced the importance of taking a multi-faceted approach to mind-wandering – one that address individual differences at the cognitive, contextual, and dispositional levels, as well as the distinction between intentional and unintentional mind-wandering.

1. Introduction

Mind-wandering is a mental state in which one's attention shifts away from the external environment to internal thoughts. As an example, many of us have had the experience of coming to the bottom of a page in a book and realizing we don't remember anything we've just read. Or, we pull into the driveway and realize we haven't been paying attention for a long stretch of the drive. Often, these instances are harmless. However, mind-wandering can have rather serious consequences. In addition to outcomes like poor academic performance (Seli, Wammes, Risko, & Smilek, 2016; Unsworth & McMillan, 2017; Wammes, Seli, Cheyne, Boucher, & Smilek, 2016), mind-wandering can lead to driving accidents (Galéra et al., 2012), catastrophic industrial failures (Reason, 1990), and can be a symptom of psychopathology (Marchetti, Koster, Klinger, & Alloy, 2016). In the present study, we are particularly focused on the task-irrelevant aspects of mind-wandering – thoughts that occur during an ongoing task that draw attention away from the task and to internal thoughts instead.

Although we focus heavily on mind-wandering in the present study, it is worth noting that mind-wandering is just one form of attentional diversion, and there are different aspects of self-generated thoughts. For the purposes of the present investigation, we will operate under the definition of mind-wandering as any task-unrelated thought that is relatively independent of any immediate external stimulus (Stawarczyk, Majerus, Maj, Van der Linden, & D'Argembeau, 2011). When people are considering aspects of the task or their task performance, we define these thoughts as *task-related interference,* and we do not consider them task-unrelated (Stawarczyk et al., 2011). When an irrelevant stimulus captures one's attention, we would define such thoughts as *external distraction*, as they are task-unrelated but not stimulus-independent (Stawarczyk et al., 2011). A final category of thoughts that we would distinguish from mind-wandering is *mind-blanking* (Ward & Wegner, 2013). Mind-blanking can be defined as a state in which attention is certainly not focused on any specific task, but is not directed to any specific internal thought or external stimulus. Indeed, mind-blanking can be considered the absence of thought. In the present study, we allowed participants to report on-task thoughts, task-related interference, external distraction, mind-wandering, and mind-blanking in order to parse apart these various mental states during ongoing task completion.

The specific contents of any given mind-wandering episode can fall

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* Corresponding author at: Department of Psychology, 950 S. McAllister Ave., Tempe, AZ 85287, United States.
E-mail address: matthewkrobison@asu.edu (M.K. Robison).

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along a number of dimensions including emotional valence, temporal orientation, intensity, self-relevance, and intentionality, among others (Andrews-Hanna et al., 2013; Klinger, 1999). In the present study, we focus on the intentionality dimension of mind-wandering. Often, mind-wandering is conceptualized as an involuntary shift of attention away from an ongoing task. However, an individual can intentionally mind-wander during a task, as well. For example, a student sitting in class may be trying in earnest to keep her attention focused on the lecture content. However, irrelevant thoughts occasionally capture her attention. We refer to this type of thought as *unintentional mind-wandering*. Another student may find the lecture exceptionally uninteresting. So she may consciously decide to think about other things. We refer to this type of thought as *intentional mind-wandering* (Grodsky & Giambra, 1990-91; Seli, Risko, Smilek, & Schacter, 2016). We have previously used the terms deliberate and spontaneous mind-wandering to refer to intentional and unintentional mind-wandering, respectively, in prior work (Robison & Unsworth, 2018). But we will use the terms intentional and unintentional mind-wandering in the present study.

1.1. The multi-faceted framework

Because mind-wandering is associated with important outcomes like academic attainment and psychopathology, as well as being a factor in major accidents and industrial disasters, two important questions will be addressed in the present study: 1) for whom is mind-wandering most common? and 2) in what situations is mind-wandering most common? In order to answer these questions, we approached mind-wandering from a multi-faceted framework (Fig. 1). In this framework, individual differences in three categories of variables act as important correlates of mind-wandering: cognitive variables, contextual variables, and dispositional variables. The relationship between each set of variables is potentially moderated by the demands of the external task. Some situations require individuals to fully devote their attention to the task, whereas others may allow individuals the opportunity to split their attention between the task and irrelevant thoughts (Thomson, Besner, & Smilek, 2015). In other words, the correlations between various individual differences and the degree to which people mind-wander may change based on task demands. A major aim of the present study is to test whether, indeed, these relationships are moderated by task demands. In the sections below, we describe each category of variables (i.e., contextual, cognitive, and dispositional), discuss why each of these types of variables might theoretically predict variation in mind-wandering, and review evidence that demonstrates such relationships.

1.1.1. Contextual variables

The first category of individual differences comprises contextual variables. We do not consider these variables stable traits of the individual, but rather in-the-moment differences among individuals that covary with tendencies to mind-wander. They include stress, mood, motivation, alertness/fatigue, task interest, and task experience, among others. Experimental manipulations have demonstrated that sleep deprivation leads to more mind-wandering during a visual search task (Poh, Chong, & Chee, 2016). At an individual differences level, people who report feeling less alert report more mind-wandering (Robison & Unsworth, 2018; Stawarczyk & D'Argembeau, 2016), and in moments when people report feeling tired, mind-wandering tends to occur (Kane et al., 2007, 2017; Stawarczyk & D'Argembeau, 2016). So fatigue appears to be an important predictor of mind-wandering. Most generally, when people are tired, they tend to mind-wander.

With regards to mood, previous research has shown that stress and negative mood inductions lead to more mind-wandering (Antrobus, Singer, & Greenberg, 1966; Smallwood, Fitzgerald, Miles, & Phillips, 2009; Stawarczyk, Majerus, & D'Argembeau, 2013). At an individual differences level, Killingsworth and Gilbert (2010) found that people who reported more mind-wandering during their daily lives via experience-sampling reported being less happy. Poerio, Totterdell and Miles (2013) found that whereas sadness tended to predict later mind-wandering, mind-wandering only predicted later sadness if the content of the mind-wandering episode was negative. In their experience-sampling studies, Kane et al. (2007), Kane et al. (2017) have observed that people are more likely to report mind-wandering when they are experiencing negative affect – feeling anxious, sad, irritable, or confused. Further, Stawarczyk, Majerus, Van der Linden and D'Argembeau (2012) found that people who reported more mind-wandering in their daily lives tended to report more negative affect. But this effect could be accounted for by a more general lack of mindful awareness to present experience. According to concerns theory (Klinger, 1999, 2009; McVay & Kane, 2010), many mind-wandering episodes constitute thoughts about an individual's current concerns – unresolved short-term and/or long-term personal goals. Thus, if a person is in a state of mind during which the salience of personal concerns is elevated (e.g., recently learned about a close relative's illness, anxious about an upcoming exam), then this anxiety/worry may lead to more instances of mind-wandering during the completion of other tasks. In more colloquial terms, some people have a lot on their minds.

In addition to fatigue and mood, prior research has demonstrated that individual differences in motivation, task interest, and task experience all correlate with mind-wandering during reading tasks (Robison & Unsworth, 2015; Unsworth & McMillan, 2013). Motivation correlates with mind-wandering during a sustained attention task (Seli, Cheyne, Xu, Purdon, & Smilek, 2015), and motivation, alertness, and perceptions of task unpleasantness are all correlated with mind-wandering during attention control tasks (Robison & Unsworth, 2018). Importantly, individual differences in such contextual variables typically do not correlate with cognitive abilities such as working memory capacity (WMC; Robison & Unsworth, 2018, 2015; Unsworth &

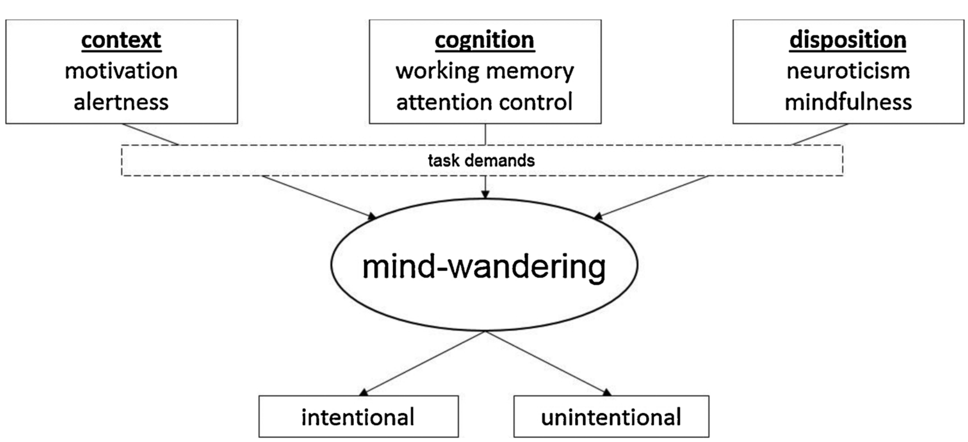

Fig. 1. The multi-faceted framework.

McMillan, 2013), but do seem to correlate with attention control (AC) abilities (Robison & Unsworth, 2018). Additionally, experimental conditions that provide additional motivational incentives have been shown to reduce intentional mind-wandering (Seli, Schacter, Risko, & Smilek, 2019). Collectively, these findings reinforce the idea that contextual variables represent a distinct set of predictors at the level of individual differences. Of course, it is also possible that some dispositional traits lead people feel chronically unmotivated or fatigued. But for the purposes of the present investigation, we assume that contextual variables mostly reflect a person's feelings in the moment.

To measure individual differences in these contextual factors, the present study included several questions throughout the laboratory session to measure subjective ratings of motivation and alertness. At the end of the session, participants received several questionnaires which measured subjective affective states/moods (e.g., state anxiety; positive and negative affect) and previous night's sleep. Together these questions were included to account for the contextual factors described above.

1.1.2. Cognitive variables

The second category of predictors comprises cognitive variables. This category of variables has received a wealth of attention in prior research. Generally, research has found that individuals with better cognitive abilities mind-wander less. A recent meta-analysis of the relationship between cognitive abilities and mind-wandering tendencies estimates the relationship at $\rho = -.14$ (Randall, Oswald, & Beier, 2014). More specifically, prior research has demonstrated that individuals with greater WMC and AC report fewer instances of mind-wandering during a variety of tasks, including reading comprehension tasks (McVay & Kane, 2012b; Robison & Unsworth, 2015; Unsworth & McMillan, 2013), the Sustained Attention to Response Task (SART; Kane et al., 2016, 2017; McVay & Kane, 2012b; Unsworth & McMillan, 2014), complex span working memory tasks (Mrazek, Smallwood, Franklin et al., 2012; Mrazek, Smallwood, & Schooler, 2012), visual working memory tasks (Krimsky, Forster, Llabre, & Jha, 2017; Unsworth & Robison, 2016), the psychomotor vigilance task (Robison, Gath, & Unsworth, 2017; Unsworth & McMillan, 2014), the antisaccade task (Kane et al., 2016, 2017; Robison & Unsworth, 2018; Robison et al., 2017; Unsworth & McMillan, 2014), and the Stroop task (Kane et al., 2016, 2017; Robison & Unsworth, 2018; Robison et al., 2017; Unsworth & McMillan, 2014). Furthermore, individuals with greater WMC and AC have reported fewer instances of mind-wandering and distraction in their day-to-day lives, especially in cognitively demanding situations (i.e., class lectures, studying; Kane et al., 2007, 2017; Unsworth, Brewer, & Spillers, 2012; Unsworth & McMillan, 2017; Unsworth, McMillan, Brewer, & Spillers, 2012).

The consistent finding that individual differences in WMC and AC correlate with fewer instances of mind-wandering and other task-unrelated thoughts led McVay and Kane (2010) to propose the control failure x concerns account. Building off work by Klinger (1999), Klinger (2009), McVay and Kane argue that individual differences in mind-wandering are jointly determined by one's ability to exert control over the occurrence of task-unrelated thoughts and the salience of personal concerns. When personal concerns rise to the level of conscious thought during an ongoing task, these instances constitute control failures. Individuals with lower executive control abilities are less able to exert control over these instances. Further, individuals with more salient personal concerns, or who have been recently cued to their personal concerns, will exhibit more frequent mind-wandering (McVay & Kane, 2010, 2013). The "concerns" side of the control failure x concerns account is an issue we will return to later.

Although a large body of evidence is consistent with the control failure account, several pieces of evidence are inconsistent with this account. Despite the well-established finding that older adults have lower executive control abilities than younger adults, studies comparing older and younger adults have consistently demonstrated that older adults actually experience *fewer* instances of mind-wandering than their younger counterparts (Frank, Nara, Zavagnin, Touron, & Kane, 2015; Giambra, 1977-78; Jackson & Balota, 2012; Jackson, Weinstein, & Balota, 2013; Krawietz, Tamplin, & Radvansky, 2012; McVay, Meier, Touron, & Kane, 2013; Zavagnin, Borella, & De Beni, 2014). However, the control failure x concerns account posits that older adults have fewer current concerns – fewer unresolved personal goals – and that is why they mind-wander less. Another potential challenge for the control failure account is the finding that sometimes, cognitive abilities positively correlate with mind-wandering reports. For example, Levinson, Smallwood and Davidson (2012) found an interactive effect between WMC and perceptual load on mind-wandering in a visual search task. Whereas WMC positively correlated with mind-wandering during low-load search, it did not correlate with mind-wandering during high-load search. Further, Baird, Smallwood and Schooler (2011) found that while WMC did not correlate with mind-wandering rates overall, it positively correlated with future-oriented thoughts during a relatively low-demand task. Finally, Rummel and Boywitt (2014) found that WMC negatively correlated with mind-wandering during a 3-back task, but that WMC positively correlated with mind-wandering during a 1-back task.

To account for these findings, two similar hypotheses have been proposed. Smallwood and Andrews-Hanna (2013) proposed the context-regulation hypothesis. Smallwood and Andrews-Hanna argue that executive control abilities operate not to inhibit mind-wandering altogether, but to control the contexts within which mind-wandering occurs. When heavy demands are placed upon the individual by the external environment (e.g., driving on a busy highway during rush hour), it is important for the individual to exert control over task-irrelevant thoughts, as their occurrence may have negative consequences. However in situations where relatively few attentional demands are placed upon an individual, mind-wandering may actually allow us to be more productive with our excess cognitive capacity (e.g., Baird et al., 2011). Thus, the relationship between cognitive abilities and mind-wandering should be sensitive to changes in task demands. In a similar vein, Rummel and Boywitt (2014) proposed the cognitive-flexibility hypothesis. Using the *n*-back task, they showed that high-WMC individuals are more flexible in adapting to the external demands of the environment. Using latent change modeling, Rummel and Boywitt showed that the degree of change in mind-wandering from 3- to 1-back task blocks was positively correlated with WMC, suggesting that high-WMC individuals can be flexible in adjusting their attention-regulation settings to meet the external environment, whereas low-WMC individuals are less able to do so. This finding was recently corroborated by Y. Ju and Lien (2018), Y-J. Ju and Lien (2018), who found a negative relationship between WMC and mind-wandering during a 2-back task but not during a 0-back task.

It should be noted that the evidence favoring the context-regulation and cognitive-flexibility hypotheses is limited. In their original study, Baird et al. (2011) had a relatively small sample size ($N = 47$) for an individual differences analysis and only used one task (operation span) to measure WMC. Levinson et al. (2012) had a larger sample size in their first experiment ($N = 93$) but had a small sample size in their second experiment ($N = 45$). In both experiments, Levinson et al. only used one task to measure WMC. In a recent attempted replication of Levinson et al. (2012), Meier (2018) did not observe a positive correlation between WMC and mind-wandering in the breath-counting task, but rather observed a significant negative correlation between WMC and mind-wandering at the latent level. In another recent study, we tried to replicate Baird et al. (2011) in demonstrating that WMC was positively correlated with future-oriented mind-wandering (Robison & Unsworth, 2017). Baird et al. argued that such future-oriented mind-wandering reflects productive episodes of autobiographical planning. To overcome some methodological limitations of prior studies, we used the same task as Baird et al. (2011) and one additional low-demand task, three complex span tasks to measure WMC, and collected data from a larger sample (N = 124). We did not replicate the finding that WMC correlates with more future-oriented mind-wandering. In fact, at the latent level, we observed a negative correlation between WMC and overall mind-wandering similar in magnitude to other latent variable analyses of these constructs (e.g., Kane et al., 2016, 2017; McVay & Kane, 2012a, 2012b; Robison & Unsworth, 2015, 2018; Unsworth & McMillan, 2013, 2014). McVay, Unsworth, McMillan and Kane (2013) similarly did not find a positive correlation between WMC and future-oriented mind-wandering during reading comprehension across two separate experiments. Therefore, one aim of the present study was to examine results in light of predictions made by the context-regulation and cognitive flexibility hypotheses.

1.1.3. Dispositional variables

The third and final category of predictors of mind-wandering comprises dispositional variables. Among these are personality traits, affective dispositions, and psychopathological symptoms. Consistent with the "concerns" side of the control failure x concerns account (McVay & Kane, 2010), several studies have previously shown that neuroticism positively correlates with mind-wandering during laboratory tasks (Jackson et al., 2013; Kane et al., 2017; Robison et al., 2017). Theoretically, individuals with more neurotic personalities have a greater focus on negative self-relevant concerns, making such concerns more salient, which in turn manifests in more frequent mind-wandering. While it did not correlate with laboratory rates of mind-wandering, openness positively correlated with mind-wandering during daily life sampling (Kane et al., 2017). To measure such dispositions, the present study included measures of Big Five personality traits and a trait anxiety scale.

We also considered other psychological traits that may account for variance in mind-wandering. Specifically, we included three scales that have been used previously to measure general tendencies to mind-wandering in day-to-day life. The first is the 12-item Daydreaming Frequency Scale (DDFS) of the Imaginal Process Inventory (Singer & Antrobus, 1970). Prior research has shown a correlation between the DDFS and mind-wandering measured during laboratory tasks (Smeekens & Kane, 2016). To measure a general tendency to feel bored, we used the Boredom Proneness Scale (Vodanovich & Kass, 1990). Some participants may not mind-wander because they have poor cognitive ability, are high in anxiety/neuroticism, or have low alertness, for example, but rather because they tend to mind-wander or are prone to feel bored. If this is the case, daydreaming frequency and boredom proneness should positively correlate with mind-wandering. Evidence consistent with this idea comes from at least one study that examined the relationship between boredom proneness and sustained attention (Malkovsky, Merrifield, Goldberg, & Danckert, 2012). People who reported higher boredom proneness reported more attention failures in everyday life, more self-reported ADHD symptoms, lower trait mindfulness, and higher depression scores. Further, boredom proneness predicted more commission errors on the SART, as well as less SART post-error slowing. So although Malkovsky et al. (2012) did not directly measure mind-wandering, the relationships between boredom proneness, SART errors, and questionnaire-based measures of mind-wandering led us to believe boredom proneness would be a dispositional predictor of task-unrelated thoughts in the lab. Finally, we included the 15-item Mindful Attention Awareness Scale (MAAS) to measure trait mindfulness. Prior research has demonstrated that individuals who are higher in trait mindfulness exhibit less frequent mind-wandering (Deng, Li, & Tang, 2014; Epel et al., 2013; Mrazek, Franklin, Tarchin Phillips, Baird, & Schooler, 2013; Mrazek, Phillips, Franklin, Broadway, & Schooler, 2013; Mrazek, Smallwood, Franklin et al., 2012; Mrazek, Smallwood, Schooler, 2012; Ottaviani & Couyoumdjian, 2013; Seli, Carriere, & Smilek, 2015; Stawarczyk et al., 2012; Y. Ju & Lien, 2018; Y-J. Ju & Lien, 2018). Furthermore, interventions that attempt to increase mindfulness have been shown to decrease subsequent tendencies to mind-wander, either through extensive training (Mrazek, Franklin et al., 2013; Mrazek, Phillips et al., 2013) or through brief mindful breathing exercises (Mrazek, Smallwood, Franklin et al., 2012; Mrazek, Smallwood, Schooler, 2012). Other evidence suggests brief mindfulness exercises may only be effective for particularly anxious individuals (Xu, Purdon, Seli, & Smilek, 2017). Theoretically, individuals who are higher in trait mindfulness (or have been trained to be more mindful of their attention) should exhibit less mind-wandering and other task-unrelated thoughts because they have a greater awareness of where their thoughts are any given moment. Thus, when they are completing a task and notice their thoughts have moved off-task, they may be more apt at bringing their thoughts back to the task.

2. Present study

Based on the multi-faceted framework outlined in Fig. 1, we designed an individual differences investigation that would simultaneously address many of the putative correlates of mind-wandering in the literature. In turn, the present study had several specific research questions. First, how do task demands moderate the frequency of mind-wandering? That is, do people mind-wander more often during low-demand tasks compared to high-demand tasks? And, do task demands affect intentional mind-wandering, unintentional mind-wandering, or both? Second, how do WMC and AC correlate with mind-wandering? Are these relationships moderated by task demands? Further, are intentional and unintentional mind-wandering differentially related to cognitive abilities, and are these specific relationships moderated by task demands? Are there any situations in which high-ability individuals will actually mind-wander more than low-ability individuals? If so, is this because they are intentionally mind-wandering more often during situations in which minimal attention is required by an external task? Third, how do contextual variables (e.g., motivation, alertness, mood) correlate with mind-wandering? Do these variables differentially correlate with intentional and unintentional mind-wandering, and are these relationships moderated by task demands? Fourth, how do dispositional traits (e.g., neuroticism, trait anxiety, boredom proneness, etc.) correlate with mind-wandering, and are these relationships moderated by task demands? Finally, are these dispositions differentially related to intentional and intentional forms of mind-wandering?

Participants completed a series of tasks during a single laboratory session. We measured WMC with three complex span tasks (operation span, symmetry span, reading span) and AC with three additional tasks (antisaccade, Stroop, psychomotor vigilance). These tasks have been used extensively to measure WMC and AC, as well as mind-wandering in prior studies (e.g., Baird et al., 2011; Kane et al., 2007, 2016; Kane et al., 2017; Levinson et al., 2012; Mrazek, Smallwood, Franklin et al., 2012; Mrazek, Smallwood, Schooler, 2012; Robison & Unsworth, 2015, 2017; Robison & Unsworth, 2018; Robison et al., 2017; Unsworth, Brewer et al., 2012; Unsworth, McMillan et al., 2012; Unsworth & McMillan, 2013, 2014). We measured mental states with thought probes embedded in 8 tasks: reading span, psychomotor vigilance, 1-back, 3-back, low-load visual search, high-load visual search, digit reaction time, and breath counting. The thought probes were designed so participants could report on-task thoughts, task-related interference, external distraction, intentional mind-wandering, unintentional mind-wandering, and mind-blanking.

The tasks were selected based on prior research. Forster and Lavie (2009) used a visual search task with high- and low-perceptual load to examine associated changes in mind-wandering. Levinson et al. (2012) also used this task as well as a breath counting task to examine the relationship between WMC and mind-wandering during relatively low-demand tasks. For those reasons we included the visual search task (both high- and low-load conditions) and the breath counting task. Smallwood et al. (2009) used a digit reaction time task specifically because it placed relatively low demands on attention compared to a slightly more difficult task (1-back). Further, Baird et al. (2011) used this task to demonstrate that high-WMC individuals prospectively mind-wander more often during low-demand tasks. We have also used this task in past experiments when examining mind-wandering during low demand tasks (Robison & Unsworth, 2017). For those reasons we included the digit reaction time task. The 1- and 3-back tasks were included as an attempt to replicate the findings of Rummel and Boywitt (2014). We considered the reading span, psychomotor vigilance, 3-back, and high-load visual search as high-demand tasks, and the 1-back, low-load visual search, breath counting, and digit reaction time as low-demand tasks. By examining multiple cognitive, contextual, and dispositional factors, the present study should provide important information on normal variation in mind-wandering tendencies that occur while performing tasks that vary in attentional demands.

3. Method

We report how we determined our sample size, all measures and manipulations, and all data exclusions, when necessary.

3.1. Participants and procedure

Our target sample size was 300 participants. We collected data across three full academic terms, and we used the end of the third term as our stopping rule for data collection, ending with a final sample of 332 participants. Participants were recruited through the human subjects pool at the University of Oregon and completed the study in exchange for partial course credit. After providing informed consent and completing a brief demographics form, participants completed 10 tasks and a set of computerized questionnaires. Sessions lasted 2 h. After the session, we debriefed participants. The Institutional Review Board at the University of Oregon approved the study protocol, and we treated all participants according to the ethical standards of the American Psychological Association.

3.2. Tasks

Participants completed the 10 tasks in the following order: operation span, symmetry span, reading span, antisaccade, psychomotor vigilance, Stroop, *n*-back, visual search, breath counting, and digit reaction time. After the tasks, participants completed a set of questionnaires, which are described below. Fig. 2 shows a summary of the tasks in chronological order within the session, which cognitive construct they were included to measure, which tasks included thought probes, and which tasks included post-task questionnaires. We attempted to replicate tasks used in prior studies as closely as possible (Baird et al., 2011; Forster & Lavie, 2009; Levinson et al., 2012; Robison & Unsworth, 2018; Robison et al., 2017; Rummel & Boywitt, 2014). In some cases (e.g. *n*-back and visual search), it was necessary to shorten tasks so that they all could be completed during the 2-hr session.

3.3. Working memory capacity

3.3.1. Operation span

In this task, participants solved a series of math operations while trying to remember a set of unrelated letters (Unsworth, Heitz, Schrock, & Engle, 2005). Participants were required to solve a math operation, and after solving the operation, they were presented with a letter for 1 s. Immediately after the letter was presented the next operation was presented. At recall participants were asked to recall letters from the current set in the correct order by clicking on the appropriate letters. For all of the span measures, items were scored correct if the item was recalled correctly from the current list in the correct serial position. Participants were given practice on the operations and letter recall tasks only, as well as two practice lists of the complex, combined task. List length varied randomly from three to seven items, and there were two lists of each length for a total possible score of 50. The score was total number of correctly recalled items in the correct serial position. The task took about 12 min to complete.

3.3.2. Symmetry span

Participants recalled sequences of red squares within a matrix while performing a symmetry-judgment task (Unsworth, Redick, Heitz, Broadway, & Engle, 2009). In the symmetry-judgment task, participants were shown an 8 × 8 matrix with some squares filled in black. Participants decided whether the design was symmetrical about its vertical axis. The pattern was symmetrical half of the time. Immediately after determining whether the pattern was symmetrical, participants were presented with a 4 × 4 matrix with one of the cells filled in red for 650 ms. At recall, participants recalled the sequence of red-square locations by clicking on the cells of an empty matrix. Participants were given practice on the symmetry-judgment and square recall task as well as two practice lists of the combined task. List length varied randomly from two to five items, and there were two lists of each length for a total possible score of 28. We used the same scoring procedure as we used in the operation span task. The task took about 10 min to complete.

3.3.3. Reading span

While trying to remember an unrelated set of letters, participants were required to read a sentence and indicated whether or not it made sense (Unsworth et al., 2009). Half of the sentences made sense, while the other half did not. Nonsense sentences were created by changing one word in an otherwise normal sentence. After participants gave their response, they were presented with a letter for 1 s. At recall, participants were asked to recall letters from the current set in the correct order by clicking on the appropriate letters. Participants were given practice on the sentence judgment task and the letter recall task, as well as two practice lists of the combined task. List length varied randomly from three to seven items, and there were two lists of each length for a total possible score of 50. We used the same scoring procedure as we used in the operation span and symmetry span tasks. The task took about 12 min to complete. Thought probes appeared after 5 trials, one of each set size.

3.4. Attention control

3.4.1. Antisaccade

In this task (Kane, Bleckley, Conway, & Engle, 2001) participants were instructed to stare at a fixation point which was onscreen for a variable amount of time (200 − 2200 ms). A flashing white "=" was then flashed 12.7 cm either to the left or right of fixation for 100 ms. The target stimulus (a B, P, or R) then appeared onscreen for 100 ms, followed by masking stimuli (an H for 50 ms followed by an 8, which remained onscreen until a response was given). The participants' task was to identify the target letter by pressing a key for B, P, or R (the keys 4, 5, 6 on the numberpad) as quickly and accurately as possible. In the prosaccade condition the flashing cue (=) and the target appeared in the same location. In the antisaccade condition the target appeared in the opposite location as the flashing cue. Participants received, in order, 10 practice trials to learn the response mapping, 15 trials of the prosaccade condition, and 50 trials of the antisaccade condition. The dependent variable was proportion correct on the antisaccade trials. The task took about 6 min to complete.

3.4.2. Psychomotor vigilance

The psychomotor vigilance task (Dinges & Powell, 1985) was used as the primary measure of sustained attention. Participants were presented with a row of zeros on screen. After a variable amount of time the zeros began to count up in 17 ms intervals from 0 ms (as determined by the 60 Hz monitor refresh rate). The participants' task was to press the spacebar as quickly as possible once the numbers started counting up. After pressing the space bar the response time was left on screen for 1 s to provide feedback to the participants. Interstimulus intervals were

Task (in order)	Cognitive construct	Thought probes	Demand (high/low)	Motivation question	Alertness question
Operation span	WMC	No	---	No	No
Symmetry span	WMC	No	---	No	No
Reading span	WMC	Yes	High	Yes	Yes
Antisaccade	AC	No	---	No	No
PVT	AC	Yes	High	Yes	Yes
Stroop	AC	No	---	No	No
1-back	---	Yes	Low	No	No
3-back	---	Yes	High	No	No
Visual search (low load)	---	Yes	Low	No	No
Visual search (high load)		Yes	High	No	No
Breath count	---	Yes	Low	Yes	Yes
Digit RT	---	Yes	Low	No	Yes

Fig. 2. Summary of tasks in chronological order.

randomly distributed and ranged from 2 s to 10 s. The entire task lasted for 10 min for each individual (roughly 75 total trials). The dependent variable was the average reaction time for the slowest 20 % of trials (Dinges & Powell, 1985). Thought probes were randomly presented after 20 % of trials. The task took 10 min to complete.

3.4.3. Stroop

Participants were presented with a color word (red, green, or blue) presented in one of three different font colors (red, green, or blue; Stroop, 1935). The participants' task was to indicate the font color via key press (red = 1, green = 2, blue = 3). Participants were told to press the corresponding key as quickly and accurately as possible. Participants received 15 trials of response mapping practice and 6 trials of practice with the real task. Participants then received 135 experimental trials. Of these trials, 67 % were congruent such that the word and the font color matched (i.e., red printed in red) and the other 33 % were incongruent (i.e., red printed in green). The dependent variable was the difference in mean reaction time for accurate incongruent and congruent trials. The task took about 8 min to complete.

3.4.3.1. Visual search. The participants' task was to find an X or N among a set of other items/letters as quickly as possible (Forster & Lavie, 2009). In the high-load blocks, distractor letters were other capitalized letters (H, K, M, W, and Z). An additional distractor letter appeared to the left or right of the target array on some trials, and participants were instructed to ignore this letter. In the low-load blocks, distractor letters were always Os, and target letters were Xs or Ns. Participants received a set of instructions and 3 practice trials for each load condition. During the practice trials, the letter arrays remained on-screen for 10 s or until the participant made a response. During experimental trials, the arrays appeared for 100 ms. Participants completed four blocks of 48 trials load in the following order: low load, high load, high load, low load. Participants used the X and N keys on the keyboard to make their response. If they did not respond within 2900 ms or made an incorrect response, participants heard a short beep through a pair of headphones. Participants wore headphones only for this task. Thought probes appeared at the end of each block (4 total probes). The task took about 15 min to complete.[1]

3.4.3.2. N-back. This task was included to replicate that used by Rummel and Boywitt (2014). The participants' task was to identify if a letter was the same or different as the letter presented either directly before (1-back) or 3 letters prior (3-back). Participants first received instructions and practice on a 0-back task in which they pressed a green key when they saw the letter X and a red key for all other letters. They then received instructions and practice trials for the 1-back task and completed 4 blocks of the 1-back task. Each block began with a buffer set of 3 letters followed by 9 other letters. Letters appeared for 500 ms in blank font centered on a grey screen. Each letter was separated by a 3000-ms blank screen intertrial interval. Each block of trials ended with a thought probe. Participants then received instructions and practice trials for the 3-back task and completed 4 blocks of 3-back. Each block ended with a thought probe. The task took about 15 min to complete.[2]

3.4.3.3. Breath counting. This task was included to replicate that used by Levinson et al. (2012). Participants were instructed to breathe normally and to press the spacebar each time they exhaled. During the breathing task, the screen contained only a black fixation cross centered on a light grey background. Participants were instructed to press the enter key any time they caught their mind wandering during the breathing task. The task consisted of 5 segments lasting 60, 75, 90, 105, and 120 s, presented in a random order for each participant. Thought probes appeared at the end of each segment (5 total probes). To warn participants that the thought probe was imminent, the screen turned blue for 2 s prior to each probe. The task took about 9 min to complete.

3.4.3.4. Digit reaction time. This task was designed to replicate that used by Baird et al. (2011), Smallwood et al. (2009), and Robison and Unsworth (2017). Participants were presented with a string of single digits (1–9). Digits appeared for 1,750 ms. Between each digit was a 1,250-ms fixation screen a black + on centered on a white background.

[1] We would like to thank Dr. Sophie Forster for sending us this task.

[2] We would like to thank Dr. Jan Rummel for sending us this task.

Participants were instructed to indicate whether a target digit was even or odd. Participants did not respond to non-target digits. Targets were presented in green font, whereas non-targets were presented in black font. Targets appeared on 8 % of trials. Participants completed 30 practice trials and 110 experimental trials. Thought probes appeared after 10 randomly selected experimental trials. The task took about 8 min to complete.

3.5. Thought probes

Thought probes were included in the reading span, psychomotor vigilance, *n*-back, visual search, breath counting, and digit reaction time tasks. The response options for the thought probes were based on prior investigations of mind-wandering and other thought content (i.e., external distraction, task-related interference; mind-blanking; Robison et al., 2017; Robison & Unsworth, 2018; Stawarczyk et al., 2011; Unsworth & Robison, 2016; Ward & Wegner, 2013). After a certain percentage of trials (listed for each task above), probes appeared asking participants to report the current contents of their thoughts. Specifically, they saw a screen that said, "Please characterize your current conscious experience." Possible responses were 1) I am totally focused on the current task, 2) I am thinking about my performance on the task, 3) I am distracted by sights/sounds/physical sensations, 4) I am intentionally thinking about things unrelated to the task, 5) I am unintentionally thinking about things unrelated to the task and 6) My mind is blank. Participants responded by pressing the appropriate number on the keyboard. We scored response 1 as on-task, response 2 as task-related interference, response 3 as external distraction, response 4 as intentional mind-wandering, response 5 as unintentional mind-wandering, and response 6 as mind-blanking.

3.6. Subjective state questions

After the reading span, psychomotor vigilance, breath counting, and digit reaction time tasks, participants were asked to rate how difficult they found the task, how motivated they felt to perform well on the task, how interested they were in the task, how alert they felt, and how unpleasant they found the task on 1–6 scales (Robison & Unsworth, 2018). Because of a programming error, the motivation question responses were not recorded for the digit reaction time task. Although we still included measures of task interest, performance, difficulty, and unpleasantness to be consistent with prior work (Robison & Unsworth, 2018) we did not analyze these responses and focused our analyses on self-reported motivation and alertness. In prior analyses task interest and unpleasantness were highly correlated with motivation (Robison & Unsworth, 2018). So to avoid issues of collinearity, we did not include these ratings in the analyses.

3.7. Questionnaires

Participants completed a set of questionnaires to asses various state variables and trait characteristics. The questionnaires were delivered in the following order for all participants: Big Five Inventory, state anxiety, Positive and Negative Affectivity Scale, Boredom Proneness Scale, sleep, trait anxiety, Daydreaming Frequency Scale, Mindful Attention Awareness Scale, and mind-wandering content. In total the questionnaires took about 15 min to complete.

3.7.1. Personality

Participants completed the 44-item Big Five Inventory (BFI; John, Naumann, & Soto, 2008). The BFI contains 8 items to measure extraversion, 9 items to measure agreeableness, 9 items to measure conscientiousness, 8 items to measure neuroticism, and 10 items to measure openness. Participants rated how well each item (e.g., "I see myself as someone who is talkative") described them on a 5-point scale (1 = disagree strongly, 5 = agree strongly).

3.7.2. State/Trait anxiety

Participants completed the 6-item Spielberger State-Trait Anxiety Inventory (STAI; Marteau & Bekker, 1992). Participants rated how well an adjective (e.g., calm) described them. For the state scale, participants were instructed to "click the option the best describes how you feel right now." For the trait scale, participants were instructed to "click the option that best describes how you generally feel." Participants rated each adjective on a 4-point scale (1 = not at all, 4 = very much).

3.7.3. Affect

Participants completed the 20-item Positive and Negative Affectivity Scale (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS contains 10 items to measure positive affect and 10 items to measure negative affect. Participants were given an adjective (e.g., irritable) and asked, "to what extent do you feel this way right now, at the present moment?" Participants responded on a 5-point scale (1 = very slight or not at all, 5 = extremely).

3.7.4. Boredom proneness

The 28-item Boredom Proneness scale (Vodanovich & Kass, 1990) asks participants to rate how a variety of traits (e.g., "It is easy for me to concentrate on my activities) describe them. Participants responded on a 7-point scale (1 = not at all, 7 = extremely well).

3.7.5. Daydreaming frequency

The 12-item Daydreaming Frequency Scale of the Imaginal Process Inventory (Singer & Antrobus, 1970) asks participants to rate how often they experience a variety of daydreaming-related phenomena (e.g., "I recall and think over my daydreams"). The scale is slightly different on each item, but every item has 5 response options.

3.7.6. Trait mindfulness

The 15-item Mindful Attention Awareness Scale (Brown & Ryan, 2003) asks participants to rate how a variety of statements/experiences describe them (e.g., "I find it difficult to stay focused on what's happening in the present"). Participants responded on a 6-point scale (1 = almost always, 6 = almost never).

Sleep. Participants were asked 4 questions regarding their previous night's sleep. The first question asked, "How many hours of sleep did you get last night?" Response options were 0 − 5 h, 5 − 6 h, 6 − 7 h, 7 − 8 h, or 8 + h. The second question asked, "How much does this compare to how much you typically sleep?" Response options were "much less than normal," "slightly less than normal," "about normal," "slightly more than normal," and "much more than normal." The third question asked, "How awake/alert do you feel right now?" Response options were on a 9-point scale (1 = extremely alert, 9 = extremely sleepy/fighting sleep). The fourth question asked, "How awake/alert do you typically feel at this time of day?" The response options were the same as the previous question.

3.7.7. Mind-wandering content

After all other questionnaires, we asked participants, "In the preceding tasks, we asked you about mind-wandering. Please write a brief description of what you were thinking about when you found yourself mind-wandering. Press the ENTER key to submit your response." Participants typed their response into a text box on the screen.

4. Results and discussion

Table 1 shows descriptive statistics for all measures, and Table 2 shows zero-order correlations among all measures. The full zero-order correlation matrix is included as a standard practice for latent variable modeling. Due to computer errors, some participants were missing data files for some tasks. The valid sample sizes for each individual measure are listed in Table 1. Four participants were excluded list-wise because they failed to complete at least 6 tasks. Due to time constraints for

Table 1
Descriptive statistics for all measures.

Measure	N	Mean	SD	Skew	Kurtosis	Reliability
Operation span	330	38.27	8.3	−.1.04	1.24	0.67
Symmetry span	330	19.19	5.11	−0.47	−0.1	0.58
Reading span	331	37.63	8.6	−0.79	0.25	0.72
Antisaccade	332	0.57	0.15	0.09	−0.92	0.78[s]
PVT	331	501	171	2.98	12.29	0.96
Stroop	329	760	235	6.52	75.1	0.83[s]
RSpan: On-task	331	0.36	0.33	0.52	−0.9	
RSpan: TRI	331	0.46	0.31	0.07	−1.01	
RSpan: ED	331	0.01	0.06	4.59	22.17	
RSpan: MW-I	331	0.03	0.11	5.34	35	
RSpan: MW-U	331	0.1	0.18	1.86	3.01	
RSpan: MW sum	331	0.13	0.21	1.82	2.98	
RSpan: Blank	331	0.04	0.14	3.78	15.76	
PVT: On-task	332	0.39	0.31	0.41	−1.07	
PVT: TRI	332	0.24	0.23	1.17	1.08	
PVT: ED	332	0.04	0.09	3.47	16.06	
PVT: MW-I	332	0.05	0.11	3.29	13.42	
PVT: MW-U	332	0.2	0.21	1.3	1.61	
PVT: MW sum	332	0.25	0.23	1	0.41	
PVT: Blank	332	0.09	0.14	2.05	4.25	
1-back: On-task	328	0.33	0.35	0.64	−0.98	
1-back: TRI	328	0.25	0.29	1.17	1.02	
1-back: ED	328	0.04	0.12	3.5	13.76	
1-back: MW-I	328	0.05	0.15	3.94	17.17	
1-back: MW-U	328	0.23	0.29	1.12	0.27	
1-back: MW sum	328	0.28	0.31	0.92	−0.22	
1-back: Blank	328	0.12	0.24	2.36	5.05	
3-back: On-task	328	0.27	0.35	0.98	−0.47	
3-back: TRI	328	0.3	0.33	0.87	−0.3	
3-back: ED	328	0.04	0.12	3.5	13.76	
3-back: MW-I	328	0.05	0.16	3.64	14.19	
3-back: MW-U	328	0.18	0.26	1.52	1.6	
3-back: MW sum	328	0.23	0.29	1.15	0.36	
3-back: Blank	328	0.16	0.29	1.82	2.47	
Low-load: On-task	324	0.35	0.39	0.6	−1.14	
Low-load: TRI	324	0.17	0.29	1.62	1.56	
Low load: ED	324	0.05	0.17	4.04	16.57	
Low-load: MW-I	324	0.07	0.21	2.94	8.27	
Low-load: MW-U	324	0.23	0.32	1.14	0.11	
Low-load: MW sum	324	0.3	0.37	0.79	−0.77	
Low-load: Blank	324	0.14	0.3	1.96	2.59	
High-load: On-task	324	0.35	0.41	0.63	−1.24	
High-load: TRI	324	0.22	0.35	1.26	0.14	
High-load: ED	324	0.06	0.21	3.74	13.25	
High-load: MW-I	324	0.05	0.18	3.66	13.71	
High-load: MW-U	324	0.17	0.3	1.54	1.24	
High-load: MW sum	324	0.23	0.33	1.18	0.15	
High-load: Blank	324	0.15	0.3	1.9	2.31	
Breath: On-task	313	0.29	0.34	0.97	−0.36	
Breath: TRI	313	0.22	0.26	1.18	0.67	
Breath: ED	313	0.06	0.14	3.2	12.67	
Breath: MW-D	313	0.11	0.23	2.21	4.24	
Breath: MW-S	313	0.18	0.25	1.57	1.88	
Breath: MW sum	313	0.29	0.31	0.81	−0.45	
Breath: Blank	313	0.13	0.24	2.04	3.64	
Digit RT: On-task	305	0.52	0.38	−0.05	−1.55	
Digit RT: TRI	305	0.17	0.24	1.73	2.51	
Digit RT: ED	305	0.02	0.06	3.18	11.62	
Digit RT: MW-I	305	0.06	0.15	3.57	13.91	
Digit RT: MW-U	305	0.14	0.2	1.94	4.06	
Digit RT: MW sum	305	0.2	0.26	1.48	1.47	
Digit RT: Blank	305	0.09	0.2	2.57	6.48	
RSpan: Alertness	332	3.95	1.21	−0.58	0.3	
RSpan: Motivation	332	4.3	1.36	−1	0.75	
PVT: Alertness	332	3.31	1.35	0.08	−0.54	
PVT: Motivation	332	3.86	1.41	−0.31	−0.65	
Breath: Alertness	313	2.55	1.31	0.59	−0.32	
Breath: Motivation	313	3.04	1.53	0.23	−0.81	
Digit RT: Alertness	305	2.92	1.31	0.28	−0.36	
Positive affect	291	2.68	0.83	0.09	−0.79	0.9
Negative affect	291	1.56	0.54	1.56	2.91	0.82
State anxiety	291	3.27	0.54	−1.05	1.03	0.8
Openness	290	3.64	0.61	−0.28	0.19	0.77
Conscientiousness	290	3.55	0.62	−0.27	−0.3	0.78
Extraversion	290	3.27	0.89	−0.13	−0.66	0.87
Agreeableness	290	3.96	0.63	−0.52	−0.15	0.77
Neuroticism	290	3	0.79	−0.25	−0.51	0.82
Trait anxiety	291	3.04	0.55	−0.5	−0.3	0.79
Mindfulness	291	3.83	0.7	0.09	−0.11	0.83
Boredom Proneness	291	3.66	0.49	0.07	0	0.72
DDFS	291	3.01	0.9	0.08	−0.57	0.94

Note. SD = standard deviation, α = reliability estimate (Cronbach's alpha). [s]Split-half reliability estimate. PVT = psychomotor vigilance task, RSpan = reading span, Breath = breath counting task, Digit RT = digit reaction time task TRI = task-related interference, ED = external distraction, MW-I = intentional mind-wandering, MW-U = unintentional mind-wandering, MW sum = sum of unintentional and intentional mind-wandering, Blank = mind-blanking. Some measures have large kurtosis values because of floor effects and outliers.

various reasons[3], some participants did not complete all the tasks or the questionnaires. For the correlations and model-fitting, we used all available data after exclusions (pairwise correlations). To estimate standard errors around parameter estimates in the latent variable analyses, we specified a sample size of 320. A data file with all dependent measures and a correlation matrix are available on the Open Science Framework at the unique URL osf.io/zrtf8.

4.1. Experimental analyses

Our first set of analyses examined how mind-wandering changed as a function of task demands. First, we compared the low- and high-perceptual-load blocks of the visual search task. A 2 × 2 repeated-measures analysis of variance (ANOVA) with intention (unintentional, intentional) and load (low, high) as within-subjects factors revealed a main effect of load ($F(1, 323) = 13.33$, $p < .001$, partial $\eta^2 = .04$), such that mind-wandering was more common in the low-load blocks compared to the high-load blocks. The ANOVA also revealed a main effect of intentionality ($F(1, 323) = 59,14$, $p < .001$, partial $\eta^2 = .16$), such that unintentional mind-wandering was more common than intentional mind-wandering. However the ANOVA did not reveal a significant intention x load interaction ($F(1, 323) = 1.59$, $p = .21$, partial $\eta^2 = .005$). So perceptual load seemed to affect unintentional and intentional mind-wandering about equally. Follow-up paired-samples *t*-tests revealed that participants reported significantly fewer instances of both unintentional ($t(323) = 2.68$, $p = .01$) and intentional mind-wandering ($t(323) = 2.30$, $p = .02$) in the high-load blocks.

Next we examined mind-wandering in the 1- and 3-back blocks of the *n*-back task. Again, we submitted responses to a 2 × 2 repeated-measures ANOVA with within-subjects factors of intention (intentional, unintentional) and load (1-back, 3-back). The ANOVA revealed a significant main effect of intention ($F(1, 327) = 103.65$, $p < .001$, partial $\eta^2 = .24$), such that unintentional mind-wandering was more common than intentional mind-wandering. The ANOVA also revealed a main effect of load ($F(1, 327) = 7.81$, $p = .006$, partial $\eta^2 = .02$), such that mind-wandering was more common during the 1-back task compared to the 3-back task. And in this case, the ANOVA also revealed a significant interaction between intention and task ($F(1, 327) = 8.78$, $p = .003$, partial $\eta^2 = .03$). Thus, in the *n*-back task, the changes in mind-wandering were primarily due to changes in unintentional mind-wandering. Participants reported significantly less unintentional mind-wandering during 3-back task compared to 1-back ($t(327) = -3.29$, $p = .001$), but not significantly less intentional mind-wandering ($t(327) = -.67$, $p = .50$). Both ANOVAs show that people tended to mind-wander less

[3] These reasons included late arrival to the session, early departure from the session, and relatively slow completion of the 10 behavioral tasks.

Table 2
Zero-order correlations among all measures.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Operation span	1.00																	
2. Symmetry span	0.42	1.00																
3. Reading span	0.53	0.43	1.00															
4. PVT	−0.17	−0.20	−0.08	1.00														
5. Antisaccade	0.25	0.30	0.30	−0.36	1.00													
6. Stroop	−0.14	−0.21	−0.10	0.33	−0.28	1.00												
7. RSpan: MW-I	−0.16	−0.22	−0.21	0.26	−0.13	0.07	1.00											
8. RSpan: MW-U	−0.06	−0.02	−0.12	0.15	−0.05	0.10	0.06	1.00										
9. RSpan: MW sum	−0.13	−0.12	−0.21	0.25	−0.10	0.12	0.55	0.87	1.00									
10. PVT: MW-I	0.02	0.05	0.04	0.15	0.04	0.02	0.15	0.11	0.16	1.00								
11. PVT: MW-U	−0.04	−0.13	−0.03	0.07	0.03	−0.01	0.01	0.29	0.25	−0.01	1.00							
12. PVT: MW sum	−0.03	−0.10	−0.01	0.14	0.05	0.00	0.08	0.30	0.30	0.47	0.88	1.00						
13. 1-back: MW-I	−0.05	−0.05	−0.11	0.16	−0.09	0.03	0.32	0.00	0.15	0.29	−0.02	0.13	1.00					
14. 1-back: MW-U	−0.01	−0.05	−0.01	0.00	0.05	0.06	−0.02	0.25	0.20	0.05	0.43	0.40	−0.12					
15. 1-back: MW sum	−0.03	−0.08	−0.06	0.08	0.01	0.07	0.13	0.23	0.26	0.18	0.40	0.43	0.36	0.88	1.00			
16. 3-back: MW-I	−0.06	−0.10	−0.08	0.17	−0.03	0.03	0.11	0.07	0.12	0.23	−0.01	0.10	0.42	0.05	0.24	1.00		
17. 3-back: MW-U	−0.05	−0.07	−0.01	0.03	−0.10	0.06	−0.03	0.17	0.13	−0.04	0.35	0.29	−0.05	0.43	0.39	−0.09	1.00	
18. 3-back: MW sum	−0.08	−0.12	−0.04	0.12	−0.11	0.07	0.03	0.19	0.18	0.09	0.31	0.31	0.18	0.42	0.48	0.45	0.85	1.00
19. Low-load: MW-I	−0.03	−0.02	−0.04	0.03	0.02	0.00	0.04	0.12	0.12	0.25	0.05	0.17	0.30	0.08	0.22	0.27	0.06	0.20
20. Low-load: MW-U	0.10	0.01	0.06	−0.07	0.18	−0.04	0.03	0.18	0.17	0.02	0.37	0.33	−0.08	0.29	0.24	−0.07	0.14	0.09
21. Low-load: MW sum	0.07	0.00	0.03	−0.05	0.17	−0.04	0.05	0.23	0.22	0.16	0.36	0.39	0.10	0.31	0.33	0.09	0.16	0.19
22. High-load: MW-I	−0.01	−0.07	−0.10	0.07	−0.06	0.16	0.10	0.18	0.20	0.18	0.09	0.17	0.31	0.05	0.18	0.39	0.06	0.26
23. High-load: MW-U	−0.02	−0.04	−0.04	−0.06	0.03	−0.03	0.02	0.16	0.15	0.14	0.32	0.35	−0.03	0.41	0.37	0.03	0.29	0.28
24. High-load: MW sum	−0.03	−0.07	−0.09	−0.01	0.00	0.05	0.07	0.24	0.24	0.22	0.34	0.40	0.13	0.39	0.43	0.23	0.29	0.38
25. Breath: MW-I	0.04	0.05	0.02	−0.10	0.09	−0.09	0.05	0.07	0.08	0.13	0.07	0.12	0.06	0.15	0.17	0.11	−0.02	0.04
26. Breath: MW-U	0.01	−0.06	0.05	−0.12	0.13	0.01	−0.02	0.15	0.12	0.03	0.29	0.27	−0.03	0.19	0.17	−0.10	0.17	0.10
27. Breath: MW sum	0.04	−0.01	0.06	−0.17	0.18	−0.06	0.02	0.17	0.15	0.12	0.29	0.31	0.02	0.27	0.26	0.00	0.13	0.12
28. Digit RT: MW-I	−0.02	−0.01	−0.01	−0.02	0.08	0.00	−0.05	0.13	0.09	0.24	0.00	0.11	0.21	0.11	0.20	0.17	0.00	0.09
29. Digit RT: MW-U	−0.01	−0.07	0.02	−0.01	0.05	0.20	−0.06	0.21	0.15	−0.01	0.33	0.28	−0.04	0.32	0.29	−0.03	0.28	0.24
30. Digit RT: MW sum	−0.02	−0.07	0.01	−0.02	0.08	0.16	−0.08	0.24	0.17	0.13	0.25	0.28	0.09	0.32	0.34	0.08	0.22	0.24
31. RSpan: Alertness	0.09	0.12	0.22	−0.21	0.13	−0.06	−0.26	−0.22	−0.31	−0.09	−0.11	−0.14	−0.12	−0.17	−0.22	−0.07	−0.13	−0.15
32. RSpan: Motivation	0.01	0.06	0.17	−0.36	0.22	−0.14	−0.23	−0.18	−0.27	−0.12	−0.02	−0.08	−0.13	−0.06	−0.11	−0.07	0.01	−0.03
33. PVT: Alertness	−0.02	0.11	−0.01	−0.19	0.09	0.01	−0.08	−0.08	−0.10	−0.10	−0.24	−0.26	−0.02	−0.16	−0.16	−0.04	−0.17	−0.17
34. PVT: Motivation	−0.06	−0.04	−0.05	−0.37	0.10	−0.11	−0.06	−0.07	−0.09	−0.30	−0.20	−0.32	−0.11	−0.08	−0.13	−0.11	−0.13	−0.18
35. Breath: Alertness	0.04	−0.05	−0.03	−0.03	−0.09	0.03	−0.03	−0.05	−0.06	0.04	−0.08	−0.05	0.03	−0.07	−0.05	−0.09	−0.15	−0.18
36. Breath: Motivation	−0.13	−0.14	−0.14	−0.07	−0.04	0.01	0.07	−0.02	0.01	−0.04	0.03	0.01	−0.05	−0.11	−0.13	−0.09	−0.06	−0.11
37. Digit RT: Alertness	−0.05	0.01	−0.09	−0.07	−0.05	0.07	−0.04	−0.02	−0.04	0.02	−0.01	0.00	−0.07	−0.05	−0.08	−0.05	−0.09	−0.11

(*continued on next page*)

Table 2 (*continued*)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
38. Agreeableness	−0.07	−0.04	−0.05	−0.08	−0.04	−0.08	−0.12	0.00	−0.06	−0.17	0.02	−0.07	−0.14	0.01	−0.05	−0.10	0.02	−0.04
39. Extraversion	−0.03	−0.06	0.02	0.12	0.01	0.04	0.08	0.01	0.05	0.03	−0.09	−0.06	0.11	0.01	0.06	0.02	0.10	0.10
40. Conscientiousness	−0.11	0.02	−0.05	0.06	−0.03	0.01	−0.06	−0.14	−0.14	−0.12	−0.05	−0.11	−0.09	−0.07	−0.10	−0.09	0.02	−0.03
41. Neuroticism	0.04	−0.05	−0.06	−0.02	−0.10	0.03	0.03	0.04	0.05	0.05	0.07	0.09	0.01	0.06	0.06	0.03	−0.02	0.00
42. Openness	0.04	0.09	0.16	0.06	−0.02	−0.08	0.04	0.03	0.04	0.08	0.03	0.06	0.05	0.05	0.07	0.01	0.04	0.04
43. Mindfulness	−0.05	0.04	0.01	0.00	0.13	−0.04	−0.02	0.00	−0.01	−0.05	−0.07	−0.09	−0.08	−0.12	−0.15	0.03	−0.06	−0.04
44. State anxiety	0.06	−0.06	−0.01	0.19	−0.11	0.13	0.17	0.06	0.13	0.16	−0.01	0.07	0.16	0.05	0.11	0.12	−0.02	0.05
45. Trait anxiety	0.05	−0.08	−0.06	0.05	−0.09	0.10	0.10	0.05	0.09	0.10	0.03	0.08	0.04	0.03	0.05	0.02	−0.02	−0.01
46. Positive affect	−0.12	0.05	−0.02	0.01	0.11	−0.03	0.02	−0.09	−0.07	−0.01	−0.16	−0.15	0.04	0.00	0.02	0.00	−0.06	−0.06
47. Negative affect	−0.05	−0.02	−0.12	0.20	−0.10	0.14	0.21	0.14	0.22	0.23	−0.05	0.06	0.18	0.00	0.08	0.14	−0.05	0.03
48. Boredom proneness	0.14	0.11	0.15	0.08	0.00	0.07	0.00	−0.01	−0.01	0.14	−0.02	0.05	0.12	0.09	0.14	0.05	−0.04	−0.01
49. Daydreaming frequency	0.03	0.04	0.10	−0.02	0.02	−0.06	0.01	0.14	0.12	−0.03	0.17	0.14	−0.05	0.15	0.13	0.00	0.10	0.09

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1. Operation span																		
2. Symmetry span																		
3. Reading span																		
4. PVT																		
5. Antisaccade																		
6. Stroop																		
7. RSpan: MW-I																		
8. RSpan: MW-U																		
9. RSpan: MW sum																		
10. PVT: MW-I																		
11. PVT: MW-U																		
12. PVT: MW sum																		
13. 1-back: MW-I																		
14. 1-back: MW-U																		
15. 1-back: MW sum																		
16. 3-back: MW-I																		
17. 3-back: MW-U																		
18. 3-back: MW sum	1.00																	
19. Low-load: MW-I	0.20	1.00																
20. Low-load: MW-U	0.09	−0.10	1.00															
21. Low-load: MW sum	0.19	0.48	0.83	1.00														
22. High-load: MW-I	0.26	0.57	−0.12	0.22	1.00													
23. High-load: MW-U	0.28	0.06	0.37	0.37	−0.10	1.00												
24. High-load: MW sum	0.38	0.36	0.27	0.44	0.44	0.85	1.00											
25. Breath: MW-I	0.04	0.31	0.08	0.24	0.17	0.12	0.20	1.00										
26. Breath: MW-U	0.10	−0.09	0.33	0.24	−0.08	0.26	0.20	−0.19	1.00									
27. Breath: MW sum	0.12	0.16	0.34	0.38	0.06	0.31	0.31	0.58	0.69	1.00								

(*continued on next page*)

Table 2 (*continued*)

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
28. Digit RT: MW-I	0.09	0.28	0.08	0.23	0.16	0.10	0.17	0.24	−0.04	0.14	1.00							
29. Digit RT: MW-U	0.24	0.04	0.32	0.30	0.03	0.27	0.26	−0.02	0.42	0.34	0.06	1.00						
30. Digit RT: MW sum	0.24	0.20	0.29	0.37	0.12	0.27	0.30	0.11	0.31	0.34	0.62	0.81	1.00					
31. RSpan: Alertness	−0.15	−0.02	−0.06	−0.06	−0.04	−0.07	−0.08	0.06	−0.04	0.01	−0.06	−0.10	−0.11	1.00				
32. RSpan: Motivation	−0.03	−0.06	0.02	−0.02	−0.05	−0.04	−0.06	0.03	0.00	0.02	−0.11	−0.10	−0.14	0.43	1.00			
33. PVT: Alertness	−0.17	−0.04	−0.04	−0.06	−0.13	−0.07	−0.13	−0.07	0.02	−0.04	−0.07	−0.15	−0.16	0.39	0.27	1.00		
34. PVT: Motivation	−0.18	−0.13	0.02	−0.06	−0.17	0.01	−0.08	−0.09	0.01	−0.06	−0.07	−0.09	−0.11	0.18	0.30	0.48	1.00	
35. Breath: Alertness	−0.18	−0.02	−0.02	−0.03	−0.05	0.00	−0.02	−0.08	0.00	−0.05	−0.17	−0.10	−0.18	0.26	0.17	0.29	0.14	1.00
36. Breath: Motivation	−0.11	−0.06	−0.07	−0.09	0.00	−0.05	−0.05	−0.08	−0.03	−0.08	−0.19	−0.17	−0.24	0.11	0.22	0.16	0.24	0.39
37. Digit RT: Alertness	−0.11	−0.03	−0.04	−0.05	−0.04	−0.05	−0.06	−0.18	0.05	−0.08	−0.22	−0.17	−0.26	0.26	0.21	0.32	0.17	0.53
38. Agreeableness	−0.04	−0.07	0.04	0.00	−0.06	0.00	−0.03	0.03	−0.04	−0.01	−0.09	−0.04	−0.08	0.09	0.17	0.07	0.07	0.08
39. Extraversion	0.10	0.01	−0.02	−0.01	−0.02	−0.09	−0.09	−0.06	0.10	0.04	0.05	−0.02	0.02	0.06	−0.04	−0.07	−0.09	0.00
40. Conscientious-ness	−0.03	−0.03	0.12	0.09	−0.06	−0.03	−0.05	−0.08	−0.05	−0.09	−0.18	−0.12	−0.20	0.13	0.21	0.16	0.12	0.11
41. Neuroticism	0.00	0.05	−0.02	0.01	0.05	0.07	0.09	−0.03	−0.05	−0.06	0.04	0.04	0.05	−0.08	0.05	−0.11	0.00	0.01
42. Openness	0.04	0.15	0.01	0.09	0.02	−0.01	0.00	0.08	0.02	0.08	0.01	−0.01	0.00	0.05	0.02	0.01	−0.01	−0.03
43. Mindfulness	−0.04	0.04	0.03	0.05	0.06	−0.14	−0.10	0.03	−0.04	−0.01	0.03	−0.14	−0.09	0.10	0.07	0.19	0.12	0.12
44. State anxiety	0.05	0.03	−0.02	0.00	0.14	−0.01	0.06	−0.06	−0.03	−0.07	0.08	0.09	0.12	−0.17	−0.15	−0.14	−0.12	−0.14
45. Trait anxiety	−0.01	0.04	−0.02	0.00	0.06	0.05	0.08	−0.06	0.05	−0.01	−0.04	0.08	0.04	−0.05	0.01	−0.12	−0.08	0.02
46. Positive affect	−0.06	0.03	−0.04	−0.02	−0.05	−0.05	−0.07	−0.01	−0.04	−0.04	−0.14	−0.21	−0.25	0.21	0.16	0.31	0.18	0.22
47. Negative affect	0.03	0.04	−0.05	−0.02	0.18	−0.07	0.02	−0.13	−0.01	−0.11	−0.06	0.04	−0.01	−0.07	−0.11	−0.09	−0.08	0.00
48. Boredom proneness	−0.01	−0.01	−0.07	−0.06	−0.01	0.04	0.03	−0.02	0.03	0.01	0.04	−0.01	0.02	−0.06	−0.13	0.01	−0.04	−0.11
49. Daydreaming frequency	0.09	0.07	0.08	0.11	0.06	0.20	0.21	0.10	0.08	0.14	0.04	0.15	0.14	−0.03	−0.01	−0.08	0.02	−0.12

	36	37	38	39	40	41	42	43	44	45	46	47	48	49
1. Operation span														
2. Symmetry span														
3. Reading span														
4. PVT														
5. Antisaccade														
6. Stroop														
7. RSpan: MW-I														
8. RSpan: MW-U														
9. RSpan: MW sum														
10. PVT: MW-I														
11. PVT: MW-U														
12. PVT: MW sum														
13. 1-back: MW-I														
14. 1-back: MW-U														
15. 1-back: MW sum														
16. 3-back: MW-I														
17. 3-back: MW-U														

(*continued on next page*)

Table 2 (*continued*)

	36	37	38	39	40	41	42	43	44	45	46	47	48	49
18. 3-back: MW sum														
19. Low-load: MW-I														
20. Low-load: MW-U														
21. Low-load: MW sum														
22. High-load: MW-I														
23. High-load: MW-U														
24. High-load: MW sum														
25. Breath: MW-I														
26. Breath: MW-U														
27. Breath: MW sum														
28. Digit RT: MW-I														
29. Digit RT: MW-U														
30. Digit RT: MW sum														
31. RSpan: Alertness														
32. RSpan: Motivation														
33. PVT: Alertness														
34. PVT: Motivation														
35. Breath: Alertness														
36. Breath: Motivation	1.00													
37. Digit RT: Alertness	0.29	1.00												
38. Agreeableness	0.13	0.14	1.00											
39. Extraversion	−0.01	−0.10	0.01	1.00										
40. Conscientious-ness	0.16	0.15	0.36	0.03	1.00									
41. Neuroticism	0.02	−0.09	−0.22	−0.23	−0.23	1.00								
42. Openness	0.00	−0.03	0.05	0.13	0.03	−0.01	1.00							
43. Mindfulness	0.00	0.17	0.19	0.12	0.36	−0.35	−0.03	1.00						
44. State anxiety	−0.12	−0.23	−0.27	−0.13	−0.21	0.40	−0.01	−0.28	1.00					
45. Trait anxiety	−0.02	−0.14	−0.28	−0.15	−0.19	0.67	−0.05	−0.35	0.62	1.00				
46. Positive affect	0.11	0.28	0.23	0.16	0.29	−0.23	0.10	0.16	−0.25	−0.27	1.00			
47. Negative affect	−0.02	−0.06	−0.25	0.04	−0.18	0.32	−0.01	−0.24	0.62	0.46	0.11	1.00		
48. Boredom proneness	−0.05	−0.07	−0.29	−0.03	−0.21	0.18	0.30	−0.31	0.27	0.22	0.05	0.34	1.00	
49. Daydreaming frequency	0.00	−0.10	−0.14	−0.14	−0.26	0.26	0.28	−0.39	0.21	0.21	−0.16	0.12	0.20	1.00

Note: MW-I = intentional mind-wandering; MW-U = unintentional mind-wandering; MW sum = sum of intentional and unintentional mind-wandering; PVT = psychomotor vigilance task; Breath = breath counting task; RSpan = reading span. *correlation significant at $p < .05$.

Table 3
Factor loadings for the cognitive and contextual latent variables.

Measure	WMC	AC	Latent variable Motivation	Alertness	Mood
Operation span	0.58*				
Symmetry span	0.75*				
Reading span	0.56*				
Antisaccade		0.54*			
PVT		−0.65*			
Stroop		−0.25*			
RSpan: Motivation			0.57*		
PVT: Motivation			0.50*		
Breath: Motivation			0.42*		
RSpan: Alertness				0.47*	
PVT: Alertness				0.55*	
Breath: Alertness				0.62*	
Digit: Alertness				0.70*	
State anxiety					0.80*
Negative affect					0.74*
Positive affect					−0.37*

Note. WMC = working memory capacity, AC = attention control, PVT = psychomotor vigilance task, RSpan = reading span, Breath = breath counting task, Digit = digit reaction time task. *loading significant at $p < .05$.

when the demands of the task were higher. In the *n*-back task this seemed driven by a decrease in *unintentional* mind-wandering. In the visual search task, intentional and unintentional mind-wandering decreased to a similar degree from low- to high-demand blocks.

4.2. Cognitive, contextual, and dispositional relations

Our next set of analyses focused on individual differences in mind-wandering tendencies. [4] To examine such relationships, we used latent variable analyses. We used several fit indices to assess model fit: the chi-square (χ^2) test, Comparative Fit Index (CFI), the Non-Normed Fit Index (NNFI), Root Mean Squared Error of Approximation (RMSEA), and Standardized Root Mean Residual (SRMR). Typically, χ^2 tests with *p*-values greater than .05 are considered acceptable, but models with many degrees of freedom often reveal significant ($p < .05$) χ^2 values. χ^2/model degrees of freedom should be as low as possible, but ratios between 2 and 3 typically indicate acceptable fit (Schermelleh-Engel, Moosbrugger, & Müller, 2003). CFIs and NNFIs greater than .90 and RMSEAs and SRMRs below .10 typically indicate adequate model fit (Kline, 2011).[5]

Our first step was to perform a confirmatory factor analysis on the cognitive (WMC, AC) contextual (motivation, alertness, mood, sleep), and dispositional (personality, daydreaming frequency, mindfulness) variables. In this model ("Cog Context Disp" in Table 5), we allowed operation span, symmetry span, and reading span scores to load onto a WMC latent variable. Scores on the antisaccade, Stroop, and PVT loaded onto an AC latent variable. Self-reports of motivation (obtained upon completion of reading span, PVT, and breath counting tasks) loaded onto a motivation latent variable. Self-reports of alertness (obtained following reading span, PVT, breath counting, and digit RT tasks) loaded onto an alertness latent variable. Positive affect, negative affect, and state anxiety to load onto a negative mood latent variable. Scores from the Big Five Inventory measuring each of the five personality traits, scores on the Daydreaming Frequency Scale of the Imaginal Process Inventory, trait mindfulness scores from the Mindful Attention and Awareness Scale, scores on the Boredom Proneness Scale, and responses to the first question regarding previous night's sleep ("How many hours of sleep did you get last night?") were all included as manifest variables. The error variances from operation span and reading span were allowed to correlate, as these tasks use identical memoranda and thus share some method variance. Because trait anxiety was so highly correlated with neuroticism and state anxiety, it caused problems with model fitting and was not included. Error variances between motivation and alertness ratings from the same task (e.g., motivation and alertness ratings after reading span) were also allowed to correlate. Finally, the error variances for positive and negative affect were allowed to correlate since these measures came from the same scale. All variables were allowed to correlate. The factor loadings for the cognitive and contextual latent variables are listed in Table 3, and the correlations among all variables in the model are listed in Table 4. The model fit acceptably ($\chi^2(188) = 410.67$, $\chi^2 / \text{df} = 2.18$, CFI = .91, NNFI = .85, RMSEA = .06, SRMR = .06; see Table 5).

The cognitive, contextual, and dispositional confirmatory factor analysis (CFA) yielded several expected and interesting relationships. As expected, WMC and AC were significantly correlated, although not isomorphic. Highlighting their distinction is the fact that although WMC was uncorrelated with motivation, AC and motivation positively correlated. WMC weakly but significantly correlated with openness, and surprisingly, WMC also positively correlated with boredom proneness. AC also appeared sensitive to differences in mood, as participants who reported being in a more negative mood showed tended to show worse AC. Participants who rated themselves as more agreeable and conscientious tended to report having higher motivation, whereas participants who reported being in a negative mood and high in boredom proneness tended to report being less motivated. Motivation and alertness positively correlated. Further, people who reported getting more sleep the prior night reported having higher alertness. But this correlation was rather weak, indicating these two measures are not providing redundant information. Finally, the personality measurements correlated in ways that would be theoretically consistent. For example, participants who reported being high in mindfulness also reported being high in conscientiousness and agreeableness and low in neuroticism. Therefore, we had confidence moving forward that these measures were tapping into the psychological constructs we intended to measure.

First, we examined whether individual differences in MW are best conceptualized as one general factor, or whether there are differences in terms of task demands. To examine this we specified two models – one in which mind-wandering from all tasks loaded onto a single factor and another in which mind-wandering from high- and low-demand tasks loaded onto separate factors. The cognitive, contextual, and dispositional factors were specified in the same way as in previous models. We also allowed the error variances from 1-back and 3-back mind-wandering and low-load and high-load mind-wandering to correlate. Both models fit the data adequately (see Table 5), but the two-factor model fit significantly better. Factor loadings for this model are listed in Table 6, and correlations between the mind-wandering factors and the cognitive, contextual, and dispositional factors are listed in Table 7. Although MW-High and MW-Low were highly correlated ($r = .90$), the model-fit comparison suggests that high- and low-demand task contexts do produce qualitatively different patterns of inter-individual variance in MW.

Several dissociations in the correlations are worth noting. WMC and AC only significantly (and negatively) correlated with mind-wandering in the high-demand tasks. Motivation, alertness, and daydreaming frequency significantly correlated with mind-wandering in both the high- and low-demand tasks. The correlation between mood and mind-

[4] In the Supplementary Materials, we have included models that account for all task-unrelated thoughts (external distraction, intentional mind-wandering, unintentional mind-wandering, and mind-blanking).

[5] As will be seen, the estimates for CFI and NNFI in our models are often below traditional thresholds for acceptance. However, incremental fit indices (e.g., CFI and NNFI) are usually only informative when the RMSEA of a null model is above 0.158 (http://davidakenny.net/cm/fit.htm). In all models we test, the RMSEA of the null model is below this value. Therefore, CFI and NNFI may not be very informative in the present study. But for completeness we report all five fit statistics.

Table 4
Correlations among cognitive, contextual, and dispositional factors.

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Working memory capacity	—												
2. Attention control	0.54*	—											
3. Motivation	−0.1	0.62*	—										
4. Alertness	0.05	0.14	0.61*	—									
5. *Agreeableness*	−0.08	0.05	0.26*	0.16*	—								
6. *Extraversion*	−0.05	−0.12	−0.12	−0.07	0.01	—							
7. *Conscientiousness*	−0.03	−0.11	0.31*	0.23*	0.36*	0.03	—						
8. *Neuroticism*	−0.05	−0.04	0.06	−0.1	−0.22*	−0.23*	−0.23*	—					
9. *Openness*	0.14*	−0.05	0	−0.01	0.05	0.13*	0.03	−0.01	—				
10. *Mindfulness*	0.01	0.05	0.12	0.24*	0.19*	0.12*	0.36*	−0.35*	−0.03	—			
11. Mood	−0.06	−0.30*	−0.33*	−0.35*	−0.38*	−0.09	−0.32*	0.49*	−0.05	−0.35*	—		
12. *Boredom proneness*	0.19*	−0.06	−0.17*	−0.11	−0.29*	−0.03	−0.32*	0.28*	0.30*	−0.30*	0.33*	—	
13. *Daydreaming frequency*	0.07	0.05	0	−0.15*	−0.14*	−0.14*	−0.26*	0.26*	0.28*	−0.39*	0.24*	0.20*	—
14. *Sleep*	−0.07	0	0.02	0.14*	−0.06	0	0.13*	−0.07	−0.07	0.09	−0.20*	−0.13*	−0.08

Note. Italicized measures were included in the model as manifest variables. *correlation is significant at $p < .05$.

Table 5
Model fit statistics.

Model	χ^2 (df)	χ^2/df	CFI	NNFI	RMSEA	SRMR	$\Delta\ \chi^2$ (df)	*p*
Cog Context Disp	410.67 (188)	2.18	0.91	0.85	0.06	0.06		
One-factor MW	836.62 (393)	2.13	0.88	0.84	0.06	0.07		
Two-factor MW	799.56 (377)	2.12	0.89	0.84	0.06	0.06	37.06 (16)	0.002
Bi-factor MW	771.71 (374)	2.06	0.89	0.85	0.05	0.06		
Intent/Unint MW	1244.90 (626)	1.98	0.81	0.86	0.06	0.06		
Intent/Unint Bifac	1140.28 (620)	1.84	0.82	0.77	0.06	0.06		

Note. df = model degrees of freedom, CFI = comparative fit index, NNFI = non-normed fit index, RMSEA = root mean squared error of approximation, SRMR = standardized root mean residual.

wandering was only significant for the high-demand contexts. This was also the case for conscientiousness. MW did not significantly correlate with boredom proneness or previous night's sleep. Collectively, it does appear that the relationship between cognitive abilities and MW is moderated by task-demands, which is consistent with the cognitive-flexibility and context-regulation hypotheses. But the relationships between MW and contextual and some of the dispositional factors were less affected by changes in task demands.

Despite the finding that individual differences in MW were highly correlated in high- and low-demand task contexts, we wanted to further examine whether there is anything unique about low-demand task contexts and their relationships with the cognitive, contextual, and dispositional factors. In particular, while specifying the models, it occurred to us that the lack of a relation between mind-wandering in low demand tasks and cognitive abilities could be due to suppression. Specifically, both the context-regulation and cognitive flexibility hypotheses make the prediction that cognitive abilities should be negatively related to mind-wandering in high demand tasks, but positively related in low demand tasks. Furthermore, implicit in these hypotheses is the assumption that mind-wandering in high and low demand tasks should be positively correlated given that individuals who mind-wander in one context likely mind-wander in the other context. Thus, the relation between mind-wandering in low demand tasks and cognitive abilities could be obscured by the strong relation between mind-wandering in high and low demand tasks. If this is the case, then a partial correlation analysis where variance from mind-wandering in high demand tasks is controlled should result in a boost of the correlation between mind-wandering in low demand tasks and cognitive abilities (i.e., an instance of classical suppression; Horst, 1941; Paulhus, Robins, Trzesniewski, & Tracy, 2004; Watson, Clark, Chmielewski, & Kotov, 2013). Indeed, this was the case for both WMC and AC. When controlling for mind-wandering in high demand tasks, the correlation between WMC and mind-wandering in low demand tasks was positive and significant ($r = .40$, $p < .001$) as was the correlation between AC and mind-wandering in low demand tasks ($r = .86$, $p < .001$). Thus, these preliminary analyses suggest that there is a positive relation between cognitive abilities and mind-wandering in low demand tasks, but this relation may have been obscured. Another more general way of examining this notion is to specify a bi-factor model in which separate factors are specified for general mind-wandering tendencies in both high and low demand tasks and more specific tendencies related to mind-wandering in low demand tasks. That is, as noted by Watson et al. (2013), "suppressor analyses separate these two components and, therefore, allow them to be observed, whereas they are masked in the zero-order correlations" (p. 937).

To examine this potential effect, we specified a bi-factor model in which mind-wandering from all tasks was allowed to load onto one mind-wandering factor (MW-common), and mind-wandering from low-demand tasks was allowed to load onto a residual factor (MW-low R). This model fit the data significantly better than the two-factor model (see Table 5). The loadings for this model are listed in Table 6, and the interactor correlations are listed in Table 7.

Several relationships in the bi-factor model are worth noting. First, while WMC and AC were both significantly negatively correlated with the common MW factor, they were significantly positively correlated with the low-demand MW residual factor. So in general, the tendency to experience MW negatively correlated with cognitive abilities. But after controlling for such general tendencies, high-ability individuals actually tended to show *more* MW in specifically low-demand contexts, consistent with suppression effects. This finding is consistent with the context-regulation and cognitive flexibility hypotheses, both of which argue that high-ability individuals are better at adjusting their attention-regulation settings to meet the external demands of the situation, and thus may potentially allow MW to occur when their attention is not fully demanded by some task. Furthermore, the low-demand MW residual factor positively correlated with mindfulness, and negatively

Table 6
Factor loadings for MW models.

	Model			
	Two-factor		Bi-factor	
Measure	MW-High	MW-Low	MW-common	MW-low R
Reading span	0.45*		0.44*	
PVT	0.65*		0.65*	
3-back	0.44*		0.47*	
High-load	0.63*		0.63*	
1-back		0.60*	0.64*	0.03
Low-load		0.62*	0.53*	0.53*
Breath count		0.56*	0.44*	0.38*
Digit RT		0.56*	0.52*	0.19*

Note. MW-High = shared variance in mind-wandering during high-demand tasks, MW-Low = shared variance in mind-wandering during low-demand tasks, MW-common = shared variance in mind-wandering from all tasks, MW-low R = residual variance in mind-wandering unique to low-demand tasks, PVT = psychomotor vigilance task. *factor loading significant at $p < .05$.

correlated with mood, neuroticism, and boredom proneness consistent with suppression effects.

As a final step, we further broke down mind-wandering by intentionality and task context. However, before discussing these models it should be noted that as seen in Table 1, rates of intentional mind-wandering were very low, resulting in skewed and leptokurtic distributions and thus may have problematic psychometric properties. As such, the results from these models should be interpreted very cautiously. Because the separation of intentional and unintentional mind-wandering was a major goal of the present study, for completeness we report the results of this model-fitting procedure. In this model, we allowed reports of intentional mind-wandering and unintentional mind-wandering from the high- and low-demand tasks to load onto four separate factors. We allowed these factors to correlate with the cognitive, contextual, and dispositional factors as specified in previous models. Model fit statistics are listed in Table 5, factor loadings are listed in Table 8, and correlations among these factors with the cognitive, contextual, and dispositional factors are listed in Table 9. Intentional and unintentional mind-wandering did not significant correlate in either the high- ($r = .11$) or low-demand ($r = .14$) tasks. Intentional mind-wandering in low- and high-demand tasks highly correlated ($r = .85$), as did unintentional mind-wandering in low- and high-demand tasks ($r = .95$).

Table 7
Correlations among factors in the MW models.

	Model			
	Two-factor		Bi-factor	
Factor	MW-High	MW-Low	MW-common	MW-low R
Working memory capacity	−0.21*	−0.04	−0.20*	0.29*
Attention control	−0.20*	0.16	−0.20*	0.75*
Motivation	−0.31*	−0.29*	−0.34*	0.09
Alertness	−0.29*	−0.26*	−0.31*	0.09
Mood	0.20*	0.07	0.21*	−0.31*
Sleep	−0.11	−0.06	−0.11	−0.1
Agreeableness	−0.09	−0.06	−0.09	0.06
Extraversion	−0.04	0.03	−0.02	0.08
Conscientiousness	−0.15*	−0.12	−0.17*	0.11
Neuroticism	0.11	0.03	0.12	−0.20*
Openness	0.06	0.1	0.06	0.12
Mindfulness	−0.12	−0.08	−0.16*	0.20*
Boredom proneness	0.04	0.04	0.09	−0.16*
Daydreaming frequency	0.27*	0.22*	0.25*	0.01

Note. MW-High = shared variance in mind-wandering from high-demand tasks, MW-Low = shared variance in mind-wandering in low-demand tasks, MW-common = mind-wandering from all tasks, MW-low R = residual variance in mind-wandering in low-demand tasks. *correlation significant at $p < .05$.

Table 8
Factor loadings for intentional and unintentional MW model.

Measure	Intent-High	Unint-High	Intent-Low	Unint-Low
Reading span: MW-I	0.31*			
PVT: MW-I	0.49*			
3-back: MW-I	0.46*			
High-load: MW-I	0.53*			
Reading span: MW-U		0.40*		
PVT: MW-U		0.66*		
3-back: MW-U		0.44*		
High-load: MW-U		0.54*		
1-back: MW-I			0.49*	
Low-load: MW-I			0.62*	
Breath count: MW-I			0.40*	
Digit RT: MW-I			0.46*	
1-back: MW-U				0.57*
Low-load: MW-U				0.55*
Breath count: MW-U				0.53*
Digit RT: MW-U				0.58*

Note. Intent-High = intentional mind-wandering in high-demand tasks, Unint-High = unintentional mind-wandering in high-demand tasks, Intent-Low = intentional mind-wandering in low-demand tasks, Unint-Low = unintentional mind-wandering in low-demand tasks. MW-I = intentional mind-wandering, MW-U = unintentional mind-wandering. *factor loading significant at $p < .05$.

Several distinctions between intentional and intentional mind-wandering are worth noting. First, AC negatively correlated with intentional mind-wandering, but not unintentional mind-wandering, and only in the high-demand tasks. Second, motivation correlated more strongly with intentional mind-wandering than with unintentional mind-wandering, and this was consistent across task contexts. Mood only significantly correlated with intentional mind-wandering, and only in the high-demand tasks. Agreeableness only significantly correlated with intentional mind-wandering, similar to conscientiousness, and this was consistent across task contexts. Openness positively correlated with intentional mind-wandering, but only in the low-demand tasks. Mindfulness correlated with unintentional mind-wandering, and only in the high-demand tasks, and daydreaming frequency only correlated with unintentional mind-wandering, but consistently across task

Table 9
Correlations among factors in intentional and unintentional MW model.

Factor	Intent-High	Unint-High	Intent-Low	Unintent-Low
Working memory capacity	−0.19*	−0.17*	−0.06	−0.04
Attention control	−0.35*	−0.09	−0.04	0.17
Motivation	−0.42*	−0.17	−0.38*	−0.16
Alertness	−0.23*	−0.26*	−0.20*	−0.19*
Mood	0.41*	0.04	0.1	0.07
Sleep	−0.07	−0.09	0	−0.08
Agreeableness	−0.22*	0.01	−0.16*	−0.02
Extraversion	0.04	−0.07	0.08	0.02
Conscientiousness	−0.20*	−0.09	−0.17*	−0.06
Neuroticism	0.08	0.08	0.05	0.02
Openness	0.06	0.04	0.17*	0.03
Mindfulness	0.03	−0.14*	0.01	0.02
Boredom proneness	0.1	−0.01	0.07	0.02
Daydreaming frequency	0.04	0.29*	0.06	0.21*

Note. Intent-High = intentional mind-wandering in high-demand tasks, Unint-High = unintentional mind-wandering in high-demand tasks, Intent-Low = intentional mind-wandering in low-demand tasks, Unint-Low = unintentional mind-wandering in low-demand tasks. *correlation significant at $p < .05$.

Table 10
Factor loadings for intentional and unintentional MW bi-factor model.

Measure	Int-Common	Int-Low R	Unint-Common	Unint- Low R
Reading span: MW-I	0.34*			
PVT: MW-I	0.50*			
3-back: MW-I	0.51*			
High-load: MW-I	0.49*			
1-back: MW-I	0.63*	−0.12		
Low-load: MW-I	0.49*	0.28*		
Breath count: MW-I	0.23*	0.57*		
Digit RT: MW-I	0.36*	0.31*		
Reading span: MW-U			0.39*	
PVT: MW-U			0.65*	
3-back: MW-U			0.48*	
High-load: MW-U			0.56*	
1-back: MW-U			0.66*	−0.1
Low-load: MW-U			0.48*	0.15*
Breath count: MW-U			0.43*	0.86*
Digit RT: MW-U			0.53*	0.22*

Note. Int-common = shared variance in intentional mind-wandering across all tasks, Int-low R = residual variance in intentional mind-wandering unique to low-demand tasks, Unint-Common = shared variance in unintentional mind-wandering across all tasks, Int-Low R = variance in unintentional mind-wandering unique to low-demand tasks. *factor loading significant at $p < .05$.

Table 11
Correlations among factors in intentional and unintentional MW bi-factor model.

Factor	Int-Common	Int-Low R	Unint-Common	Unint-Low R
Working memory capacity	−0.17	0.16	−0.12	0.02
Attention control	−0.33*	0.45*	−0.02	0.23*
Motivation	−0.39*	−0.1	−0.18*	0.1
Alertness	−0.17*	−0.18*	−0.26*	0.16*
Mood	0.34*	−0.34*	0.06	−0.03
Sleep	−0.05	0.06	−0.09	−0.01
Agreeableness	−.23*	0.1	0.01	−0.05
Extraversion	0.1	−0.11	−0.05	0.14*
Conscientiousness	−0.17*	−0.07	−0.08	−0.01
Neuroticism	0.06	−0.03	0.08	−0.1
Openness	0.09	0.13	0.04	0.01
Mindfulness	−0.03	0.1	−0.15*	0.03
Boredom proneness	0.13	−0.09	0.02	0.01
Daydreaming frequency	−0.01	0.17*	0.27*	−0.04

Note. Int-Common = Int-common = shared variance in intentional mind-wandering across all tasks, Int-low R = residual variance in intentional mind-wandering unique to low-demand tasks, Unint-Common = shared variance in unintentional mind-wandering across all tasks, Int-Low R = variance in unintentional mind-wandering unique to low-demand tasks. *correlation significant at $p < .05$.

contexts.

Similar to the MW models above, we also specified a model in which intentional and unintentional mind-wandering from all tasks were allowed to load onto two factors representing shared variance across all tasks, and intentional and unintentional mind-wandering from the low-demand tasks were allowed to load onto separate residual factors. Fit statistics for this model are listed in Table 5, factor loadings are listed in Table 10, and correlations among factors are listed in Table 11.

A few relationships in this model are worth noting. First, AC negatively correlated with the Int-Common latent variable. Thus in general, people with relatively good AC abilities reported fewer instances of intentional mind-wandering. However, after extracting the common variance across all tasks, the residual variance in intentional and unintentional mind-wandering in low-demand tasks positively correlated with AC. Thus, there is something unique about the low-demand task situations in that people with high AC tend to mind-wander more in these situations, even though they still tend to mind-wander less overall. Similarly, negative mood correlated with more intentional mind-wandering overall. But for the residual variance in low-demand task situations, it negatively correlated. Finally, while daydreaming frequency positively correlated with the common variance in unintentional mind-wandering, it also positively correlated with the residual variance in intentional mind-wandering in low-demand tasks. Thus, people who are prone to daydreaming tend to unintentionally mind-wander more overall. But in particularly low-demand situations, they also tend to intentionally mind-wander. In general, these distinctions highlight that several correlates of mind-wandering tendencies are sensitive to changes in task demands. Further, intentional and unintentional mind-wandering tend to correlate differently with several cognitive, contextual, and dispositional variables. Although, again given the rarity of intentional mind-wandering reports, these results must be interpreted cautiously.

5. General discussion

In the present study, we examined a multi-faceted approach to understanding individual differences in mind-wandering. By measuring mind-wandering across tasks that differed in their attentional demands, we were able to examine how the relationships among cognitive, contextual, dispositional factors, and tendencies to mind-wander changed or remained stable across task contexts. Further, in several cases, intentional and unintentional mind-wandering showed substantially different relationships with several factors. The findings, which we address and explain below, highlight the importance of taking such a multi-faceted approach to mind-wandering. Further, the results highlight the importance of distinguishing intentional and unintentional mind-wandering. In the subsequent sections, we address the most important findings and explain their implications for theories of mind-wandering – specifically the control failure x concerns, context-regulation, and cognitive flexibility hypotheses.

Our first set of findings regards the task-dependence of mind-wandering. Prior work has shown that when the attentional demands of a task are low, people tend to mind-wander more often (Forster & Lavie, 2009; Rummel & Boywitt, 2014; Seli, Risko and Smilek et al., 2016a; Seli, Risko and Smilek et al., 2016b; Smallwood et al., 2009). We partially replicated this finding in the visual search and *n*-back tasks. Specifically, we observed fewer reports of mind-wandering when tasks made more demands on attention. Whereas some prior work has shown that increasing task demands selectively reduces intentional mind-wandering (Forster & Lavie, 2009; Seli et al., 2016a, 2016b; but see Unsworth & Robison, 2018), we did not replicate that pattern. In the *n*-back task, unintentional mind-wandering decreased more than intentional mind-wandering. We should also note that because the intentional mind-wandering reports were zero-inflated (i.e., most participants did not report intentional mind-wandering), the distributions were skewed.

While we specifically selected high- and low-demand tasks based on prior work, some have argued that there is a curvilinear relationship between task-demands and mind-wandering (Xu & Metcalfe, 2016). In other words, mind-wandering will occur least often when task demands are moderate. Xu and Metcalfe (2016) measured mind-wandering during the study of easy, moderately difficult (region of proximal learning), and difficult Spanish-English word pairs. They observed the lowest rates of mind-wandering in the region of proximal learning. In theory, at extremely low levels of attentional demand, participants will be bored and able to simultaneously complete the task and mind-wander frequently. At extremely high levels of attentional demand, participants will be overwhelmed and mind-wander because they either cannot fully engage with the task or because they choose not to put forth the effort required. In the present study, we could not address the possibility of a curvilinear relationship. Future research should address how Xu and Metcalfe's (2016) findings extend to other tasks and contexts, as well as how shifts in mind-wandering are due to changes in intentional mind-wandering, unintentional mind-wandering, or both.

The second crucial set of findings concerns the relationships between cognitive ability, measured here by a combination of working memory and attention control tasks, and mind-wandering tendencies. The control failure x concerns, context-regulation, and cognitive-flexibility hypotheses all make the prediction that in high-demand task contexts, individuals with superior cognitive abilities will mind-wander less often. This prediction was supported by the finding that both WMC and AC negatively correlated with mind-wandering in high-demand tasks (two-factor MW model). Under low-demand task conditions, the correlations between WMC and AC and mind-wandering significantly changed. Neither WMC nor AC significantly correlated with mind-wandering in the low-demand tasks. We further investigated this relationship with a bi-factor model (bi-factor MW model). This model revealed that people with better WMC and AC mind-wandered less overall. But interestingly, both WMC and AC *positively* correlated with the residual variance in mind-wandering that was unique to low-demand task contexts. This finding is consistent with prior theorizing that high-ability individuals adaptively adjust the occurrence of mind-wandering and other task-unrelated thoughts based on the demands of the external task situation (e.g., context-regulation and cognitive flexibility hypotheses; Rummel & Boywitt, 2014; Smallwood & Andrews-Hanna, 2013; Y. Ju & Lien, 2018; Y-J. Ju & Lien, 2018). When specifying separate latent variables for intentional and unintentional mind-wandering, AC positively correlated with the residual variance in both intentional and unintentional mind-wandering unique to low-demand task contexts. This finding suggests that at least some of the change in mind-wandering from high- to low-demand tasks among high-ability individuals could be an intentional decision. However, as noted earlier, the rarity of intentional mind-wandering caused non-normality in its distribution, and thus this finding must be interpreted cautiously.

We should note that we have not previously observed a marked reduction in the correlation between WMC and mind-wandering in low-demand tasks (Robison & Unsworth, 2017). But a few differences are worth noting. In Robison and Unsworth (2017), we collapsed across all task-unrelated thought categories provided (current, past-, future-, and other-related mind-wandering). These options did not account for external distraction and mind-blanking. So the shared variance in mind-wandering across the two tasks used to measure the construct in that study is most similar to the "common" mind-wandering factor in the bi-factor models, both of which negatively correlated with WMC. It is still not entirely clear why the latent correlation between WMC and mind-wandering in low-demand tasks is significantly negative in some studies (Meier, 2018; Robison & Unsworth, 2017), whereas it was closer to zero in the present study. However, as noted previously, it is possible that the relation between cognitive abilities and mind-wandering in low demand tasks was obscured by the shared variance between mind-wandering in high and low demand tasks. That is, once the high-demand mind-wandering variance is controlled for, the correlation between mind-wandering in low demand tasks and cognitive abilities may be observed (i.e., classical suppression). Consistent with suppression effects we found that the correlation between mind-wandering in low demand tasks and cognitive abilities (WMC and AC) was positive once mind-wandering in high demand tasks was partialed out. A similar finding is also observed in the data of Rummel and Boywitt (2014) who found that WMC was negatively correlated with mind-wandering rates in a 3-back task ($r = -.19$), but were positively correlated with mind-wandering rates in a 1-back task ($r = .18$). Mind-wandering in the 3-back and 1-back tasks were positively correlated ($r = .49$). Doing a partial correlation analysis on their data where mind-wandering rates in the 3-back task are partialed out of the relation between WMC and mind-wandering rates in the 1-back reveals a stronger positive correlation ($r = .32$, $p < .001$). Thus, consistent with the current research, this suggests that the relation between mind-wandering in low demand tasks and cognitive abilities is likely masked by shared variance with mind-wandering in high demand tasks. Once this shared variance is accounted for, the relation with cognitive abilities can be better observed.

Collectively, the results are largely consistent with the context-regulation, cognitive flexibility, and control failure x concerns hypotheses, yet in different ways. The control failure x concerns hypotheses argues that instances of mind-wandering represent a failure of the executive control system to suppress irrelevant internal thoughts from reaching consciousness and thus drawing attention away from an external goal-directed task. Thus, people with greater executive control abilities (i.e., WMC and AC) should mind-wander less often. The fact that the common variance in mind-wandering across task contexts negatively correlated with both WMC and AC is consistent with this account. The context-regulation account posits that in certain situations, executive control is not necessarily required. Thus, the relationship between executive control abilities and mind-wandering tendencies may be sensitive to changes to task demands. That was also the case in the present study, as the correlations between WMC and AC significantly decreased in the low-demand tasks. Finally, the cognitive flexibility account posits that people with greater executive control can adapt the degree to which they allow mind-wandering to occur based on task demands. The bi-factor models were consistent with this prediction, as the residual variance in mind-wandering in low-demand tasks positively correlated with WMC and AC. Thus, we found support for all three theories in the present study.

The third set of findings regards the importance of contextual variables in accounting for individual differences in mind-wandering. Across both task contexts, alertness negatively correlated with both intentional and unintentional mind-wandering. This is a rather consistent finding that has been demonstrated in both experimental and correlational work (Poh et al., 2016; Robison & Unsworth, 2018; Stawarczyk & D'Argembeau, 2016). People who reported being less alert throughout the session reported more intentional and unintentional mind-wandering. Motivation also consistently correlated with mind-wandering in the present study. But whereas alertness correlated with both types of mind-wandering about equally, motivation correlated more strongly with intentional compared to unintentional mind-wandering. This pattern replicates prior experimental and individual differences studies (Robison & Unsworth, 2018; Seli et al., 2016a, 2016b).

In our prior work, cognitive ability and motivation have not typically correlated (Robison & Unsworth, 2015; Robison & Unsworth, 2018; Unsworth & McMillan, 2013). But whereas those studies used WMC as the measure of cognitive ability, the present study used both WMC and AC. Indeed, motivation has correlated with AC in our own prior work (Robison & Unsworth, 2018). But because we measured motivation only during the AC tasks in the past, we figured this covariance was confounded by shared method variance. In the present study, motivation did not correlate with WMC, but it did correlate with AC. Importantly, in the present study, motivation was not only measured after each AC task. Rather, it was measured after three tasks (reading span, psychomotor vigilance, and breath counting) at various points throughout the experimental session. Thus, it is not necessarily the case that motivation correlated with AC because of shared temporal/method variance. While it could be the case that AC tasks are more sensitive to individual differences in intrinsic motivation than WMC tasks, this specific pattern begs future research.

In regards to the other contextual variables, negative mood positively correlated with mind-wandering, as expected. Negative mood rather strongly correlated with intentional mind-wandering. This suggests that people who are in an anxious, irritable, or unhappy state tend to mind-wander more, and this is often intentional. Interestingly, this relationship was stronger for the high-demand tasks than the low-demand tasks. We had no specific hypotheses about how task demands would moderate the relationship between mood and mind-wandering, nor about whether mood would correlate with intentional or unintentional mind-wandering more strongly. To our knowledge this is the first study to examine mood as a correlate of mind-wandering in high- and low-demand contexts. So this finding begs replication. However, it is clear that negative mood is an important predictor of mind-wandering. Previous night's sleep did not significantly correlate with mind-wandering, as hypothesized. But collectively, the contextual factors contributed heavily to our ability to explain individual differences in mind-wandering. While alertness and motivation were relatively immune to changes in task demands, task demands significantly moderated mood's relationship with mind-wandering. Further, motivation and mood showed differential relationships with intentional and unintentional mind-wandering, which may be theoretically important.

Our fourth important set of findings regards dispositional variables. We had hypothesized that some differences at the trait level would correlate with tendencies to mind-wander. Based on prior work, as well as the concerns theory (2009, Klinger, 1999; McVay & Kane, 2010), we expected neuroticism to positively correlate with mind-wandering (Kane et al., 2017; Robison et al., 2017). Additionally, we expected traits like daydreaming frequency and boredom proneness to positively correlate with mind-wandering, as they reflect a general tendency toward attentional wavering. Finally, we expected trait mindfulness to negatively correlate with mind-wandering, based on prior individual differences investigations and experiments (Deng et al., 2014; Epel et al., 2013; Mrazek, Smallwood, Franklin et al., 2012, 2013; Ottaviani & Couyoumdjian, 2013; Seli et al., 2013). We found only partial evidence for the hypothesized relationships. We did not replicate the finding that neuroticism positively correlates with mind-wandering. It did not significantly correlate with either intentional or unintentional in either the high- or low-demand contexts. It is unclear why this relationship was not observed, given it has been demonstrated in two other rather large-scale individual differences investigations (Kane et al., 2017; Robison et al., 2017). We did, however, observe significant negative correlations between conscientiousness and intentional mind-wandering in both high- and low-demand tasks. Given the theoretical personality traits that comprise conscientiousness ("socially prescribed impulse control that facilitates task- and goal-directed behavior," John et al., 2008, p. 120), it makes sense that highly conscientious individuals would not mind-wander intentionally. Although we and others have not previously observed significant relationships between conscientiousness and mind-wandering, this may have been because we did not dissociate between intentional and unintentional mind-wandering previously (Kane et al., 2017; Robison et al., 2017). Indeed, most instances of mind-wandering are unintentional, and conscientiousness did not show particularly strong relationships with unintentional mind-wandering. We also observed a significant negative correlation between agreeableness and intentional mind-wandering in the high- and low-demand tasks. This relationship has not been observed in prior investigations of personality and mind-wandering (Kane et al., 2017; Robison et al., 2017). But again, because agreeableness only correlated with intentional mind-wandering, and prior studies did not differentiate between intentional and unintentional mind-wandering, that relationship may have been masked. Finally, openness significantly positively correlated with intentional mind-wandering in low-demand tasks. Prior investigations of personality and mind-wandering have not observed such a correlation (Kane et al., 2017; Robison et al., 2017; Smeekens & Kane, 2016), although Kane et al. (2017) did observe a positive correlation between openness and daily life mind-wandering. Since it only correlated with intentional mind-wandering and only during the low-demand tasks, this may be a rather specific relationship. However, this result also begs replication.

Daydreaming frequency and mindfulness also correlated with mind-wandering, as expected. In general, daydreaming frequency positively correlated with unintentional mind-wandering. But it also correlated with the residual variance in intentional mind-wandering unique to low-demand tasks. Finally, mindfulness negatively correlated with mind-wandering, which is consistent with prior work (Deng et al., 2014; Epel et al., 2013; Mrazek, Smallwood, Franklin et al., 2012; Mrazek, Smallwood, Schooler, 2012; Mrazek, Franklin et al., 2013; Mrazek, Phillips et al., 2013; Ottaviani & Couyoumdjian, 2013; Seli et al., 2013; Stawarczyk et al., 2012; Y. Ju & Lien, 2018; Y-J. Ju & Lien, 2018). However, when mind-wandering was broken down by intentionality and task-demands, mindfulness only significantly correlated with unintentional mind-wandering, and more strongly in the high-demand tasks. This finding is slightly different than what Y. Ju and Lien (2018), Y-J. Ju and Lien (2018) observed. They found that the relationship between mind-wandering and mindfulness was rather stable across 0-back and 2-back task blocks. Nonetheless, it is clear that dispositional factors are important for understanding individual differences in mind-wandering. Again, the findings underscore the importance of a framework that incorporates cognitive, contextual, and dispositional factors.

5.1. Limitations and future directions

A few weaknesses and caveats of the present study are worth mentioning. First and foremost, this study was entirely contained in a laboratory. For the purposes of the present investigation, this was necessary, as we specifically controlled the attentional demands of the task situations within which we measured mind-wandering. However, as Kane et al. (2017) recently demonstrated, mind-wandering in the lab and in daily life are not necessarily the same. While people who often mind-wander in daily life tend to do so in the lab as well, cognitive, contextual, and dispositional factors differentially predict lab and life mind-wandering. For example, while neuroticism significantly correlated with mind-wandering in the lab, it did not correlate with daily life mind-wandering (Kane et al., 2017). Openness showed the opposite pattern. While it significantly correlated with mind-wandering in daily life, openness did not predict mind-wandering in the lab (Kane et al., 2017). As another example, WMC predicted fewer instances of mind-wandering in the lab, but it only predicted fewer instances of daily life mind-wandering in situations where individuals were trying hard to concentrate on their current task. In another study, Unsworth and McMillan (2017) measured cognitive abilities and mind-wandering in the lab, and participants subsequently kept diaries for one week charting when they experienced mind-wandering and distraction during lectures and while studying. Mind-wandering in the lab and mind-wandering in school settings actually negatively correlated. So while the present study rather comprehensively examined mind-wandering in the lab, the results may be different for mind-wandering as it occurs in daily life. This is an area for future research.

A second weakness of the current study is that task-demands and time were confounded to a certain extent. Two of the low-demand tasks (breath counting and digit reaction time) came toward the end of the experimental session, and two of the high-demand tasks (psychomotor vigilance and reading span) came rather early in the session. Thus, some of the changes across task-demands may have also been affected by the duration of the experimental session. However, we do not believe the temporal order of the tasks would have produced the observed pattern of correlations. Indeed, in a meta-analysis of the relationship between cognitive abilities and mind-wandering, Randall et al. (2014) observed a strengthening of the relationship between ability and mind-wandering for longer tasks. The opposite pattern was observed here. In future work, we will need to disentangle the effects of time and task-demands more carefully.

A third weakness, mentioned previously, is that intentional mind-wandering rates were very low, resulting in skewed and leptokurtic distributions that might not be appropriate for multivariate analysis. Given these measurement issues, the models that separate intentional and unintentional mind-wandering need to be interpreted cautiously. Although some of the current results replicate prior research examining individual differences in intentional and unintentional mind-wandering (e.g., Robison & Unsworth, 2018), it is clear that more research is needed to replicate and expand on these findings with paradigms that potentially allow for more intentional mind-wandering. The use of additional modeling techniques to better model these types of distributions is also recommended. Finally, in order to fit the measures into a single 2-hr experimental session, the *n*-back and visual search tasks had to be shortened from the versions run in the original experiments (Forster & Lavie, 2009; Rummel & Boywitt, 2014). Thus, some tasks had relatively few thought probes embedded in them, which may have limited our ability to measure mind-wandering during these tasks.

6. Conclusion

In summary, the results of the present study underlie one overarching theme: mind-wandering is a complex and multiply-determined phenomenon. People mind-wander for a number of reasons. At the most general level, people with better cognitive abilities are better able to exert control over their thoughts, thus showing fewer instances of mind-wandering. But it does seem like these same people can control the occurrence of task-unrelated thoughts to an extent that they do allow themselves to mind-wander more in low-demand situations. People who expressed having low motivation reported more instances of mind-wandering, specifically more intentional mind-wandering. Similarly, people who reported low levels of alertness reported more mind-wandering. Further, people who were in a negative emotional state (e.g., irritable, anxious) expressed more intentional mind-wandering. Finally, there are some people who are dispositionally prone to daydreaming, and these people seem to have trouble controlling the occurrence of spontaneous thoughts. Additionally, people who rated themselves as more conscientious and agreeable reported less mind-wandering.

Overall, the current results broadly replicate and extend prior research by suggesting that cognitive abilities, contextual factors, and dispositional traits all influence who is likely to mind-wander and in what situations mind-wandering is most likely. In trying to understand why people mind-wander, it is important to consider a host of factors. These findings have generalizable implications. For example, in educational settings, a teacher might notice that one of her students is particularly inattentive and appears to be mind-wandering frequently throughout the day. This can be happening for a number of reasons. While it is certainly possible, it is not necessarily the case that this student has low cognitive ability, nor is it necessarily the case that they are unmotivated to learn. But by knowing which factors are worth consideration, the teacher may be able to intervene to learn what the underlying cause of the student's inattentiveness is. Do they need to be sleeping more so they are more alert? Do they need an additional incentive to motivate them? Are they anxious about an upcoming exam? All of these are potential reasons for the student's inattentiveness. By understanding the most important situational and individual factors that contribute to mind-wandering, we may be better able to design interventions to reduce some of its negative consequences like poor academic and work performance, automotive and industrial accidents, and psychopathological symptomology.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.cognition.2019.104078.

References

Andrews-Hanna, J. R., Kaiser, R. H., Turner, A. E. J., Reineberg, A. E., Godinez, D., Dimidjian, S., & Banich, M. T. (2013). A penny for your thoughts: Dimensions of self-generated thought content and relationships with individual differences in emotional wellbeing. *Frontiers in Psychology, 4*, 900.

Antrobus, J. S., Singer, J. L., & Greenberg, S. (1966). Studies in the stream of consciousness: Experimental enhancement and suppression of spontaneous cognitive processes. *Perceptual and Motor Skills, 23*, 399–417.

Baird, B., Smallwood, J., & Schooler, J. W. (2011). Back to the future: Autobiographical planning and the functionality of mind-wandering. *Consciousness and Cognition, 20*, 1604–1611.

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*, 822–848.

Deng, Y.-Q., Li, S., & Tang, Y.-Y. (2014). The relationship between wandering mind, depression and mindfulness. *Mindfulness, 5*, 124–128.

Dinges, D. F., & Powell, J. W. (1985). Microcomputer analysis of performance on a portable, simple visual RT task during sustained operations. *Behavior Research Methods Instruments & Computers, 17*, 652–655.

Epel, E. S., Puterman, E., Lin, J., Blackburn, E., Lazara, A., & Berry Mendes, W. (2013). Wandering minds and aging cells. *Clinical Psychological Science, 1*, 75–83.

Forster, S., & Lavie, N. (2009). Harnessing the wandering mind: The role of perceptual load. *Cognition, 111*, 345–355.

Frank, D. J., Nara, B., Zavagnin, M., Touron, D. R., & Kane, M. J. (2015). Validating older adults' reports of less mind-wandering: An examination of eye movements and dispositional influences. *Psychology and Aging, 30*, 266–278.

Galéra, C., Orriols, L., M'Bailara, K., Laborey, M., Contrand, B., Ribéreau-Gayon, R., et al. (2012). Mind wandering and driving: Responsibility case-control study. *British Medical Journal, 385*, e8105.

Giambra, L. M. (1977). Adult male daydreaming across the lifespan: A replication, further analyses, and tentative norms based upon retrospective reports. -78 *International Journal of Aging & Human Development, 8*, 197–228.

Grodsky, A., & Giambra, L. M. (1990). The consistency across vigilance and reading tasks of individual differences in the occurrence of task-unrelated and task-related images and thoughts. Imagination. -91 *Cognition and Personality, 10*, 39–52.

Horst, P. (1941). The role of the predictor variables which are independent of the criterion. *Social Science Research Council, 48*, 431–436.

Jackson, J. D., & Balota, D. A. (2012). Mind-wandering in younger and older adults: Converging evidence from the Sustained Attention to Response Task and reading for comprehension. *Psychology and Aging, 27*, 106–119.

Jackson, J. D., Weinstein, Y., & Balota, D. A. (2013). Can mind-wandering be timeless? Atemporal focus and aging in mind-wandering paradigms. *Frontiers in Psychology, 4*, 742.

John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative Big Five trait taxonomy. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.). *Handbook of personality: Theory and research* (pp. 114–158). New York: Guilford Press.

Kane, M. J., Bleckley, M. K., Conway, A. R. A., & Engle, R. W. (2001). A controlled-attention view of working-memory capacity. *Journal of Experimental Psychology General, 130*, 169–183.

Kane, M. J., Brown, L. E., Little, 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*, 614–621.

Kane, M. J., Meier, M. E., Smeekens, B. A., Gross, G. M., Chun, C. A., Silvia, P. J., et al. (2016). Individual differences in executive control of attention, memory, and thought, and their associations with schizotypy. *Journal of Experimental Psychology General, 145*, 1017–1048.

Kane, M. J., Gross, G. M., Chun, C. A., Smeekens, B. A., Meier, M. E., Silvia, P. J., et al. (2017). For whom the mind wanders, and when, varies across laboratory and daily-life settings. *Psychological Science, 28*, 1271.

Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science, 330*, 932.

Kline, R. B. (2011). *Principles and practice of structural equation modeling.* New York: Guilford Press.

Klinger, E. (1999). Thought flow: Properties and mechanisms underlying shifts in content. In J. A. Singer, & P. Salovey (Eds.). *At play in the fields of consciousness: Essays in honor of jerome L. Singer* (pp. 29–50). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Klinger, E. (2009). Daydreaming and fantasizing: Thought flow and motivation. In K. D. Markman, W. M. P. Klein, & J. A. Suhr (Eds.). *Handbook of imagination and mental stimulation* (pp. 225–239). New York: Psychology Press.

Krawietz, S. A., Tamplin, A. K., & Radvansky, G. A. (2012). Aging and mind wandering during text comprehension. *Psychology and Aging, 27*, 951–958.

Krimsky, M., Forster, D. E., Llabre, M. M., & Jha, A. P. (2017). The influence of time on task on mind wandering and visual working memory. *Cognition, 169*, 84–90. https://doi.org/10.1016/j.cognition.2017.08.006.

Levinson, D. B., Smallwood, J., & Davidson, R. J. (2012). The persistence of thought: Evidence for a role of working memory in the maintenance of task-unrelated thinking. *Psychological Science, 23*, 375–380.

Malkovsky, E., Merrifield, C., Goldberg, Y., & Danckert, J. (2012). Exploring the relationship between boredom and sustained attention. *Experimental Brain Research, 221*, 59–67.

Marchetti, I., Koster, E. H. W., Klinger, E., & Alloy, L. B. (2016). Spontaneous thought and vulnerability to mood disorders: The dark side of the wandering mind. *Clinical Psychological Science, 4*, 835–857.

Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory. *The British Journal of Clinical Psychology, 31*, 301–306.

McVay, J. C., & Kane, M. J. (2010). Does mind wandering reflect executive function or executive failure? Comment on Smallwood and Schooler (2006) and Watkins (2008). *Psychological Bulletin, 136*, 188–197.

McVay, J. C., & Kane, M. J. (2012a). Drifting from slow to "D'oh!": Working memory capacity and mind wandering predict extreme reaction times and executive-control errors. *Journal of Experimental Psychology Learning, Memory, and Cognition, 38*, 525–549.

McVay, J. C., & Kane, M. J. (2012b). Why does working memory capacity predict variation reading comprehension? On the influence of mind wandering. *Journal of Experimental Psychology General, 141*, 302–320.

McVay, J. C., & Kane, M. J. (2013). Dispatching the wandering mind? Toward a laboratory method for cuing "spontaneous" off-task thought. *Frontiers in Psychology, 4*, 570.

McVay, J. C., Meier, M. E., Touron, D. R., & Kane, M. J. (2013). Aging ebbs the flow of thought: Adult age differences in mind wandering, executive control, and self-evaluation. *Acta Psychologica, 142*, 136–147.

McVay, J. C., Unsworth, N., McMillan, B. D., & Kane, M. J. (2013). Working memory capacity does not always support future-oriented mind wandering. *Canadian Journal of Experimental Psychology, 67*, 41–50.

Meier, M. E. (2018). *Is there a positive association between working memory capacity and mind wandering in a low-demand breathing task? A preregistered replication of Levinson, Smallwood, and Davidson* (2012). PsyArXivhttps://doi.org/10.31234/osf.io/a7nyt.

Mrazek, M. D., Franklin, M. S., Tarchin Phillips, D., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind-wandering. *Psychological Science, 25*, 776–781.

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*, 560.

Mrazek, M. D., Smallwood, J., Franklin, M. S., Chin, J. M., Baird, B., & Schooler, J. W. (2012). The role of mind-wandering in measurements of general aptitude. *Journal of Experimental Psychology General, 144*, 788–798.

Mrazek, M. D., Smallwood, J., & Schooler, J. W. (2012). Mindfulness and mind-wandering: Finding convergence through opposing constructs. *Emotion, 12*, 442–448.

Ottaviani, C., & Couyoumdjian, A. (2013). Pros and cons of a wandering mind: A prospective study. *Frontiers in Psychology, 4*, 524.

Paulhus, D. L., Robins, R. W., Trzesniewski, K. H., & Tracy, J. L. (2004). Two replicable Suppressor situations in personality research. *Multivariate Behavioral Research, 39*, 303–328.

Poerio, G. L., Totterdell, P., & Miles, E. (2013). Mind-wandering and negative mood: Does one thing really lead to another? *Consciousness and Cognition, 22*, 1412–1421.

Poh, J.-H., Chong, P. L. H., & Chee, M. W. L. (2016). Sleepless night, restless mind: Effects of sleep deprivation on mind wandering. *Journal of Experimental Psychology General, 145*, 1312–1318.

Randall, J. G., Oswald, F. L., & Beier, M. E. (2014). Mind-wandering, cognition, and performance: A theory-driven meta-analysis of attention regulation. *Psychological Bulletin, 140*, 1411–1431.

Reason, J. (1990). *Human error.* Cambridge: Cambridge University Press.

Robison, M. K., & Unsworth, N. (2015). Working memory capacity offers resistance to mind-wandering and external distraction in a context-dependent manner. *Applied Cognitive Psychology, 29*, 680–690.

Robison, M. K., & Unsworth, N. (2017). Working memory capacity and mind-wandering during low-demand cognitive tasks. *Consciousness and Cognition, 52*, 47–54.

Robison, M. K., & Unsworth, N. (2018). Cognitive and contextual predictors of spontaneous and deliberate mind-wandering. *Journal of Experimental Psychology Learning, Memory, and Cognition, 44*, 85–98.

Robison, M. K., Gath, K. I., & Unsworth, N. (2017). The neurotic wandering mind: An individual differences investigation of mind-wandering, neuroticism, and executive control. *The Quarterly Journal of Experimental Psychology, 70*, 649–663.

Rummel, J., & Boywitt, C. D. (2014). Controlling the stream of thought: Working memory capacity predicts adjustment of mind-wandering to situational demands. *Psychonomic Bulletin & Review, 21*, 1309–1315.

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online, 8*, 23–74.

Seli, P., Risko, E. F., & Smilek, D. (2016a). Assessing the associations among trait and state levels of deliberate and spontaneous mind wandering. *Consciousness and Cognition, 41*, 50–56.

Seli, P., Risko, E. F., & Smilek, D. (2016b). On the necessity of distinguishing between unintentional and intentional mind-wandering. *Psychological Science, 27*, 685–691.

Seli, P., Schacter, D. L., Risko, E. F., & Smilek, D. (2019). Increasing participant motivation reduces rates of intentional and unintentional mind-wandering. *Psychological Research, 83*, 1057–1069.

Seli, P., Carriere, J. S. A., & Smilek, D. (2015). Not all mind wandering is created equal: Dissociating deliberate from spontaneous mind-wandering. *Psychological Research, 79*, 750–758.

Seli, P., Cheyne, J. A., Xu, M., Purdon, C., & Smilek, D. (2015). Motivation, intentionality, and mind wandering: Implications for assessments of task-unrelated thought. *Journal of Experimental Psychology Learning, Memory, and Cognition, 41*, 1417–1425.

Seli, P., Risko, E. F., Smilek, D., & Schacter, D. L. (2016). Mind-wandering with and without intention. *Trends in Cognitive Sciences, 20*, 605–617.

Seli, P., Wammes, J. D., Risko, E. F., & Smilek, D. (2016). On the relation between motivation and retention in education contexts: The role of intentional and unintentional mind wandering. *Psychonomic Bulletin & Review, 23*, 1280–1287.

Singer, J. L., & Antrobus, J. S. (1970). *Imaginal processes inventory.* Princeton, NJ: Educational Testing Service.

Smallwood, J., & Andrews-Hanna, J. (2013). Not all minds that wander are lost: The importance of a balanced perspective on the mind-wandering state. *Frontiers in Psychology, 4*, 441.

Smallwood, J., Fitzgerald, A., Miles, L. K., & Phillips, L. H. (2009). Shifting moods, wandering minds: Negative moods lead the mind to wander. *Emotion, 9*, 271–276.

Smeekens, B. A., & Kane, M. J. (2016). Working memory capacity, mind wandering, and creative cognition: An individual-differences investigation into the benefits of controlled versus spontaneous thought. *Psychology of Aesthetics, Creativity, and the Arts, 10*, 389–415.

Stawarczyk, D., & D'Argembeau, A. (2016). Conjoint influence of mind-wandering and sleepiness on task performance. *Journal of Experimental Psychology Human Perception and Performance, 42*, 1587–1600.

Stawarczyk, D., Majerus, S., Maj, M., Van der Linden, M., & D'Argembeau, A. (2011). Mind-wandering: Phenomenology and function as assessed with a novel experience sampling method. *Acta Psychologica, 136*, 370–381.

Stawarczyk, D., Majerus, S., Van der Linden, M., & D'Argembeau, A. (2012). Using the daydreaming frequency scale to investigate the relationships between mind-wandering, psychological well-being, and present-moment awareness. *Frontiers in Psychology, 3*, 363.

Stawarczyk, D., Majerus, S., & D'Argembeau, A. (2013). Concern-induced negative affect is associated with the occurrence and content of mind-wandering. *Consciousness and Cognition, 22*, 442–448.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662.

Thomson, D. R., Besner, D., & Smilek, D. (2015). A resource-control account of sustained attention: Evidence from mind-wandering and vigilance paradigms. *Perspectives on Psychological Science, 10*(82), 96.

Unsworth, N., & McMillan, B. D. (2013). Mind wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience. *Journal of Experimental Psychology Learning, Memory, and Cognition, 39*, 832–842.

Unsworth, N., & McMillan, B. D. (2014). Similarities and differences between mind-wandering and external distraction: A latent variable analysis of lapses of attention and their relation to cognitive abilities. *Acta Psychologica, 150*, 14–25.

Unsworth, N., & McMillan, B. D. (2017). Attentional disengagements in educational contexts: A diary investigation of everyday mind-wandering and distraction. *Cognitive Research: Principles and Implications, 2*, 1–20.

Unsworth, N., & Robison, M. K. (2016). The influence of lapses of attention on working memory capacity. *Memory & Cognition, 44*, 188–196.

Unsworth, N., & Robison, M. K. (2018). Tracking arousal and mind-wandering state with pupillometry. *Cognitive, Affective & Behavioral Neuroscience, 18*, 638–664.

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods, 37*, 498–505.

Unsworth, N., Redick, T. S., Heitz, R. P., Broadway, J., & Engle, R. W. (2009). Complex working memory span tasks and higher-order cognition: A latent variable analysis of the relationship between processing and storage. *Memory, 17*, 635–654.

Unsworth, N., Brewer, G. A., & Spillers, G. J. (2012). Variation in cognitive failures: An individual differences investigation of everyday attention and memory failures. *Journal of Memory and Language, 67*, 1–16.

Unsworth, N., McMillan, B. D., Brewer, G. A., & Spillers, G. J. (2012). Everyday attention failures: An individual differences investigation. *Journal of Experimental Psychology Learning, Memory, and Cognition, 38*, 1765–1772.

Vodanovich, S. J., & Kass, S. J. (1990). A factor analytic study of the Boredom Proneness Scale. *Journal of Personality Assessment, 55*, 115–123.

Wammes, J. D., Seli, P., Cheyne, J. A., Boucher, B. O., & Smilek, D. (2016). Mind-wandering during lectures II: Relation to academic performance. *Scholarship of Teaching and Learning in Psychology, 2*, 33–48.

Ward, A. F., & Wegner, D. M. (2013). Mind-blanking: When the mind goes away. *Frontiers in Psychology, 4*, 650.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063–1070.

Watson, D., Clark, L. A., Chmielewski, M., & Kotov, R. (2013). The value of suppressor effects in explicating the construct validity of symptom measures. *Psychological Assessment, 25*, 929–941.

Xu, J., & Metcalfe, J. (2016). Studying in the region of proximal learning reduces mind wandering. *Memory & Cognition, 44*, 681–695.

Xu, M., Purdon, C., Seli, P., & Smilek, D. (2017). Mindfulness and mind wandering: The protective effects of brief meditation in anxious individuals. *Consciousness and Cognition, 51*, 157–165.

Ju, Y., & Lien, Y. (2018). Who is prone to wander and when? Examining an integrative effect of working memory capacity and mindfulness trait on mind wandering under different task loads. *Consciousness and Cognition, 63*, 1–10.

Ju, Y.-J., & Lien, Y.-W. (2018). Who is prone to wander and when? Examining an integrative effect of working memory capacity and mindfulness trait on mind wandering under different task loads. *Consciousness and Cognition, 63*, 1–10.

Zavagnin, M., Borella, E., & De Beni, R. (2014). When the mind wanders: Age-related differences between young and older adults. *Acta Psychologica, 145*, 54–64.