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Does the type of mind wandering matter? Extending the inquiry about the role of mind wandering in the IT use experience

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Abstract

Purpose – This study sought to distinguish characteristics of cognitive processes while using information technology. In particular, it identifies similarities and differences between mind wandering and cognitive absorption in technology-related settings in an effort to develop a deeper understanding of the role that mind wandering plays when using information technology.

Design/methodology/approach – Data was gathered using an online survey including responses from 619 English-speaking adults in 2019. We applied a confirmatory factor analysis and used a robust variant of maximum likelihood estimator with robust standard errors and a Satorra–Bentler scaled test statistic. The data analysis procedure was conducted with the R environment using the psych package for descriptive analysis, and lavaan to investigate the factorial structure and the underlying correlations.

Findings – We discuss the benefits of carefully differentiating between cognitive processes in Information Systems research and depict avenues how future research can address current shortcomings with a careful investigation of neurophysiological antecedents.

Originality/value – To date, mind wandering has been explored as a single phenomenon, though research in reference disciplines has begun to distinguish varieties and how they distinctly impact behavior. We demonstrate that this distinction is also important for our discipline by showing how two specific types of mind wandering (i.e. deliberate and spontaneous mind wandering) are differently correlated with sub-dimensions of cognitive absorption, a well-studied construct.

Keywords Cognition, Mind wandering, Cognitive absorption, Temporal dissociation, Enjoyment, Default mode network

Paper type Research paper

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1. Introduction

Information systems (IS) researchers are often interested in the role that cognitive processes play in human behavior related to information technology (IT). Cognition is a broad term for thought, experience and the senses, and thus encompasses crucial thought processes such as attention, memory, reasoning and judgment. Researchers analyze cognition and cognitive processes from different perspectives, notably by drawing from techniques used in the fields of neuroscience, psychology, education and computer science. To date, the study of cognitive processes has been identified as foundational to research in software development, decision support and especially human–computer interaction (Davern *et al.*, 2012). However, IS researchers have only recently begun to earnestly investigate the role that internally directed cognitive processes play in technology-related settings (Riedl and Léger, 2016; Thatcher *et al.*, 2018).

One widely studied example in the IS discipline is the construct of cognitive absorption. In their seminal paper, Agarwal and Karahanna (2000) defined cognitive absorption as a state of deep engagement with software when users lose a sense of external attention. Today, it is recognized as a conceptualization of the IT use state (Burton-Jones and Straub, 2006; Sullivan and Davis, 2020; Venkatesh *et al.*, 2012). Agarwal and Karahanna (2000) highlighted five dimensions of the phenomenon: temporal dissociation, focused immersion, heightened enjoyment, control and curiosity. Sullivan and Davis (2020) explored ways that internally directed cognitive processes, such as mind wandering, play in influencing the well-studied cognitive absorption construct. They found that there is a curve–linear relationship between the two, where mind wandering can have a negative effect on cognitive absorption to a point when it turns positive. This conclusion is not necessarily supported by the literature. Given that mind wandering can impair one's ability to engage with a task, it may negatively influence the ability to experience cognitive absorption (Zhang *et al.*, 2017; Smallwood *et al.*, 2007a). However, there are studies hinting at the fact that its presence may actually facilitate cognitive absorption when a user engaged in IT use due to the link between mind wandering and a loss of sense of time and place (Braboszcz and Delorme, 2011), as well as mind wandering's propensity to facilitate creative thought (Gable *et al.*, 2019).

Both mind wandering and flow, the related construct which inspired Agarwal and Karahanna's cognitive absorption construct (2000), are associated with activity of the brain's executive and default mode networks (DMN) (Ulrich *et al.*, 2014, 2016; Golchert *et al.*, 2017). Though the activation of similar underlying brain networks does not suggest that the constructs share an underlying equivalency, it nonetheless suggests that mind wandering may play a role in shaping the IT use experience. The expected relationship between these constructs is thus inconclusive, though it is possible that this is due to the lack of clarity in the mind wandering construct. In this paper, we further refine this relationship described by Sullivan and Davis (2020) with evidence that the relationship between mind wandering and cognitive absorption may be influenced by the variety of mind wandering reported. Learning more about the relationship between internally directed cognitive processes, such as mind wandering and states of IT use, such as cognitive absorption, can give insight into the mental antecedents of IT use. Such insights can eventually inform how to effectively design and organize information systems. By identifying the contexts in which the correlates of mind wandering are present, we can identify the contexts where mind wandering may affect the way that people use IT.

Psychologists studying mind wandering have distinguished its varieties, most notably a distinction between spontaneous and deliberate components (Carriere *et al.*, 2013; Seli *et al.*, 2016c). We investigated whether the two varieties of mind wandering differently affected degrees of experienced cognitive absorption. The results of our survey study ($n = 619$) show that the degree of reported deliberate and spontaneity sub-dimensions of mind wandering were correlated differently with sub-dimensions of cognitive absorption. In this study, we focus on two specific sub-dimensions of cognitive absorption, namely enjoyment and temporal dissociation. These sub-dimensions have been well studied in previous IS literature as well as related disciplines and can be considered important antecedents for IS-related concepts such as technology use and adoption as well as performance and creativity (Sullivan and Davis, 2020; Agarwal and Karahanna, 2000; Smallwood and Schooler, 2015; Conrad and Newman, 2019; Lee *et al.*, 2012; Mazzoni *et al.*, 2017; Rutkowski *et al.*, 2007; Brooks and Longstreet, 2015; Baird *et al.*, 2011, 2012). Moreover, both seem relevant when designing IS systems that motivate user or avoid boredom (Oschinsky *et al.*, 2019).

We are led to conclude that future work related to mind wandering in IS would benefit from exploring the varieties of mind wandering experienced during technology use. We also highlight the importance of distinguishing cognitive processes and call for a neuroscientific study of internal mental processes which are associated with cognitive constructs commonly used in IS research. To address our objective, this study is guided by two research questions (RQs):

(1) How do varieties of mind wandering relate to mood (e.g. enjoyment)?

(2) How do varieties of mind wandering impact our temporal perception?

The remainder of this paper is structured as follows. First, we provide a background on how information systems research and cognitive neuroscience have investigated mind wandering so far (Section 2.1 and 2.2.). Based on existing literature, we highlight a need to further explore varieties of mind wandering and develop our hypothesis (Section 2.3). In Section 3, we provide details about our research methodology and present the results in Section 4. We conclude with a discussion of our results (Section 5) and conclude by highlighting avenues for future research.

2. Background and hypotheses

2.1 Mind wandering and IS research

It is common to notice mind wandering during lectures, while reading, meditating, driving, taking a shower, or even when simply staring out the window (Baldwin *et al.*, 2017; Zhang *et al.*, 2017). Mind wandering is a common experience during which our attention becomes detached from the external environment and turns to our internal notions and feelings (Fox and Christoff, 2018; Smallwood and Schooler, 2015; Giambra, 1995). Mind wandering episodes are characterized by an easeful way to move away from ongoing tasks and a seemingly haphazard manner to switch from topic to topic (Posner and Petersen, 1990; Schooler, 2002; Schooler *et al.*, 2011; Giambra, 1989). As such, it is defined as “a mental state, or a sequence of mental states, that arise relatively freely due to an absence of strong constraints on the contents of each state” (Christoff *et al.*, 2016, p. 719).

Mind wandering predominantly occurs during the resting state, in non-demanding circumstances and during task-free activity (Buckner and Vincent, 2007; Smith *et al.*, 2009) and is seen as is highly undesirable in many situations (Smallwood *et al.*, 2007a; Smallwood and Schooler, 2015; Smeekens and Kane, 2016). It is promoted by stress and substance abuse (Epel *et al.*, 2013; Sayette *et al.*, 2012; Smallwood *et al.*, 2007b) and is often associated with a lack of awareness, unhappiness, poor performance, errors, disruption, disengagement and carelessness (Baldwin *et al.*, 2017; Drescher *et al.*, 2018; Zhang *et al.*, 2017). Although mind wandering can have various undesirable consequences, studies have also demonstrated that it offers benefits (Mooneyham and Schooler, 2013). It has been shown to positively relate to creativity, the planning of the future and positive mood (Agnoli *et al.*, 2018; Baird *et al.*, 2012).

With an increasing interest in mind wandering episodes, several distinct characteristics and subtypes have been discussed. First, mind wandering is a state, however, researchers also investigated the tendency to mind wander as a trait (Seli *et al.*, 2016a, b). As a state, mind wandering has conventionally been studied using various real-time reporting techniques such as experience sampling probes (Forster and Lavie, 2009). When investigating mind wandering traits, researchers have asked participants to report on levels of mind wandering throughout the day as they go about their regular business (Seli *et al.*, 2015). It has been demonstrated that people reliably report both state and trait mind wandering and that there is a general correspondence between the varieties of measures used (Seli *et al.*, 2016a, b).

Second, a distinction has been made between deliberate (i.e. intentional) and spontaneous (i.e. unintentional) mind wandering (Seli *et al.*, 2016c). This distinction goes back to Giambra (1989, 1995), who argued that voluntary shifts of attention involve a higher degree of control compared to involuntary shifts. The intention to begin or to continue to mind wander implies meta-awareness and purposefulness, which is not present when it is spontaneous. Various studies show that this distinction causes different effects. Agnoli *et al.* (2018) demonstrate that deliberate mind wandering positively predicts creative performance, whereas spontaneous mind wandering is negatively associated with it. In contrast, spontaneous mind wandering seems to be associated with negative consequences such as reduced performance.

Over the last six years, IS researchers have acknowledged the ubiquity and complex nature of mind wandering while using technology (Wati *et al.*, 2014; Conrad and Newman, 2019; Oschinsky *et al.*, 2019; Bockarova, 2016; Sullivan and Davis, 2020). They began to study how mind-wandering episodes shape a technology user's response to external stimuli or her or his primary task performance (Bockarova, 2016). For instance, Sullivan *et al.* (2015) showed that mind wandering while using IT correlates significantly with creativity and knowledge retention. They developed a domain-specific definition understanding technology-related mind wandering as "task-unrelated thought which occurs spontaneously, and the content is related to the aspects of computer systems" (Sullivan *et al.*, 2015, p. 4). They clarified that an IS research agenda on this concept has yet to emerge. We believe that this conceptualization of mind wandering is too specific, because the content of wandering thoughts is not necessarily set in relation to the system at hand (e.g. thinking about web design), but on an unconstrained array of internal notions and feelings. Thus, we broaden their definition and see mind wandering while using technology as "task-unrelated thought which occurs spontaneously, and related to the aspects of information systems".

Because the interaction with technology is considered a pivotal factor for the cognitive process of mind wandering in an IS context (Bockarova, 2016), some scholars have called to investigate contextual characteristics, such as technological characteristics, and their associations with mind wandering in more detail (Sullivan *et al.*, 2015). This position is in line with the more general demand raised by Briggs (2015) for a more elaborated examination of human elements in IS research, namely human cognition and its relationships with technology-related aspects. Other IS scholars highlighted the benefits of more deeply exploring brain functionality when exploring new IS constructs, even when neuroscience tools are not employed (Riedl *et al.*, 2017). By exploring the reference literature on mind wandering from psychology and neuroscience, we can better understand how this construct relates to research from the IS discipline. Against this background, we seek to fill this gap by exploring the role of mind wandering while using technology and by highlighting important sub-dimensions and boundaries of the concept. Furthermore, by exploring this relationship we may reveal a framework for understanding cognitive constructs used in IS research.

2.2 Brain networks, mind wandering and cognitive absorption

Though some research on mind wandering has been conducted from a behavioral perspective, much of the extant research on the topic takes a neurophysiological perspective.

Cognitive neuroscience is the scientific study of how the brain produces thoughts, emotions and ideas, usually through the application of neuroethologies such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET) or electroencephalography (EEG) (Newman, 2019). Brains consist of a series of cells which are interconnected and work together to conduct brain functions. Though the connections between networks of cells are dynamic and incredibly numerous (estimated to number around 86 trillion connections), many cell networks are organized at a large scale and are possible to study (Hebb, 2005). For IS scholars, the study of cognitive neuroscience promises to add deeper insight about the antecedents of IT behavior (Riedl and Léger, 2016). In the case of mind wandering, which has not yet been well-studied in IS, the reference disciplines of neuroscience and psychology can offer insights into what role it may play in influencing IT behavior.

It is believed that the mind wandering phenomenon is the result of two distinct brain networks: the default mode network (DMN) and frontoparietal control network (Fox *et al.*, 2015; Christoff *et al.*, 2009; Golchert *et al.*, 2017). The DMN is responsible for the consistent "default mode" of the brain and was originally discovered by observing the resting state during neuroimaging experiments (Raichle, 2015; Raichle *et al.*, 2001; Buckner and Vincent, 2007). The DMN has been associated with inwardly focused cognitive functions, ranging from future thinking tasks (Beaty *et al.*, 2018) to the encoding of experience information and its level of detail (Sormaz *et al.*, 2018). In the early days following its discovery, it was also hypothesized that the DMN was responsible for spontaneous thoughts (Raichle *et al.*, 2001), a hypothesis which was later supported with strong evidence and accepted by the cognitive neuroscience community (Fox *et al.*, 2015).

As neuroimaging evidence emerged over time, however, it became increasingly clear that the DMN alone was insufficient to capture the basis of spontaneous thoughts and mind wandering. Executive regions, specifically frontoparietal regions associated with control, were soon found to play an important role in the process (Fox *et al.*, 2015). Executive functions are cognitive processes which contribute to higher thinking such as working memory, selective attention and response inhabitation (Diamond, 2013). The frontoparietal control network is associated with goal-directed behavior, a subset of broader executive functioning (Niendam *et al.*, 2012). It has been suggested that the activation of the default mode and frontoparietal control networks during mind-wandering episodes is the result of coupling with the default mode network, where the control networks guide and evaluate between various streams of conscious thoughts (Fox and Christoff, 2014; Smallwood and Schooler, 2015).

Though a meta-analyses of neuroimaging studies found consistency in the relationship between the two networks (Fox *et al.*, 2015), the causal relationship between the networks is not yet conclusive and may depend on the context during which mind wandering takes place (Seli *et al.*, 2018). For instance, the demandingness of a task may influence how the networks interact. An association between increased cognitive control abilities and decreased mind wandering has been observed in cognitive demanding situations (Rummel and Boywitt, 2014; McVay and Kane, 2009); however, an association between increased cognitive control abilities and more off-task thoughts has also been observed in environments where participants had non-demanding tasks (Levinson *et al.*, 2012). Findings such as these have led researchers to scrutinize a variety of contexts during which mind wandering occurs (Smallwood and Andrews-Hanna, 2013; Seli *et al.*, 2018), including the conditions during which mind wandering may be spontaneous or deliberate (Seli *et al.*, 2016c).

A recent neuroimaging study explored the differences in the brain between situations of reported deliberate and spontaneous mind wandering and found significant differences in brain between the states (Golchert *et al.*, 2017). In addition, using neuroimaging, Golchert *et al.* (2017) observed that differences in patterns representative of the integration between the DMN and the frontoparietal control network were associated with the intentionality of the participants (i.e. whether the mind wandering was reported to be deliberate). This finding lends support to the notion that executive control is important to constraining deliberate mind wandering, though not spontaneous mind wandering (Golchert *et al.*, 2017), a notion which is further supported by other studies which have found a relationship between intentional mind wandering which depends on task difficulty (Seli *et al.*, 2016c).

By contrast, there has been limited work conducted on the neurophysiological correlates of the cognitive absorption construct. Léger *et al.* (2014) investigated the cognitive absorption construct as participants played a serious game and found a significant positive association between EEG alpha oscillation activity and reported cognitive absorption as well as a negative relationship between EEG beta activity and the construct. These results suggest that the cognitive absorption construct is associated with a relaxed state and moderate levels of task load. A short review conducted by Michailidis *et al.* (2018) investigated the role of flow, the phenomenon on which cognitive absorption is based, in video games and found results that both corroborated this conclusion and conflicted with it. Some studies have suggested that the loss of self-reflective thoughts during flow experiences is the result of reduced activity in the prefrontal cortex, which contains the brain's executive networks (Dietrich, 2004; Bavelier *et al.*, 2012; Ulrich *et al.*, 2014), as well as decreased activity in brain regions associated with the DMN (Ulrich *et al.*, 2016). Others have instead suggested an association with emotional reward processing (Yoshida *et al.*, 2014) or attentional mechanisms (Harris *et al.*, 2017). At very least, there is evidence to support the notion that flow and cognitive absorption can be contrasted between states of boredom and heightened brain activity, which can be observed by relative decreased or increased activity in the DMN and prefrontal networks. Both cognitive absorption and mind wandering are therefore complex, multi-faceted cognitive phenomena which are associated with similar processes of the DMN and prefrontal networks. It is thus possible that the mind wandering process relates to extant IS research concerning artifacts that involve sustained attention and intervention, such as click baits (Aswani *et al.*, 2018; Osatuyi and Hughes, 2018), online learning (Conrad and Newman, 2019; Sullivan *et al.*, 2015) or fake news (Ross *et al.*, 2018). It is also possible that mind wandering relates to creativity processes, such as those triggered during group collaboration software use (Seeber *et al.*, 2017). Future research in mind wandering might benefit from investigating the presence of mind wandering during the use of these artifacts.

2.3 Hypothesis development

Both mind wandering and cognitive absorption are cognitive phenomena, which could impact user engagement during technology use. Given the academic attention to varieties of mind wandering (Fox and Christoff, 2018; Seli *et al.*, 2018) and the call for a greater focus on cognitive factors in IS research (Briggs, 2015), we were led to investigate the relationship between varieties of mind wandering and the sub-dimensions of the well-studied IS construct. With a greater understanding of the associations between the varieties of mind wandering and the sub-dimensions of cognitive absorption, we might infer instances when varieties of mind wandering influence IT use.

Since the main purpose of this study is the investigation of varieties of mind wandering and their relation on cognitive absorption, we deliberately distinguish specific sub-dimensions of cognitive absorption instead of using cognitive absorption as a conglomerate. Previous literature has followed similar paths. For instance, Burton-Jones and Straub (2006) only selected one specific sub-dimension of cognitive absorption to investigate the relationship to system use. Likewise, Saadé and Bahli (2005) only use three out of five dimensions to investigate cognitive absorption within a learning context. In this line of argument, we select two specific sub-dimensions of cognitive absorption that are associated with varieties of mind wandering.

In their recent study, Sullivan and Davis (2020) reported correlations between mind wandering and the various cognitive absorption sub-dimensions. They discovered that mind wandering was positively correlated with temporal disassociation and curiosity; but no relationship was found between it and focused immersion or enjoyment. It was also reported to be negatively correlated with control (Sullivan and Davis, 2020). The positive correlation between mind wandering and temporal disassociation is not surprising, as prominent understandings of the mind wandering concept concern disengagement from sensory input and present environmental factors (Smallwood and Schooler, 2015).

However, it was surprising that Sullivan and Davis (2020) did not observe correlations between mind wandering and enjoyment. In contrast, Oschinsky *et al.* (2019) found that hedonic IT system use is associated with increased mind wandering, though not in the case of utilitarian IT use. In addition, enjoyment has also been identified as a product of some varieties of mind wandering, especially those that are deliberate rather than spontaneous in nature (Seli *et al.*, 2016a). It is possible that varieties of mind wandering are similarly distinguished by the way that they interact with the enjoyment sub-dimensions of the cognitive absorption construct, and that the findings of Sullivan and Davis (2020) are explained by the lack of specificity about the variety of mind wandering that they observed.

For the purpose of this study, we focus on two important considerations of mind wandering that have been established in previous literature (Smallwood *et al.*, 2011; Franklin *et al.*, 2013; Fox and Christoff, 2018; Schooler *et al.*, 2011). First, how does mind wandering relate to mood? Second, how does it impact our temporal perception? Since Killingsworth and Gilbert (2010) proposed that a "wandering mind is an unhappy mind", research has substantiated and refined this claim (e.g. Franklin *et al.*, 2013). While previous studies primarily focused on happiness, we assume similar effects can be observed in terms of enjoyment. Consequently, we propose that spontaneous episodes of mind wandering (MWT-S) are positively correlated with enjoyment (H1a) while deliberate episodes (MWT-D) are primarily negatively correlated with enjoyment (H1b).

H1a. MWT-S is positively correlated with enjoyment.

H1b. MWT-D is negatively correlated with enjoyment.

Similarly, mind wandering has been consistently identified by the de-coupling or diversion of attention from imminent experience and toward self-generated thoughts (Smallwood and Schooler, 2006; Mooneyham and Schooler, 2013). This does not always impact experience or performance negatively however, as several studies suggest that such shifts in attention away from external experience helps individuals on autobiographical planning (Baird *et al.*, 2011) or develop creativity (Mooneyham and Schooler, 2013). Consequently, it is clear that mind wandering can have a significant effect on temporal disassociation, which is part of cognitive absorption. Since both varieties of mind wandering relate to perceptual decoupling (Smallwood and Schooler, 2015; Annerer-Walcher *et al.*, 2020; Schooler *et al.*, 2011; Zedelius and Schooler, 2018), we assume that it likewise positively correlates with temporal disassociation. We thus propose that both MWT-S and MWT-D positively correlated with temporal disassociation (H2a and H2b).

H2a. MWT-S is positively correlated with temporal disassociation.

H2b. MWT-D is positively correlated with temporal disassociation.

3. Methodology

3.1 Participants

Since the focus of this research is to develop a better understanding of general perceptions and IS-related traits, we used a survey-based methodology instead of neurological tools and interpret the results in light of the cognitive neuroscience and cognitive psychology literature. Our approach has been recommended for IS researchers when exploring novel constructs (Riedl *et al.*, 2017, p. 13) and is also consistent with previous literature which explored varieties of mind wandering (e.g. Carriere *et al.*, 2013). This research is part of a larger project on mind wandering where we gathered data using an online survey on Amazon's Mechanical Turk's website. The data was collected in 2019 from English-speaking countries (United States of America, Canada, United Kingdom, Australia and New Zealand). From the overall number of participants (N = 700), we excluded participants who finished their survey in more than 15 min, to avoid uniform or defective answers by checking the overall time that participants took to answer our questions (Galesic and Bosnjak, 2009). As a consequence, 619 answers are used here. The participants had an average age of 36 years (M = 36.67, SD = 11.56). In this sample, 54.1% of the participants are male and 44.7% are female. The remaining 1.2% did not indicate or identify themselves as male or female. Most participants (above 50%) received some form of college degree. More than 59.3% have a full-time job while 13.7% held a part-time job, and 27.0% indicated other forms (e.g. being a student). The majority of participants reported working more than 15 years at their company (M = 15.75, SD = 11.20). A detailed overview of the demographics is provided in Table 1.

3.2 Measurements

To explore this phenomenon, we chose to compare measures of MWT-S and MWT-D (Carriere *et al.*, 2013) and correlated them with the selected sub-dimensions of the cognitive

Dimension	Classification	Percentage
Age	18–28	21.0
	29–38	38.6
	39–48	22.5
	48–58	12.8
	58–68	3.5
	68–78	1.3
	NA	0.3
Gender	Male	54.1
	Female	44.7
	NA	1.2
Education	Less than high school	1.1
	High school	11.8
	Some college	24.6
	2-year college degree	13.3
	4-year college degree	35.4
	Master's degree	11.0
	Doctoral degree	1.2
	Professional degree	1.6
Years working at the organization	1–15	49.8
	16–30	36.8
	31–45	11.8
	46–60	1.4
	NA	0.2
Job	Full-time	59.3
	Part-time	13.7
	Other (e.g. student)	27.0

Table 1. Demographics, sample size N = 619

absorption construct (Agarwal and Karahanna, 2000). By asking questions about general perceptions of mind wandering and cognitive absorption experiences during technology use, we can learn about commonalities and relationships between the constructs. We adapted the items proposed by Agarwal and Karahanna (2000) to operationalize enjoyment and temporal dissociation. All items were measured on a 7-point Likert scale. To quantify MWT-D and MWT-S, we adapted existing scales (Carriere *et al.*, 2013; Agarwal and Karahanna, 2000) using three items to measure MWT-D and ten items to measure MWT-S. All items are on the trait level. An overview is given in Table 2.

The data analysis procedure is conducted with the R environment (R Core Team, 2018) using the *psych* package (Revelle, 2020) for descriptive analysis, and *lavaan* (Rosseel, 2012) to investigate the factorial structure and the underlying correlations.

To ensure the validity of our measurement model, we first investigated the reliability of each construct based on Cronbach's alpha MWT-S (α = 0.95), MWT-D (α = 0.84) and temporal dissociation (α = 0.91). To increase the reliability of enjoyment, we dropped ENJ3

Construct	Item	Question
MWT-S (Carriere *et al.*, 2013)		*When using technology,. . .*
	MWT-S1	. . . I find my thoughts wandering spontaneously
	MWT-S2	. . . my thoughts tend to be pulled from topic to topic
	MWT-S3	. . . I mind wander even when I'm supposed to be doing something else
	MWT-S4	. . . I have difficulty controlling my thoughts
	MWT-S5	. . . I find it hard to switch my thoughts off
	MWT-S6	. . . my thoughts are disorganized and "all over the place"
	MWT-S7	. . . I find it difficult to think about one thing without another thought is entering my mind
	MWT-S8	. . . I find my thoughts are distracting and prevent me from focusing on what I am doing
	MWT-S9	. . . I have difficulty slowing my thoughts down and focusing on one thing at a time
	MWT-S10	. . . I find myself flitting back and forth between different thoughts
MWT-D (Carriere *et al.*, 2013)		*When using technology,. . .*
	MWT-D1	. . . I allow my thoughts to wander on purpose
	MWT-D2	. . . I enjoy mind-wandering
	MWT-D3	. . . I find mind-wandering is a good way to cope with boredom
Enjoyment (Agarwal and Karahanna, 2000)		*When using technology,. . .*
	ENJ1	. . . I always have fun to interact with it
	ENJ2	. . . I always have a lot of enjoyment
	ENJ3[2]	. . . I always enjoy using it
	ENJ4[1,2]	. . . I always get bored
Temporal dissociation (Agarwal and Karahanna, 2000)		*When using technology,. . .*
	TD1	. . . time always appears to go by very quickly
	TD2	. . . I always lose track of time
	TD3	. . . time always flies
	TD4	. . . I always end up spending more time that I had planned
	TD5	. . . I am always spending more time on it than I actually intended

Note(s): [1] reversed item
[2] dropped to increase reliability

Table 2.
Questionnaire

and ENJ4 for the further analysis which lead to $\alpha = 0.92$. An overview of the descriptive statistics is provided in Table 3.

Discriminant validity was assessed based on the Fornell–Larcker criterion (c.f. Table 4). Since all squared correlations are larger than the average variance extracted, discriminant validity is given.

Since some participants did not complete our survey, the results are susceptible to non-response bias (Armstrong and Overton, 1977). To test whether this is the case, we followed previous literature (Shiau and Chau, 2016) and compared early respondents with late respondents [1]. For that we extracted the responses of the first 10% of the sample (62 observations) and the responses of the last 10% in our sample and conducted a series of two-sided *t*-tests on demographic variables. A comparison of age, gender and education yields in no significant differences ($p > 0.05$). We thus concluded that non-response bias was not a problem.

4. Results

We applied a confirmatory factor analysis including all four factors to investigate the correlations between them. We use a robust variant of maximum likelihood estimator with

Construct	Item	*M*	SD	Skewness	Kurtosis	α
MWT-D	MWT-D1	3.33	1.84	0.29	−1.07	0.84
	MWT-D2	3.31	1.85	0.27	−1.13	
	MWT-D3	3.90	1.88	−0.15	−1.20	
MWT-S	MWT-S1	3.34	1.75	0.20	−1.00	0.95
	MWT-S2	4.08	1.72	−0.30	−0.75	
	MWT-S3	4.23	1.82	−0.36	−0.90	
	MWT-S4	4.02	1.82	−0.21	−1.03	
	MWT-S5	4.03	1.85	−0.18	−1.09	
	MWT-S6	3.92	1.84	−0.13	−1.07	
	MWT-S7	3.20	1.77	0.37	−0.95	
	MWT-S8	4.08	2.07	−0.12	−1.34	
	MWT-S9	3.35	1.87	0.38	−0.98	
	MWT-S10	3.82	1.85	0.00	−1.16	
Temporal dissociation	TD1	4.61	1.73	−0.44	−0.72	0.91
	TD2	4.92	1.65	−0.62	−0.37	
	TD3	4.88	1.72	−0.68	−0.41	
	TD4	5.12	1.62	−0.80	−0.03	
	TD5	4.91	1.73	−0.67	−0.44	
Enjoyment	ENJ1	5.00	1.40	−0.54	0.04	0.92
	ENJ2	4.93	1.43	−0.55	0.10	

Table 3. Descriptive statistics (mean (M), standard deviation (SD), skewness, kurtosis and Cronbach's alpha (α))

	MWT-D	MWT-S	Temporal dissociation	Enjoyment
MWT-D	*0.646*			
MWT-S	0.224	*0.670*		
Temporal dissociation	0.030	0.150	*0.665*	
Enjoyment	0.007	0.017	0.104	*0.856*

Note(s): The numbers on the diagonal are the average variance extracted (AVE). Off diagonal elements are the squared correlations between the constructs. For discriminant validity, diagonal elements should exceed the off-diagonal elements

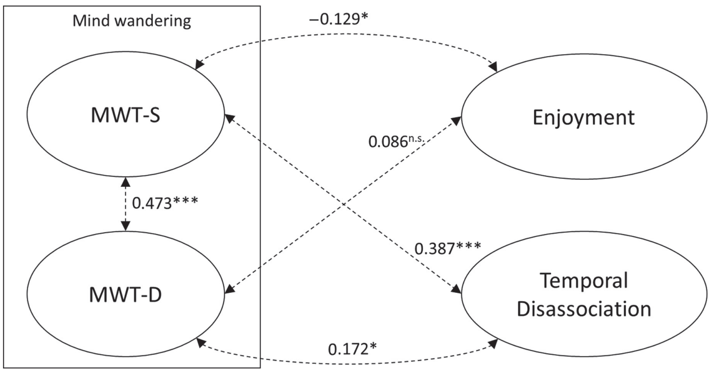
Table 4. Discriminant validity (Fornell–Larcker)

robust standard errors and a Satorra–Bentler scaled test statistic (i.e. MLM) and report the results as suggested by Kline (2016). The results suggest a significant χ^2 (164, N = 619) = 668.273, p = 0.000. The Comparative Fit Index (CFI = 0.939), Tucker–Lewis Index (TLI = 0.929), the Root Mean Square Error of Approximation (RMSEA = 0.070) and the Standardized Root Mean Square Residual (SRMR = 0.043) indicate a good model fit. The results related to the measurement model are summarized in Table 5. The standardized loadings are sufficiently high (> 0.721) and significant (p < 0.001).

The results related to the correlations between all factors is shown in Figure 1. Both dimensions of mind wandering correlate significantly (ϕ = 0.473, p < 0.001). With regards to

Table 5.
Measurement model (standardized loading (λ), standard error (se), z-value, p-value and confidence interval

Construct	Item	λ	se	z	p	95% confidence interval	
MWT-S	MWT-S1	0.842	0.015	55.575	0.000	0.813	0.872
	MWT-S2	0.867	0.013	65.628	0.000	0.841	0.893
	MWT-S3	0.866	0.013	64.630	0.000	0.840	0.893
	MWT-S4	0.820	0.017	47.714	0.000	0.786	0.854
	MWT-S5	0.727	0.025	28.977	0.000	0.677	0.776
	MWT-S6	0.808	0.018	44.944	0.000	0.773	0.843
	MWT-S7	0.834	0.018	46.350	0.000	0.798	0.869
	MWT-S8	0.804	0.018	44.018	0.000	0.768	0.839
	MWT-S9	0.811	0.017	47.428	0.000	0.777	0.844
	MWT-S10	0.822	0.017	48.888	0.000	0.789	0.855
MWT-D	MWT-D1	0.722	0.025	29.040	0.000	0.673	0.771
	MWT-D2	0.844	0.024	34.519	0.000	0.796	0.892
	MWT-D3	0.839	0.021	39.600	0.000	0.798	0.881
Enjoyment	ENJ1	0.960	0.023	41.744	0.000	0.915	1.006
	ENJ2	0.890	0.029	31.100	0.000	0.834	0.946
Temporal Dissociation	TD1	0.749	0.024	31.015	0.000	0.702	0.797
	TD2	0.756	0.025	30.430	0.000	0.707	0.805
	TD3	0.910	0.013	71.931	0.000	0.885	0.934
	TD4	0.721	0.029	24.728	0.000	0.664	0.778
	TD5	0.907	0.013	67.461	0.000	0.880	0.933



Note(s): Double-sided arrows indicate correlations. X^2(164, N = 619) = 668.273, CFI = 0.939, TLI = 0.929, RMSEA = 0.070, SRMR = 0.043. ***: p < 0.001, **: p < 0.05, *: p < 0.01, n.s.: not significant

Figure 1.
Results of the factor model

enjoyment, the results show a negative correlation with MWT-S ($\phi = -0.129$, $p < 0.01$) and a non-significant correlation with MWT-D ($\phi = 0.086$, $p > 0.1$). In terms of temporal dissociation, the results show a significant correlation with MWT-S ($\phi = 0.387$, $p < 0.001$) and positive correlations with MWT-D ($\phi = 0.172$, $p < 0.01$).

Table 6 summarizes our results with regards of the proposed hypothesis. H1a could not be supported as the data suggested a negative correlation. H1b could also not be supported as we could not interfere a significant relationship at all. H2a and H2b can both be supported.

5. Discussion

5.1 Discussion of the results

Our results indicate that the two sub-dimensions of perceived mind wandering relate differently to enjoyment, though not in the way originally supposed. Specifically, our study provides initial evidence that spontaneous mind wandering is negatively related with enjoyment while deliberate mind wandering is not. The finding of a negative association between spontaneous wandering and enjoyment is in line with Killingsworth and Gilbert (2010) who proposed that a "wandering mind is an unhappy mind", following their investigation of happiness and mind wandering. The lack of a positive correlation between deliberate mind wandering is possibly an effect of the MWT-D item, which is related to the prevention of boredom. This nonetheless suggests that it may be useful to distinguish between enjoyable mind wandering when investigating this construct in IS research. It also raises a question about whether deliberate mind wandering may specifically play a mediating role in constructs related to enjoyment.

Both MWT-S and MWT-D were found to be correlated with temporal dissociation. This is not surprising because the mind wandering and cognitive absorption constructs are used to describe phenomena where attention is directed from the outside world toward inwardly focused ideas (Sullivan and Davis, 2020), hinting at perceptual decoupling from the external environment. The temporal dissociation captured by the original cognitive absorption construct (Agarwal and Karahanna, 2000) similarly reflects the inward direction of attention of mind wandering. This finding is consistent with findings by Sullivan and Davis (2020) who reported a correlation between temporal dissociation and mind wandering, significant at the 0.01 level. Mind wandering experiences may consistently reflect temporal dissociation and may similarly influence IT use.

With regards to theory development, we interpret this research to lend evidence to the importance of distinguishing the varieties of mind wandering when conducting research in IT use or user experience. In line with Seli *et al.* (2018), future IS research on mind wandering would benefit from viewing mind wandering as a heterogeneous construct united by family resemblances rooted in common neurophysiology. Distinct varieties of mind wandering may interact differently with various well-studied IS constructs, though may consistently reflect temporal dissociation. This extends the current view of mind wandering in the IS discipline, which has so far investigated the construct as a singular phenomenon. Furthermore, the

Hypothesis	Support
H1a: MWT-S is positively correlated with enjoyment	no
H1b: MWT-D is negatively correlated with enjoyment	no
H2a: MWT-S is positively correlated with temporal disassociation	yes
H2b: MWT-D is positively correlated with temporal disassociation	yes

Table 6. Summary hypothesis

finding of negative correlation between spontaneous mind wandering and enjoyment, but no such correlation with deliberate mind wandering, suggests that the presence of spontaneous mind wandering specifically may have a moderating effect on the degree of enjoyment experienced during technology use.

5.2 On the importance of distinguishing cognitive processes

So far, we focused on two distinct types of mind wandering to demonstrate different effects on sub-dimensions of cognitive absorption. However, this raises an issue which has implications for IS research in cognitive processes broadly. When studying cognitive processes, such as those related to attention, memory or language, it is critical to precisely distinguish the variety of the process and its context. We argue that this is particularly relevant for cognitive constructs that have already been used as multi-dimensional concepts in previous IS literature such as IT mindfulness (Thatcher *et al.*, 2018).

Figure 2 conceptualizes the proposition that behavioral effects while using technology (right box) are built on cognitive processes (left box). Since cognition research is wide-ranging, IS scholars commonly refer to specific sub-processes in this regard, such as deliberate or spontaneous mind wandering. Those processes are operationalized and put into context by including the resulting effects (e.g. technology use behavior).

Following the above example, we identify three potential pitfalls that can occur if cognitive processes are not carefully distinguished in advance. First (point 1), specific effects of interest (e.g. technology use behavior) may not be adequately explained due to inaccurate conceptualizing of cognitive processes. In other words, relevant relationships might not be established, because the underlying mechanism (i.e. the cognitive process that is responsible for the relationship) is not explicit. Consequently, some amount of the explained variance might not be leveraged if scholars oversee the distinct sub-process of the overall cognitive processes.

Second (point 2), interrelationships between sub-processes and other more complex relationships cannot be considered if such distinctions are not made. In case of mind wandering, we assume that both types (deliberate and spontaneous) correlate with cognitive absorption but do so differently with various effects. Therefore, it is important to operationalize the sub-dimensions accordingly to conduct more detailed analysis with regards to specific effects.

Finally (point 3), accurately distinguishing cognitive processes can lead to profound new knowledge about humans' relationship with IT. IS research is increasingly drawing knowledge from other disciplines, such as neuroscience, and there are greater efforts to conduct interdisciplinary research (Riedl and Léger, 2016). Such efforts promise to not only create new areas of inquiry for IS researchers but also offer new insights that could improve the accuracy of models or inform the psychological or neurological origins of IS constructs and further expand the discipline. While we use mind wandering as an example in this study, the above points generalize to cognitive processes broadly, and the opportunities at hand are relevant to most cognitive processes used in the IS discipline.

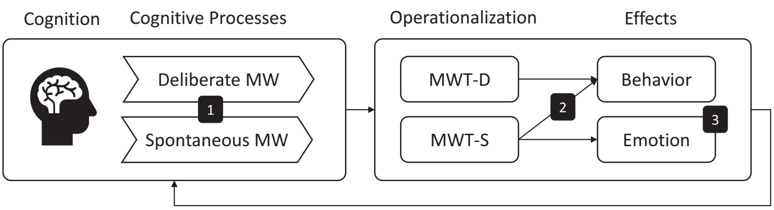


Figure 2.
Issues related to the operationalization of cognitive processes

5.3 Limitations

There are limitations to these findings, which must be considered when interpreting the results. First, though we observed a distinction between two varieties of mind wandering and a sub-dimensions of the cognitive absorption construct, it is important to note that many of the sub-dimensions were not observed to be correlated with mind wandering at all (Appendix). This contrasts with findings by Sullivan and Davis (2020) who found correlations between mind wandering and control and curiosity (though not enjoyment or focused immersion). This can in-part be accounted for by differences in the measures employed, though raises potential concerns about the consistency of mind wandering in relation to the cognitive absorption construct.

A second limitation is that the analysis conducted investigated perceptions about mind wandering and cognitive absorption during technology use, rather than use during a specific information use task. As discussed, the effects of varieties of mind wandering may be different depending on the specific context employed. Past and ongoing work in IS research investigates the differences between real-time experience and perceptions of mind wandering experiences (Conrad and Newman, 2019). By refraining from asking participants to identify a specific IT use instance, it is possible that the results reflect general perceptions, rather than causal relationships between the constructs in a specific IT context.

5.4 Future work

As IS researchers become more interested in the study of inwardly directed cognitive processes it is critical that they pursue clarity about the constructs being investigated. In this paper we presented evidence that two varieties of mind wandering (spontaneous and deliberate) may differently relate to cognitive absorption and consequently IT use. It is desirable to extend this research to findings in different IT use contexts. For example, Seli *et al.* (2018) point to literature where mind wandering has been observed to be beneficial to goal-directed thinking (Baird *et al.*, 2011) and creativity (Baird *et al.*, 2012), but also detrimental to successful learning (Wammes *et al.*, 2016) and completion of driving tasks (Yanko and Spalek, 2014). The varieties of mind wandering reported by researchers in psychology have varied greatly in terms of content intentionality, task relatedness and relationship to stimuli, which has been partially responsible for these seemingly contradictory findings (Seli *et al.*, 2018).

Research on mind wandering in the IS domain is in its nascent stages, which may be a benefit to researchers interested in pursuing questions related to it. By specifying the varieties of mind wandering in the context of an IT use task, we may discover ways that different varieties produce different effects, though may also discover commonalities between such contexts. If there is such a family of mind wandering constructs, does it have implications for IT design? What is the role of using different kinds of technologies such as voice assistance systems? By conducting inquiries to a many different IS phenomena and being specific about the mind wandering features being explored, we may discover a general theory about the role that mind wandering plays in IT use and the conditions under which mind wandering is either beneficial or a hindrance.

All of this underscores a more important point however, which is that the varieties of IS constructs studied in IT use settings are fundamentally the result of underlying cognitive mechanisms which could better explain the phenomenon in question. In the example explored in this paper, both the mind wandering and cognitive absorption constructs have been associated with processes of the DMN and executive brain networks. By studying the role that these networks play in an IT use setting, researchers may discover improved constructs for explaining user experience generally. The consistency of temporal dissociation may give insight into antecedents which underlie both the mind wandering and cognitive absorption constructs. Future work may also benefit by exploring the relationship between temporal dissociation and the performance of attentional mechanisms during IT use.

6. Conclusion

This research was motivated by a desire to better understand the role that mind wandering may play in IT use. We have evidence that mind wandering may be most relevant to IT use contexts when temporal dissociation is present, and that the variety of mind wandering experienced by users may be affected by hedonic experience. Moving forward, future research in mind wandering during IT use would benefit from exploring varieties of mind wandering and potentially its underlying psychophysiological mechanisms. Mind wandering is still a new field of research in the reference disciplines and is in its nascent stages in IS. By exploring the antecedents of constructs such as mind wandering and cognitive absorption, we may yet uncover better explanations about how we use IT and potentially design technologies which are better suited to humans' cognitive processes.

Note

1 We would like to thank one anonymous reviewer for raising a potential issue related to non-respondent bias and for suggesting to follow the procedure by Shiau and Chau (2016).

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Appendix

Cognitive absorption

Agarwal and Karahanna (2000) introduced cognitive absorption to the IS domain as a construct which includes five sub-dimensions: curiosity, control, temporal disassociation, focused immersion and heightened enjoyment. While cognitive absorption has gained significant attention in numerous studies (e.g. Saadé and Bahli, 2005), there are also authors who suggest that the concept is tighten during specific situations, and might be best observed by measuring the balance between task difficulty and the ability to attain a task (Léger *et al.*, 2014). To test the validity of cognitive absorption as originally proposed, we conducted confirmatory factor analysis to investigate whether the data support a five-dimensional second-order conceptualization and juxtaposed the results to a model with five first-order constructs. All items were measured as suggested by Agarwal and Karahanna (2000). We dropped curiosity 1 ("CU1") and two enjoyment items ("E3", "E4") to enhance the reliability of the constructs.

We carried out the analysis using the MLM estimator and compared both models based on the χ^2, the CFI, the TLI, the RMSEA and the SRMR. An overview of the results is shown in Table A1. Although both models did not exhibit high degrees of fit, there is a clear indication that the first-order model works better as it outperforms the second-order model in regard to all fit measures considered. We also carried out an analysis of variance to compare both models yielding a significant χ^2 test ($p < 0.01$).

Based on this insight, we conclude that cognitive absorption is not necessarily a second-order model in every situation and can be likewise observed with specific sub-dimensions. This is in line with Burton-Jones and Straub (2006) who already argued that it is critical to "balance parsimony with completeness" (p. 237, footnote 7) and only included focused immersion in their study. Thus, our study adds to this line of argument both on a conceptual level (as argued in the main article) and on an empirical level (as shown above) in the Appendix.

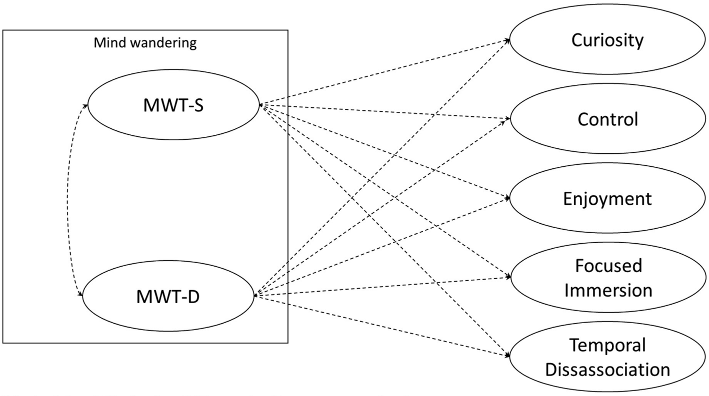
Table A1. Fit statistics for cognitive absorption (first-order model and second-order model)

Model	χ^2	df	CFI	TLI	RMSEA	SRMR
1st order	655.450	94	0.869	0.833	0.114	0.092
2nd order	539.161	73	0.877	0.846	0.121	0.106

While we fully agree that an act of balancing sub-dimensions can be defensible (Burton-Jones and Straub, 2006; Appendix), we also acknowledge that providing the results of a model that includes all sub-dimensions can also be an important contribution to inform future research. Consequently, we report an additional model that includes all sub-dimensions of cognitive absorption here. The complete model is shown in Figure A1.

We conducted a CFA to estimate the model parameter using the MLM estimator. The results suggest a significant χ^2 test $(384, N = 619) = 1559.907$, $p = 0.000$. The Comparative Fit Index (CFI $= 0.887$), Tucker–Lewis Index (TLI $= 0.872$), the Root Mean Square Error of Approximation (RMSEA $= 0.079$) and the Standardized Root Mean Square Residual (SRMR $= 0.095$) indicate a considerable model fit.

Table A2 summarizes the results related to the correlation model. The results indicate a non-significant relationship between deliberate mind wandering (MWT-D) and control ($p = 0.062$), focused immersion ($p = 0.339$) and enjoyment ($p = 0.097$). In contrast, the remaining sub-dimensions (curiosity and temporal dissociation) significantly correlate with deliberate mind wandering ($p = 0.001$



Note(s): All dashed lines indicate correlations

Figure A1. Complete model

		Coefficient	Standard error	z	p
MWT-D	CO	0.099	0.052	1.869	0.062
	CU	0.208	0.079	3.377	0.001
	FI	−0.053	0.088	−0.956	0.339
	TD*	0.172	0.087	3.262	0.001
	ENJ*	0.087	0.088	1.661	0.097
MWT-S	CO	−0.031	0.058	−0.638	0.524
	CU	0.060	0.085	1.091	0.275
	FI	−0.512	0.105	−9.313	0.000
	TD*	0.387	0.099	7.775	0.000
	ENJ*	−0.129	0.094	−2.803	0.005

Note(s): * Constructs used in the main model of this study (c.f. Figure 1). Control (CO), Curiosity (CU), Focused Immersion (FI), Temporal Disassociation (TD), Enjoyment (ENJ)

Table A2. Correlation results

and $p = 0.001$ respectively). With regards to spontaneous mind wandering, control and curiosity do not correlate significantly ($p = 0.524$ and $p = 0.275$). On the other hand, focused immersion ($p < 0.001$), temporal dissociation ($p < 0.001$) and enjoyment ($p = 0.005$) significantly correlate with spontaneous mind wandering.

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