Exploring Mind Wandering in a Technological Setting

Completed Research Paper

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Abstract

This study investigates the moderating role of mind wandering in influencing the relationships between on-task thought and two functional outcomes of interacting with technology (i.e., creativity and knowledge retention). The study extends the content regulation hypothesis of mind wandering by differentiating mind wandering into two categories—technology-related and nontechnology-related. The scales to measure mind wandering and on-task thought were first developed and validated. After that, the structural model was tested. The findings suggest that mind wandering (technology-related) positively moderates the relationship between on-task thought (technology-related) and creativity and mind wandering (nontechnology-related) positively moderates the relationship between on-task thought (nontechnology-related) and knowledge retention. The results also show that creativity is positively associated with knowledge retention. By acknowledging the potential benefits associated with mind wandering, this study is able to show that mind wandering is not always destructive; it can offer some unique benefits for technology users.

Keywords: Mind Wandering, On-task Thought, Knowledge Retention, Creativity, Information Systems
Introduction

It's a familiar scenario. You are working on your paper and realize you have been staring at the same paragraph for several minutes because you are thinking about the Facebook status you posted this morning. This phenomenon is known as self-generated thoughts or mind wandering—a shift of executive control away from a primary task to the processing of personal goals” (Smallwood and Schooler 2006, p. 946). Research has shown that people spend around 25 to 50 percent of their waking hours engaged in task-unrelated thoughts (e.g., Kane et al. 2007; Killingsworth and Gilbert 2010). Mind wandering occurs when the mind stops being present and thinks about concerns unrelated to the task at hand. For this reason, mind wandering has been associated with significant costs, including disrupted task performance, poor psychological wellbeing and unhappiness (Killingsworth and Gilbert 2010; McVay and Kane 2010; Moberly and Watkins 2008; Smallwood and Schooler 2006; Watkins 2008). So, the question arises: “if mind wandering is as costly as most studies suggest, why do we do it so often?” (McMillan et al. 2013; Schooler et al. 2014). In order to address this question, researchers in the field of mind wandering have started to explore the potential benefits of mind wandering, such as its contribution to future planning and creativity (e.g., Ruby et al. 2013; Smallwood and Schooler 2015). Given its benefits are less extensively studied, future studies answering the question of how mind wandering positively affects individuals’ functioning, are needed (Oettingen and Schwörer 2013; Smallwood and O’Connor 2011). By understanding the potential benefits of the mind wandering state, we can reveal core features of how thinking operates (Smallwood and Andrews-Hanna 2013) and in turn, identify what strategies that can be used to minimize its negative consequences and harness its potential benefits in a technology environment (Smallwood and Schooler 2015).

In a relatively short history of information systems (IS), which has inherited much of its models, theories and findings from other disciplines (e.g., management, economics, and psychology), mind wandering is virtually absent as a subject of research. As the use of technology has become an integral part of work, education, and communication (Czaja et al. 2006), the effect of mind-wandering on IS use outcomes needs to be investigated in our current technological age. The interaction between user and technology has been shown to be a major determinant of task performance (e.g., Burton-Jones and Straub 2006; DeLone and McLean 1992, 2003; van der Heijden 2004). Technology also provides a potential set of features that influence how individuals choose to perform a task (Fuller and Dennis 2009). However, it is unclear how technology users maintain their attentional process mechanism when they interact with technology, particularly during the learning process of how to use IS applications. Although research on how attention shifts between external sources in a technological setting has been extensively conducted in the IS field (e.g., Speier et al. 2003), research on how mind shifts between external events and internal thoughts unrelated to the primary task is relatively new (Smallwood and Schooler 2015). Therefore, research is needed to understand the nature, dimensionality, and relative effects of mind wandering experience on its functional outcomes.

The objective of this current paper is to investigate the potential benefits of mind wandering in a technological context. Two research questions are addressed: (1) How does mind wandering moderate the relationship between technology users’ on-task thought activities and users’ creativity? and (2) How does mind wandering moderate the relationship between technology users’ on-task thought activities and users’ knowledge retention? Although mind wandering is not always defined with respect to its relationship to a task, we focus on the occurrence of mind wandering associated with the primary task. This is also consistent with the previous literature (e.g., Smallwood and Schooler 2006) which explained that mind wandering is the process by which our attention is decoupled from the immediate task context. Whereas the majority of previous studies focused on investigating the direct effect of mind wandering and on-task thought on a variety of outcomes, such as performance (e.g., Franklin et al. 2011) and creativity (e.g., Baird et al. 2012), we argue that the effect of mind wandering should not be studied independently from on-task thought because interactions between the two variables may contribute to a successful problem solving (Christoff et al. 2009). For this reason, mind wandering is measured as a moderating variable, a variable that affects the relationship between on-task thought when individuals are engaged in a primary task and the higher-level outcomes (i.e., users’ creativity and knowledge retention).

In this study, the research questions are addressed by extending and testing a recent hypothesis that the content of mind wandering represents an important factor underlying its costs and benefits (Andrews-Hanna et al. 2013; Watkins 2008). The content regulation hypothesis proposes that the consequences of
mind wandering experiences can only be properly understood by taking into account the content of such experiences (Smallwood and Schooler 2015). In line with this hypothesis, we explore the possibility that the costs and benefits of mind wandering in a technological setting depend, in part, upon its phenomenological content (Andrews-Hanna et al. 2013). This paper makes several important contributions to the IS literature. First, by investigating the phenomena of mind wandering in a technological setting, this study advances our understanding about the consequences of mind wandering in everyday life. Second, understanding such phenomena will help technology users harness the beneficial aspects of mind wandering (Andrew-Hanna et al. 2013). By acknowledging the potential benefits associated with mind wandering, this study is able to show that mind wandering is not always destructive; it can offer some unique benefits for technology users. Third, the conceptual framework of mind wandering provided in this paper expands the hypothesis pertaining to the content of mind wandering in a technological setting, which has not been empirically investigated to this point.

Theoretical Background

What is Mind Wandering?

Mind wandering has been framed in the context of a variety of constructs, including “task-unrelated thoughts” (TUT) (Smallwood et al. 2003, 2004), “spontaneous thoughts” (Christoff et al. 2011), “day dreaming” (Giambra 1979), “task-unrelated images” (Giambra 1995), and “self-generated thoughts” (Andrews-Hanna et al. 2014). Mind wandering is a common everyday experience in which attention becomes disengaged from the external environment and focused on internal trains of thought (Schooler et al. 2014). When individuals mind wander, they become “perceptually decoupled,” showing attention becomes coupled to an internal process and decoupled from external stimuli (Smallwood 2010, 2013). Because attention is decoupled from the primary task, representations of the task may be less detailed than during periods of time when attention is focused on the task (Smallwood et al. 2006, 2007). Although most studies have focused on one or two aspects of mind wandering and their interactions, a few have assessed multiple types of thought content across a large group of individuals (Andrews-Hanna et al. 2014). Research exploring the content of mind wandering (i.e., content regulation hypothesis) has demonstrated a number of general principles that has enhanced our understanding about mind wandering (Smallwood and Schooler 2015). For example, using a thought sampling paradigm, Andrews-Hanna et al. (2013) found that individuals with more negative and more personally significant thoughts scored higher on constructs associated with depression and trait negative affect, whereas those who characterized their thoughts as less specific scored higher on constructs related to rumination. Previous research also has shown that individuals who mind wandered to positive events, and to concurrent as opposed to past activities, were attributed to boredom and therefore, led to perceived dissatisfaction with an ongoing task (Critcher and Gilovich 2010). To the same extent, Ruby et al. (2015) found that emotional content strongly predicted subsequent mood. However, this direct relationship was modulated by the socio-temporal content of thoughts: thoughts that were past- and other-related were associated with subsequent negative mood whereas future- and self-related thoughts preceded improvements of mood, even when current thought content was negative. In sum, these previous studies suggest that the outcomes of mind wandering are depending upon the content of self-generated thoughts. These studies also suggest that mind wandering can be characterized according to multiple interacting dimensions, including its personal significance, temporal orientation, valence, social orientation, and representational format (Andrews-Hanna et al. 2013) and the possible costs and benefits of mind wandering are depending on its content (Franklin et al. 2013).

Mind Wandering and On-Task Thoughts (Technology- versus Nontechnology-Related)

The content of mind wandering investigated by the previous studies have been primarily nontechnology-related (e.g., temporal focus, positive and negative events). As new technologies emerge and constantly outdate each other, it is difficult to imagine anyone living in a modern society without thinking about technologies in his/her everyday life. For example, when one is working on a financial report using Microsoft Excel, s/he could be thinking about checking his/her email. As an effort to understand the complexity of thought in the context of interaction with technology, de Guinea and Webster (2013) categorized the content of users’ thoughts into three objects: the computer system (e.g., thinking about how to insert a table), the task for which s/he is using the technology (e.g., writing a report), and
something else (e.g., mind wandering). In their study, de Guinea and Webster (2013) referred to the first category as computer-related and the latter two as non-computer-related thoughts (see de Guinea and Webster 2013 for details). However, they did not differentiate task-unrelated thought or mind wandering from on-task thought or task-related thought. Whereas mind wandering refers to “a shift of executive control away from a primary task to the processing of personal goals” (Smallwood and Schooler 2006, p. 946), task-related thought is defined as “thought maintained on the primary task at hand” (Randall et al. 2014, p. 1412). Task-related thought or on-task thought is theoretically and conceptually similar to mental or cognitive focus (Lee et al. 2003), which indicates the capacity to stay focused on the activity one is currently engaged in (Dimitrova 2015). Because on-task thought reflects conscious effort and attention directed at task completion, on-task thought activities are generally associated with high task performance and problem solving (Randall et al. 2014).

From a cognitive perspective, Orlikowski and Gash (1994) argued that understanding people interpretation of a technology is crucial to understand their interaction with it. To interact with technology, people have to make sense of it. In this making-sense process, they develop subjective assumptions, expectations and knowledge of the technology, which then lead to shape subsequent actions toward it. In other words, technology impacts our cognitive thought processes. For instance, de Guinea and Webster (2013) proposed that during regular or expected IT events, individuals tend to engage in non-computer-related thoughts whereas during unexpected IT events, computer-related thoughts will dominate individuals’ thoughts. In order to facilitate the unexpected events, users will redirect their thoughts away from other activities (e.g., task) and direct their thoughts to the technology, thus triggering computer-related thoughts. As time passes and problems are solved, individuals are likely to resume their original tasks, triggering non-computer-related thoughts. Interestingly, these different contents of thought influence individuals’ task performance over a period of time. The question arises of whether technology-related and nontechnology-related thoughts lead to different cognitive outcomes. If so, we would speculate that the content of mind may work as a vehicle for performance outcomes. Therefore, the given content of mind wandering can have a distinct effect on cognitive and behavioral outcomes (McVay et al. 2009), we extend the content regulation hypothesis by categorizing mind wandering into two dimensions: technology related—task-unrelated thought which occurs spontaneously and the content is related to the aspects of computer systems (e.g., email, social media, electronic devices)—and nontechnology related—task-unrelated thought which occurs spontaneously and the content is unrelated to the aspects of computer systems (see Table 1). The content of mind wandering is measured at the individual level (see Table 1, column 2).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Entity</th>
<th>Definition</th>
<th>Representative Thought</th>
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</thead>
<tbody>
<tr>
<td>Mind Wandering (Technology-related)</td>
<td>Person (Individual Level)</td>
<td>Task-unrelated thought which occurs spontaneously and the content is related to the aspects of computer systems.</td>
<td>Mind wandering about email, social media, and other online activities.</td>
</tr>
<tr>
<td>Mind Wandering (Nontechnology-related)</td>
<td>Person (Individual Level)</td>
<td>Task-unrelated thought which occurs spontaneously and the content is unrelated to the aspects of computer systems.</td>
<td>Mind wandering about self (Andrews-Hanna et al. 2013), other people (Ruby et al. 2013), past and future events (Baird et al. 2011), and emotional content (Poerio et al. 2013).</td>
</tr>
<tr>
<td>On-Task Thought (Technology-related)</td>
<td>Person (Individual Level)</td>
<td>Task-related thought which occurs when individuals think about the aspects of the computer systems used to complete the primary task at hand.</td>
<td>Task-related thought about how to use a technology and its various features (de Guinea and Webster 2013).</td>
</tr>
<tr>
<td>On-Task Thought (Nontechnology-related)</td>
<td>Person (Individual Level)</td>
<td>Task-related thought which occurs when individuals think about the primary task, but these thoughts are not related the aspects of computer systems.</td>
<td>Task-related thought about how to solve a work problem and how to correctly perform as many steps as possible (Kanfer and Ackerman 1989).</td>
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Oettingen and Schwörer (2013) discussed different forms of mind wandering and found that while mind wandering solely about a desired future leads to poor problem solving and behavioral change, mind wandering in the form of mental contrasting (e.g., mind wandering about future versus past events,
personal versus other people concerns, etc.) leads to skilled problem solving and substantial behavioral change. Given the perspective of mental contrasting potentially allows us to reveal the positive impact of mind wandering, we classify the thoughts about affective content, temporal content, and self-relevance into one category—nontechnology-related mind wandering and measure them as one dimension. In the context of technology interaction, on-task thought can also be differentiated into two categories—technology-related and nontechnology-related thoughts (de Guinea and Webster 2013). On-task thought (technology-related) occurs when individuals think about the aspects of the computer systems related to the task at hand whereas nontechnology-related on-task thought occurs when individuals spend thinking about the task, but these thoughts are not related to the aspects of computer systems.

Consequences of Mind Wandering

More than a decade of research has revealed the negative effect of mind wandering on task performance (e.g., McVay and Kane 2009; Smallwood et al. 2009). Although emerging evidence suggests that the role of mind wandering is not entirely pernicious, the value of mind wandering is less clear (Mooneyham and Schooler 2013; Smallwood and Schooler 2015). Recent research has suggested a functionality of mind wandering within creative thinking activities (Mooneyham and Schooler 2013). Mind wandering could be related to creative thinking because the outcomes of creative thinking depend on a capacity to generate mental contents that are divergent from current reality (Smallwood and Schooler 2015). Another potential benefit of mind wandering that has been uncovered in the literature is that mind wandering may also be useful during the completion of a primary task by providing mental breaks to relieve boredom from monotonous activities (Smallwood and Schooler 2015). It is possible that mind wandering may allow for period of dishabituation from the task, thus providing mind with an opportunity to return to the task with a refreshed capacity for attentive processing and in turn, enables individuals to retain more information or knowledge related to the task (Mooneyham and Schooler 2013). Given the primary context of the current study is users’ interaction with technology, particularly during the technology learning, we measured creativity and knowledge retention as the dependent variables.

Research Model and Hypotheses

Figure 1 presents the research model developed and tested in this study. We use the term mind wandering to represent an individual’s subjective experience of thinking off-task thoughts when s/he is on-task, regardless of whether the thinking was deliberate or not, conscious or not, spontaneous or not (Cowley, 2013). Consistent with this definition, we measured mind wandering with respect to its association with on-task thought and the effects of their interaction on two dependent variables (i.e., creative thinking and knowledge retention) discussed previously. Given we specifically focus on the interaction effect of mind wandering, we did not formally hypothesize the direct effects of mind wandering and on-task thoughts.

![Research Model](image)

We include several control variables in our model, given they may have an impact on either creative thinking or knowledge retention. These control variables are perceived software familiarity, software self-efficacy, and perceived task complexity. Perceived task complexity is arguable among external factors
shown in previous research to potentially affect knowledge retention and perceived creativity (see Kanfer and Ackerman 1989; Oldham and Cummings 1996; and Randall et al. 2014). Software self-efficacy and perceived software familiarity are both potentially associated with knowledge retention, in that individuals with high self-efficacy and who are familiar with the systems may learn faster than those who are not confident in using technology and not familiar with the systems. It is also possible that individuals with high levels of self-efficacy and familiarity with the technology may perform better in a creative thinking task. Therefore, consistent with prior research, we include software self-efficacy and perceived familiarity as control variables impacting perceived creativity.

**On-Task Thought, Mind Wandering, and Creativity**

In the study of IS, creativity has been associated with personal innovativeness—“the extent to which an individual actively generates, discovers, and promotes creative ideas” (Gray et al. 2011). Given creativity is a broad term, we specifically focus on one aspect of creativity—the generation of new and original thoughts (Dijksterhuis and Meurs 2006). Thus, in this current study, we measure creativity as an individual’s perception of his/her ability to generate novel, original ideas using IS.

The relationship among on-task thought, mind wandering, and creativity can be explained by the incubation paradigm (see Baird et al. 2012). According to this paradigm, enhanced integration of unassociated information during an incubation period of mind wandering can facilitate creative problem solving (Baird et al. 2012). Creativity has long been associated with the labor of the unconscious mind (Dijksterhuis and Meurs 2006). It is likely that unique insights are the results of a process whereby some initial conscious thought is followed by a period during which the problem is put to rest. Subsequently, after this period without conscious thought, a solution or idea presents itself. This stage during which one refrains from conscious thought and the unconscious is at work is called incubation (Dijksterhuis and Meurs 2006). Cited by Dijksterhuis and Meurs (2006), Schooler and Melcher (1995) reviewed the literature on incubation and concluded that distraction, such as mind wandering, can lead to “set-shifting.” When people approach a problem using some misleading cues, a period of mind wandering makes those such wrong approaches or cues become less accessible, and thus; allows for a fresh, unbiased new start (Dijksterhuis and Meurs 2006).

In a recent experiment, Baird et al. (2012) tested the hypothesis that mind wandering is associated with enhanced creativity. They found a positive relationship between mind wandering experience and performance of the divergent thinking task. Moreover, circumstances conducive to mind wandering (i.e., engaging in an undemanding task) during the incubation period (i.e., break time) improved creative performance on the assigned task. In a similar study, Ruby et al. (2013) found a positive relationship between mind wandering and the tendency to generate solution steps in a problem solving task. The findings from these previous studies provide convincing evidence that mind wandering can enhance creativity when on-task thought activities have already been activated. Another evidence comes from neuroimaging work indicating that executive systems (a part of the brain which is responsible for focused-attention) and default networks (a part of the brain which has been associated with the self-generated thought) interact during mind wandering episodes (Christoff et al. 2009). Given activations in both networks are observed prior to successful solution of insight problems, engaging in tasks conducive to mind wandering could contribute to incubation periods by creating a situation in which default and executive systems mutually contribute to associative processing (Baird et al. 2012). The positive, constructive perspective of mind wandering believes that self-generated thoughts provide a means to focus on and solve one’s current concerns (Smallwood et al. 2011). If mind wandering is associated with a balanced focus on the primary task, individuals could lead to the self-generation of pathways to problem solutions. Because both mind wandering and creative thinking depend on a capacity to generate mental contents that are divergent from current reality (Smallwood and Schooler 2015), individuals who are able to balance out the occurrence of mind wandering and simultaneously focus on their tasks are likely to achieve higher creative thinking. Thus, we hypothesize that mind wandering moderates the relationship between task-related thoughts and creativity—in which, an individual with high levels of task-related thought will have a higher level of creativity if s/he experiences high levels of mind wandering than if s/he experiences low levels of mind wandering.

We also argue that the content of mind wandering has to be associated with the content of task-related thought in the sense that mind wandering (technology-related) moderates the relationship between on-task thought (technology-related) and perceived creativity. This argument is consistent with the
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associative learning perspective. Although on-task thought leads people to strongly focus on a limited number of attributes associated with the primary task, it is less associative and neglects less obvious or less accessible information (Dijksterhuis and Meurs 2006). Mind wandering, on the other hand, is less convergent and more divergent. The process is more associative and able to reach the less obvious and less accessible information (Dijksterhuis and Meurs 2006). Thus, the ability to learn associations between the content of task-related thought (technology-related) and mind wandering (technology-related) appears to be more strongly related to creative thinking. Thus, we hypothesize that:

H1: Mind wandering (technology-related) moderates the relationship between on-task thought (technology-related) and perceived creativity, in which the effect of on-task thought (technology-related) on creativity is higher for users who experience high levels of mind wandering (technology-related) than for those who experience low levels of mind wandering (technology-related).

Nontechnology-related mind wandering consists of thoughts about affective content, temporal content, and self-relevance. A number of studies have revealed that such contents of mind wandering generally provide a means to focus on and solve one’s current concerns (Klinger 2009; Smallwood and Andrews-Hanna 2013). Smallwood et al. (2011) found that participants who displayed the strongest self-relevant mind wandering would be most likely to entertain thoughts about temporal content. Thoughts about past and future are often characterized by a recent and immediate focus, inviting the speculation that such thoughts provide a means to consolidate recent and upcoming experiences into long-term memory (Smallwood and Andrews-Hanna 2013; Wemsley and Stickgold 2010). From an evolutionary perspective, the temporal dynamics of mind wandering allows us to simulate plausible outcomes of alternative plans, including the emotional states of ourselves and other people in response to such plans (Gilbert and Wilson 2007; Oettingen and Schwörer 2013). When mind wandering triggered by contextual factors, such as affective and temporal content, mind wandering can work as a vehicle for problem solving through creative thinking. It is likely because when one focuses on his or her attention on how to solve the problem (i.e., on-task thought/nontechnology-related), mental contrasting strengthens the associations between the problem and instrumental means to overcome the problem (Oettingen and Schwörer 2013). Thus, in hypothesis 2, we predict that the interaction between on-task thought and nontechnology-related mind wandering will have a positive effect on creative thinking.

H2: Mind wandering (nontechnology-related) moderates the relationship between on-task thought (nontechnology-related) and perceived creativity, in which the effect of on-task thought (nontechnology-related) on creativity is higher for users who experience high levels of mind wandering (nontechnology-related) than for those who experience low levels of mind wandering (nontechnology-related).

On-Task Thought, Mind Wandering, and Knowledge Retention

Knowledge retention is an important aspect of learning processes (Bandura 1986). In the context of technology learning, successful learning requires that individuals integrate information from environment with their own internal representation (Smallwood et al. 2007). Knowledge retention has also been long considered a critical resource of firms and economies (Lam 2000). Knowledge retention activities may influence a number of business outcomes, including innovative performance, new product development performance (Marsh and Stock 2006), project implementation success (Sharma and Yetton 2007), and overall business performance (Cross and Baird 2000). In this current study, we measure perceived knowledge retention in the context of technology learning—immediately after the completion of an IS task. Although perceived knowledge may not represent individuals’ actual knowledge, actual and perceived knowledge retention are likely to coincide after knowledge has been acquired and integrated (Park et al. 1998). At this stage, individuals are aware of the extensive learning process they have gone through to acquire such knowledge (Park et al. 1998). Given we measure perceived knowledge retention after participants completed their task, we argue that the discrepancy between and actual and perceived knowledge retention may be relatively small.

During knowledge retention processes, information and/or experiences are converted for memory representation into symbolic conceptions (Yi and Davis 2003). Given that mind wandering suppresses the brain’s response to external stimuli that are either relevant or irrelevant to the primary task and instead focuses attention on internal thoughts, mind wandering has been shown to have a negative effect on knowledge or learning retention (e.g., Schooler et al. 2014; Smallwood et al. 2008). Mind wandering not only produces deficits in immediate comprehension (e.g., causing an individual to incorrectly answer a
As we mentioned previously, mind wandering can have beneficial aspects in our everyday cognition. One breaks from external tasks, thereby achieving distributed rather than masses practice (McMillan et al. 2014). Whereas mind wandering can have a negative effect on knowledge or learning retention, research and theory agree that task-related thought is positively associated with knowledge retention and high task performance (Kanfer and Ackerman 1989). The allocation of an individual’s attention to thoughts and behaviors that enhance the learning process will lead to increases in knowledge acquisition (Kanfer and Ackerman 1989). Although empirical evidence led us to predict that the correlation between mind wandering and knowledge retention would be negative, it would be unwise to ignore the theoretical argument and empirical support that mind wandering is an essential element of a healthy, satisfying mental life (Singer 1966; McMillan et al. 2013). Despite its negative consequence on performance, recent research has shown that on standardized tests, when students are allowed to mind wander and make personal connections to their own lives, they perform better on exams (Kaufman 2013). Although these findings seem contradictory to prior studies, we argue that they could be complementary to each other.

As we mentioned previously, mind wandering can have beneficial aspects in our everyday cognition. One of mind wandering adaptive functions is dishabituation which enhances learning by providing short breaks from external tasks, thereby achieving distributed rather than masses practice (McMillan et al. 2013). By disengaging from the primary task, individuals are expecting to pursue an external stream of thought that they expect to pay off in some way, such as new synthesis of material or insight (McMillan et al. 2013). If this process is initiated deliberately, it is expected that individuals who engage in task-relevant thought while mind wander will be able retain knowledge or information better than individuals who do not mind wander. A positive interaction between on-task thought and mind wandering in influencing knowledge retention is also supported by the Developmental Theory of Personal Intelligence proposed by Kaufman (2013). According to this theory, intelligence is an adaptation process to task demands that are relevant to attaining personal goals (e.g., mind wandering), not just adaptation to the external goals (e.g., primary task) (Kaufman 2013). The theory argues that individuals’ controlled forms of cognition (e.g., attention focus) and spontaneous forms of cognition (e.g., intuition, affect, insights, and spontaneous triggering of episodic memories) are important potential contributors to the personal learning process (McMillan et al. 2013).

We argue that the interaction between mind wandering and on-task thought will be beneficial if the contents of both thought processes are closely related. This argument is in line with the implicit learning perspective. As a human being, we have this ability to automatically learn, with or without our conscious awareness (Kaufman et al. 2010). This implicit learning is typically characterized by a set of automatic, associative, nonconscious, and unintentional thought processes (Kaufman et al. 2010). In this context, learning is often termed as associative, when learning proceeds incidentally, because it describes the incidental formation of associations (Kaufman et al. 2010). Given the fact that implicit learning requires the formation of associations, it is reasonable to argue that focus on and mind wander about technology-related contents will trigger learning cues that are related to technology learning. Thus, we hypothesize that:

**H3:** Mind wandering (technology-related) moderates the relationship between on-task thought (technology-related) and knowledge retention, in which the effect of on-task thought (technology-related) on knowledge retention is higher for users who experience high levels of mind wandering (technology related) than for those who experience low levels of mind wandering (technology-related).

Similarly, letting our mind wander about other issues unrelated to technology (e.g., temporal content, personal worry, and self-relevance) is likely to spontaneously trigger memories about task cues unrelated to the aspects of technology. For instance, Mind wandering about personal worry and affective content can be seen as an attempt to prepare for the worst and to problem solving. In its relationship with the primary task, it can serve as a preparation function, motivating individuals to engage in problem solving behaviors and adopt adaptive behaviors that reduce potential threats (Watkins 2008). Further, mind wandering about these nontechnology-related contexts have been associated with self-reflection—self-consciousness that involve exploration of novel and unique ideas, motivated by curiosity and pleasurable, intrinsic interest in learning (Trapnell and Campbell 1999; Watkins 2008). This self-reflection motivates individuals to learn subject matters relevant to the task at hand and is associated with an attempt to enhance their own knowledge (Watkins 2008). Moreover, mind wandering about temporal content and personal feeling during learning may provide the mind with an opportunity to relax and return to the task.
with higher attention capacity (Mooneyham and Schooler 2013). Thus, mind wandering (nontechnology-related) associated with on-task thought could potentially enhance knowledge retention beyond the level that occurs when individuals are fully on-task (Mooneyham and Schooler 2013).

**H4:** Mind wandering (nontechnology-related) moderates the relationship between on-task thought (nontechnology-related) and knowledge retention, in which the effect of on-task thought (nontechnology-related) on knowledge retention is higher for users who experience high levels of mind wandering (nontechnology related) than for those who experience low levels of mind wandering (nontechnology-related).

**Creativity and Knowledge Retention**

Creativity is indicated when one produces a novel solution that solves a problem one is facing (Mayer 1989). Individuals with high creativity are likely to discover alternative procedures or processes that are more effective (Gong et al. 2009). In the creative learning literature, it is argued that if students are given the opportunity to being creative and fully explore something new, they are more likely to create lasting memories and have a greater understanding of the topic (Mayer 1989). Active learning is associated with creativity and generation of novel ideas and innovative solutions that require divergent thinking and access to a variety of alternatives (Choo et al. 2007). Thus, it may generate more variation that can be effectively assimilated (Katz-Navon et al. 2009). In their meta-analytic, Barrick and Mount (1991) found that being imaginative and creative predicted training proficiency. They suggested that individuals who are creative and open to new experiences are more likely to have positive attitudes toward learning experiences (Gully et al. 2002). In sum, creativity may influence knowledge retention. Thus, we hypothesize:

**H5:** Creativity is positively associated with knowledge retention.

**Research Method**

Mind wandering may have been overlooked by many researchers out of concern that it was too difficult to study (Schooler et al. 2014). However, a number of studies have validated self-reports of mind wandering (e.g., Mrazek et al. 2013) and demonstrated that they reliably predict various outcomes, such as performance error (e.g., Smallwood et al. 2004) and happiness (Killingsworth and Gilbert 2010). Thus, in this current study, we adopted a self-report technique to measure the occurrence of mind wandering and on-task thought during an actual IS task—a task that requires a certain degree of computer skills.

**Instrumental Development**

After constructing our conceptual framework, we developed and validated survey measures for each thought category in our model. When possible, the measurement items of the constructs were developed based on existing scales in extant literature that have been proven reliable; otherwise, we developed new measures by following the procedures proposed by MacKenzie et al. (2011). After we developed a conceptual definition of the new constructs (see the previous section), we generated the survey items from the theoretical definitions and a review of literature. Following this, we assessed the content validity of the items. After that, we collected data to conduct pretest. After we purified and refined the items, we conducted a preliminary test of the convergent and discriminant validity of the scales. In the last stage, we collected a new dataset and tested our structural model. Items to measure mind wandering (nontechnology-related) were adapted from Sarason et al. (1986)\(^1\) and items to measure on-task thought

\(^{1}\)Given longer surveys take more time to complete and tend to have more missing data than short surveys, we decided to shorten the CIQ questionnaire proposed by Sarason et al. (1986). First, items were chosen based on their factor loading scores reported in their original scales (Stanton et al. 2002). Second, items’ clarity of expression and their relevance to our target population were taken into account in deciding which items should remain in the survey (Stanton et al. 2002). For example, the first 10 items of the CIQ questionnaire were not included to measure mind wandering because these items refer to aspects of self-evaluation (Sarason et al. 1986) and are more relevant to measure self-regulatory activities (see Kanfer and Ackerman 1989). Sarason et al. (1989) indicated that the remaining items of the CIQ questionnaire are the actual items used to measure a diversity of thoughts unrelated to the task. Given we specifically focus on the content of mind wandering, item 11 (i.e., I thought about other activities, such as assignment and work) was also dropped from the survey. Item 16 (i.e., I thought about something that made me feel tense) was also excluded from the actual survey due to its redundancy with item 15. Results indicate that the 9-item version possesses acceptable psychometric properties when used to measure the state of mind wandering. We therefore conclude that the threat to content validity for using a short version of the CIQ questionnaire is not a significant factor in this current study.
Exploring Mind Wandering in a Technological Setting

(nontechnology-related) were adapted from Kanfer et al. (1994). Items to measure mind wandering (technology-related) and on-task thoughts (technology-related) were developed for the purpose of this study. Based on a review of previous research and theory in the IS discipline (e.g., de Guinea and Webster 2013), we generated seven items to measure on-task thought (technology-related) and seven items to measure mind wandering (technology-related). Consistent with the previous theories on mind wandering (e.g., Sarason et al. 2002), all constructs were measured reflectively on seven-point Likert scales. Content validity of the items was obtained in two different stages. In the first, after we generated the items, we subjected these new items, along with the other items in the survey, to a card sorting exercise (Polites and Karahanna 2012). Seven graduate students participated in the card sorting exercise. At the end of the exercise, we asked the participants to report any issues pertaining to the wording of the items. The sorting resulted in a satisfactory classification of items into our predefined categories. In the second stage, we collected a small sample size to test whether our survey items are consistent with the definitions of our definitions of each thought. Based on the feedback, the measurement items were modified.

**Preliminary Assessment of Convergent and Discriminant Validity**

The objective in this stage was to establish the convergent and discriminant validity of the scales (Maynes and Podsakoff 2014). This assessment was conducted in two separate steps. In the first step, we conducted an exploratory factor analysis (EFA) to identify the underlying relationships between measured variables. Next, we examined the convergent and discriminant validity of the mind wandering and on-task thought measures at the item- and construct-level using confirmatory factor analysis (CFA) procedures in Lisrel 8.8.

The online questionnaire was administered to a sample of undergraduate students taking basic IS courses at a large university in the United States. Participants received extra credit as an exchange for their participation. The first author of this paper was granted a permission to visit the classes and gave a short presentation about the study. Participants were instructed to fill out the questionnaire right after they did their computer assignment for the courses. The course instructors were notified to send out the survey link by the assignment deadline. At the end of the study, a total of 406 valid responses were collected. 50 percent of the respondents were less than 20 years old and around 41 percent were between 21 and 25 years old. 49 percent were males and 51 percent were females. Based on the results of EFA, two items of mind wandering (technology-related) and two items of on-task thought (nontechnology-related) were dropped. As predicted, the final items of each category of thought loaded higher into their theoretical constructs than into other constructs. Together, four factors extracted accounted for 75 percent of the variance.

Further, we conducted a CFA to examine the adequacy of the measurement model. The first model was a four-factor model. Results indicate high levels of convergent validity. Each factor loading is strong and significant (all p values < .01), and the average variance extracted (AVE) value for each type of thought is well above a recommended value of .50 (Fornell and Larcker 1981). Results also indicate high levels of discriminant validity. As shown in Table 2, the hypothesized four-factor model fit the data significantly better than other alternative measurement models. Finally, goodness-of-fit indices for the four-factor model met the criteria suggested by Hu and Bentler (1999). Based on the results of this validation process, all of the measurement items were considered sufficient. Next, we collected a new dataset to test our structural model.

<table>
<thead>
<tr>
<th>Description</th>
<th>$X^2$</th>
<th>$df$</th>
<th>$X^2/df$</th>
<th>$\Delta X^2/\Delta df$</th>
<th>CFI</th>
<th>IFI</th>
<th>SRMR</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-factor model (hypothesized model)</td>
<td>615.63</td>
<td>262</td>
<td>2.34</td>
<td>-</td>
<td>.98</td>
<td>.98</td>
<td>.04</td>
<td>.06</td>
</tr>
<tr>
<td>3-factor model (mind wandering combined)</td>
<td>1393.20</td>
<td>265</td>
<td>5.25</td>
<td>259.19***</td>
<td>.95</td>
<td>.96</td>
<td>.06</td>
<td>.10</td>
</tr>
<tr>
<td>3-factor model (on-task thought combined)</td>
<td>2217.97</td>
<td>265</td>
<td>8.37</td>
<td>534.11***</td>
<td>.94</td>
<td>.94</td>
<td>.07</td>
<td>.13</td>
</tr>
<tr>
<td>1-factor model (all combined)</td>
<td>8060.40</td>
<td>268</td>
<td>30.07</td>
<td>1240.80***</td>
<td>.79</td>
<td>.79</td>
<td>.25</td>
<td>.27</td>
</tr>
</tbody>
</table>

Notes: df = degree of freedom; CFI = Comparative Fit Index; SRMR = Standardized Root Mean Residual; IFI = Incremental Fit Index; RMSEA = Root Mean Square Error of Approximation; ***p<.001.
Exploring Mind Wandering in a Technological Setting

Data Collection to Test the Structural Model

In order to test our proposed hypotheses, we collected data by administering a web-based survey, which was considered appropriate since our target respondents were individuals who used IS as a part of their profession. Undergraduate students majoring in business at a large university in the United States were recruited to participate in the study as an exchange for course credit. Despite concerns regarding students subjects (Compeau et al. 2012), we believe our sample was suitable for two reasons. First, research shows that students used a number of technologies for both learning and socialization (e.g., Margaryan et al. 2011). Although no study has directly assessed mind wandering in an actual learning environment, we can be certain that it occurs in an educational setting (Smallwood et al. 2007). Second, using a student sample is relevant in the context of our study because students were interacting with technology when they learn the computer concepts in their core IS courses (e.g., database management, systems analysis and design, etc.).

For the research purpose, only students enrolled in MS. Access course were invited to participate in the study. Participants were instructed to complete a specific chapter of MS. Access as a part of their class assignment. They were instructed to fill out the questionnaire immediately after they completed their assignment. The course instructors worked with the researchers to determine the deadline for both the assignment and survey. Participants were asked to report their thought experiences during their interaction with MS. Access. The items used to measure knowledge retention were adapted from Yi and Davis (2003) and the items to measure perceived familiarity were adapted from Gefen (2000). Further, the items to measure self-efficacy were adapted from Thatcher and Perrewe (2002); items to measure creativity were adapted from Zhou and George (2001); and items to measure task complexity were adapted from Seijts et al. (2004). In total, a sample of 326 valid responses was included in the data analysis. Of the 326 respondents, 53 percent were males and over 65 percent were in the 21 to 25 age range. Over 85 percent of the respondents were English native speakers.

Data Analysis and Results

Assessment of Measurement Model

The measurement and structural models were tested using structural equation modeling (SEM). The covariance-based SEM was used to evaluate the psychometric properties of measurement scales and the component-based partial least squares (PLS) (Ringle et al. 2005) was used to test the research hypotheses proposed in this study. PLS was utilized to accommodate the exploratory nature of the research model (Jöreskog and Wold 1982), which is the case in our study.

Six CFA were examined at this stage. As indicated in the first row of Table 3, the hypothesized model of 4-factor model fit the data significantly better than other alternatives models (three-factor models and one-factor model). These results were consistent with our preliminary assessment of convergent and discriminant validity reported in Table 2. The next CFA was constructed as a six-factor model wherein the measures of creativity and knowledge retention constructs were modeled as separate constructs. In the last CFA, we constructed a nine-factor model by adding the control variables in addition to the dependent variables. As we hypothesized, our measurement model demonstrates a sufficient level of discriminant validity.

### Table 3: Summary of Model Fit for All CFAs Examined (N = 323)

<table>
<thead>
<tr>
<th>Description</th>
<th>X²</th>
<th>df</th>
<th>X²/df</th>
<th>ΔX²/Δdf</th>
<th>CFI</th>
<th>IFI</th>
<th>SRMR</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-factor model (hypothesized model)</td>
<td>573.86</td>
<td>262</td>
<td>2.19</td>
<td>-</td>
<td>.98</td>
<td>.98</td>
<td>.05</td>
<td>.06</td>
</tr>
<tr>
<td>3-factor model (mind wandering combined)</td>
<td>1549.59</td>
<td>265</td>
<td>5.84</td>
<td>325.24***</td>
<td>.94</td>
<td>.94</td>
<td>.08</td>
<td>.12</td>
</tr>
<tr>
<td>3-factor model (on-task thought combined)</td>
<td>1256.72</td>
<td>265</td>
<td>4.74</td>
<td>227.62***</td>
<td>.95</td>
<td>.95</td>
<td>.08</td>
<td>.11</td>
</tr>
<tr>
<td>1-factor model (all combined)</td>
<td>5510.37</td>
<td>473</td>
<td>20.56</td>
<td>882.75***</td>
<td>.79</td>
<td>.79</td>
<td>.22</td>
<td>.25</td>
</tr>
<tr>
<td>6-factor model without control variables</td>
<td>976.54</td>
<td>473</td>
<td>2.06</td>
<td>-</td>
<td>.98</td>
<td>.98</td>
<td>.05</td>
<td>.06</td>
</tr>
<tr>
<td>9-factor model with control variables</td>
<td>1331.17</td>
<td>774</td>
<td>1.72</td>
<td>-</td>
<td>.98</td>
<td>.98</td>
<td>.05</td>
<td>.05</td>
</tr>
</tbody>
</table>

Notes: df = degree of freedom; CFI = Comparative Fit Index; SRMR = Standardized Root Mean Residual; IFI = Incremental Fit Index; RMSEA = Root Mean Square Error of Approximation; ***p<.001.
The results of CFA of the eight-factor model, reported in Table 4, indicate high levels of convergent validity. Each factor loading is strong and significant (all p values < .01), and the average variance extracted (AVE) value for each dimension of thought is well above Fornell and Larcker’s (1981) suggested cutoff of .50. Further, the composite reliability (CR) values for all of the constructs are greater than .70, demonstrating that all constructs have adequate reliability scores. The means, standard deviations, reliabilities, AVE values, and correlations are reported in Table 5. As indicated in Table 5, the square root of the AVE for each construct in the model is larger than the corresponding off-diagonal correlations of the constructs to their latent variables. These results provide substantial evidence for the convergence/discriminant validity of the items and overall measurement model.

<table>
<thead>
<tr>
<th>Constructs/Items</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mind wandering (nontechnology-related) (CR; AVE)</strong></td>
<td>(.95; .67)</td>
</tr>
<tr>
<td>1. I thought about members of my family.</td>
<td>.77</td>
</tr>
<tr>
<td>2. I thought about friends.</td>
<td>.83</td>
</tr>
<tr>
<td>3. I thought about something that made me feel guilty.</td>
<td>.63</td>
</tr>
<tr>
<td>4. I thought about personal worries.</td>
<td>.80</td>
</tr>
<tr>
<td>5. I thought about something that made me feel angry.</td>
<td>.78</td>
</tr>
<tr>
<td>6. I thought about something that happened earlier today.</td>
<td>.85</td>
</tr>
<tr>
<td>7. I thought about something that happened in the recent past (last few days, but not today).</td>
<td>.86</td>
</tr>
<tr>
<td>8. I thought about something that happened in the distant past.</td>
<td>.80</td>
</tr>
<tr>
<td>9. I thought about something that might happen in the future.</td>
<td>.78</td>
</tr>
<tr>
<td><strong>Mind wandering (technology-related) (CR; AVE)</strong></td>
<td>(.94; .77)</td>
</tr>
<tr>
<td>1. I thought about checking my email.</td>
<td>.75</td>
</tr>
<tr>
<td>2. I thought about checking my social media (e.g., Facebook).</td>
<td>.88</td>
</tr>
<tr>
<td>3. I thought about browsing other stuff.</td>
<td>.93</td>
</tr>
<tr>
<td>4. I thought about checking my phone.</td>
<td>.80</td>
</tr>
<tr>
<td>5. I thought about doing other online activities (e.g., online shopping, online game).</td>
<td>.87</td>
</tr>
<tr>
<td><strong>On-task thought (technology-related) (CR; AVE)</strong></td>
<td>(.94; .71)</td>
</tr>
<tr>
<td>1. I focused on how to use MS. Access to complete my task.</td>
<td>.87</td>
</tr>
<tr>
<td>2. I paid attention on different features of MS. Access to complete my task.</td>
<td>.91</td>
</tr>
<tr>
<td>3. I focused my attention on different options provided by MS. Access to format my task.</td>
<td>.91</td>
</tr>
<tr>
<td>4. I focused my attention on learning specific MS. Access functions.</td>
<td>.90</td>
</tr>
<tr>
<td>5. I paid close attention to the kind of errors I was making when I was using MS. Access.</td>
<td>.78</td>
</tr>
<tr>
<td>6. I focused my total attention on making sure my computer outputs were correct.</td>
<td>.70</td>
</tr>
<tr>
<td>7. I focused my total attention on following the MS. Access instructions correctly.</td>
<td>.57</td>
</tr>
<tr>
<td><strong>On-task thought (nontechnology-related) (CR; AVE)</strong></td>
<td>(.90; .70)</td>
</tr>
<tr>
<td>1. I focused my total attention on how I could solve the problem.</td>
<td>.63</td>
</tr>
<tr>
<td>2. I thought about strategies for solving the problem.</td>
<td>.91</td>
</tr>
<tr>
<td>3. I thought ahead to what I would do next to solve the problem.</td>
<td>.90</td>
</tr>
<tr>
<td>4. I focused my attention on correctly performing as many steps as I could.</td>
<td>.67</td>
</tr>
<tr>
<td><strong>Creativity (CR; AVE)</strong></td>
<td>(.96; .85)</td>
</tr>
<tr>
<td>When you were doing your assignment, to what extent do you agree with these statements?</td>
<td></td>
</tr>
<tr>
<td>1. I was able to come out with a new way to solve the problems.</td>
<td>.90</td>
</tr>
<tr>
<td>2. I could come up with new and practical ideas to complete the assignment.</td>
<td>.98</td>
</tr>
<tr>
<td>3. I searched out new technologies or techniques to solve the problems.</td>
<td>.83</td>
</tr>
<tr>
<td>4. I could come up with creative solutions to approach the problems.</td>
<td>.91</td>
</tr>
<tr>
<td><strong>Knowledge Retention (CR; AVE)</strong></td>
<td>(.96; .85)</td>
</tr>
<tr>
<td>After I was doing my assignment using MS. Access,</td>
<td></td>
</tr>
<tr>
<td>1. I was able to summarize the key aspects of MS. Access beyond what I had been taught in class.</td>
<td>.84</td>
</tr>
<tr>
<td>2. I was able to symbolically process the problem beyond what I had been taught in class.</td>
<td>.89</td>
</tr>
<tr>
<td>3. I was able to mentally visualize the specific functions of MS. Access beyond what I had been taught in class.</td>
<td>.91</td>
</tr>
<tr>
<td>4. I was able to mentally practice the specific functions of MS. Access beyond what I had been taught in class.</td>
<td>.92</td>
</tr>
<tr>
<td><strong>Perceived Familiarity (CR; AVE)</strong></td>
<td>(.96; .88)</td>
</tr>
<tr>
<td>1. I’m familiar with MS. Access before I was taking this class.</td>
<td>.97</td>
</tr>
<tr>
<td>2. I’m familiar with MS. Access through other sources (e.g., self-learning, other classes).</td>
<td>.92</td>
</tr>
<tr>
<td>3. MS. Access is not new to me.</td>
<td>.84</td>
</tr>
<tr>
<td><strong>Software Self-Efficacy (CR; AVE)</strong></td>
<td>(.91; .77)</td>
</tr>
<tr>
<td>1. I was able to use MS. Access if there was no one around me to tell me what to do.</td>
<td>.77</td>
</tr>
</tbody>
</table>
Further, common method bias can be a potential threat to the study if the independent and dependent variables are obtained from the same sources (Podsakoff et al. 2003). In order to determine whether common method bias was a concern, we performed the Harman’s single-factor test suggested by Podsakoff et al. (2003). We also performed a marker variable technique suggested by Lindell and Whitney (2001). The results of both techniques indicate common method bias is not a significant threat in this study.

**Assessment of Structural Model**

The results of the structural model are presented in Table 6. A structural model with the control variables only was first examined. After that, we ran the model without the interaction terms, and then we added the interaction terms in the third model (Aiken and West 1996). To reduce multicollinearity among the interaction terms, the score of each construct was mean-centered before the interaction terms were created (Jaccard et al. 1990). The Variance Inflation Factors (VIFs) were also computed and the results suggested that multicollinearity was not a major concern for all of the variables.

**Control Variables**

Although the effects of software self-efficacy and perceived familiarity on perceived creativity were significant, adding the main and interaction effects in the model significantly increased the total R² (see Model 2 and 3). Similarly, the effect of software self-efficacy on knowledge retention was significant. However, in the presence of main predictors and interaction terms, the result was no longer significant. The effect of perceived familiarity was also significant in the model with control variables only. However, its effect was attenuated by the main predictors and interaction terms.

**Hypotheses Testing**

As shown in Table 6, on-task thought (technology-related) did not have a significant effect on creativity. However, on-task thought (nontechnology-related) did. Whereas mind wandering (technology-related) did not have a significant effect on perceived creativity, the direct effect of mind wandering (nontechnology-related) on creativity was positive and significant. As hypothesized, H1 was supported. The interaction between on-task thought (technology-related) and mind wandering (technology related) significantly increased R² of creativity by 3 percent, indicating a small-to-medium effect size (f² = .05). For better visual clarity, we plotted this moderating effect in Figure 2. As predicted, at high level of mind
wandering (technology-related), creativity increases rapidly when on-task thought (technology-related) increases. However, at low level of mind wandering (technology-related), creativity increase marginally as on-task thought (technology-related) increases. However, the interaction between on-task thought (nontechnology-related) and mind wandering (nontechnology-related) in influencing creativity was not significant. Thus, H2 was not supported.

Further, the direct effect of on-task thought (technology-related) on knowledge retention was positive and significant. As expected, the direct effect of mind wandering (technology-related) on knowledge retention was negative and significant. However, the direct effects of on-task thought (nontechnology-related) and mind wandering (nontechnology-related) on knowledge retention were not significant. Moreover, the interaction between on-task thought (technology-related) and mind wandering (technology-related) was not significant. Thus, H3 was not supported. As we hypothesized, the interaction between on-task thought (nontechnology-related) and mind wandering (nontechnology-related) was significant, supporting H4 ($\Delta R^2=.02, f^2=.03$). We plotted this moderating effect in Figure 3. As expected, at high levels of mind wandering (nontechnology-related), knowledge retention increases rapidly as on-task thought (nontechnology-related) increases. At low levels of mind wandering (nontechnology-related), knowledge retention increases marginally as on-task thought (nontechnology-related) increases. As predicted, creativity has a positive effect on knowledge retention, supporting H5. The hypothesis results are summarized in Table 7.
Table 7: Hypotheses Results

<table>
<thead>
<tr>
<th>Statement</th>
<th>Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1  Mind wandering (technology-related) positively moderates the relationship between on-task thought (technology-related) and perceived creativity.</td>
<td>Yes</td>
</tr>
<tr>
<td>H2  Mind wandering (nontechnology-related) positively moderates the relationship between on-task thought (nontechnology-related) and perceived creativity.</td>
<td>No</td>
</tr>
<tr>
<td>H3  Mind wandering (technology-related) positively moderates the relationship between on-task thought (technology-related) and knowledge retention.</td>
<td>No</td>
</tr>
<tr>
<td>H4  Mind wandering (nontechnology-related) positively moderates the relationship between on-task thought (nontechnology-related) and knowledge retention.</td>
<td>Yes</td>
</tr>
<tr>
<td>H5  Creativity is positively associated with knowledge retention.</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Discussions**

This work aims to investigate the role of mind wandering in a technological setting. By extending the content regulation hypothesis of mind wandering, we differentiate technology-related thought from nontechnology-related thought. Although research on mind wandering is still in its infancy, investigating its occurrence from the IS perspective helps us shed light on some of the important benefits of mind wandering when we interact with technologies. After we developed and validated the scales used to measure mind wandering and on-task thought, we tested our structural model. Our empirical study shows that the content of thought does influence its functional outcomes. We found that the mind wandering (technology-related) moderates the relationship between on-task thought (technology-related) and creativity and that mind wandering (nontechnology-related) moderates the relationship between on-task thought (nontechnology-related) and knowledge retention. The results also show that creativity is positively associated with knowledge retention. Below, we synthesize our findings and offer a number of implications from both theoretical and practical perspective.

**Theoretical Implications**

The study makes contributions to the academic literature in several ways. First, we proposed an application of mind wandering in a technological setting. In a technological environment, users deal not only with external distraction, but also with internal distraction known as mind wandering. Although research on mind wandering is still in its infancy and has been primarily conducted at the laboratory setting, the current study has successfully applied the theory of mind wandering in the context of human-computer interaction. The current study indicates that mind wandering can be well-characterized along two major content dimensions: technology-related and nontechnology-related. During the interaction with technologies, users are expected to engage with the technologies. However, we found that users tend to shift between their own internal thought and their primary task at hand. Our study reveals that when users are assigned to do an IS task, mind wandering about technology-related subjects will enhance the positive relationship between their focused-attention and creativity. Based on these results, we could speculate that mind wandering (technology-related), when triggered by on-task thought (technology-related) may work as a vehicle for creative thinking.

Second, although the interaction effect of mind wandering (nontechnology-related) on creativity is not significant, its direct effect is significant. Based on these results, our study shows that various nontechnology-related thought contents (e.g., past- versus future- thought, other versus self-thought, affective content, etc.) can be generated to enhance creativity. These findings support the conception of mind wandering via mental contrasting (Oettingen and Schwörer 2013). Combining different thought contents during mind wandering episodes could be a strategy for creative thinking. For instance, by imagining the future and thereafter imagining obstacles of reality, one will potentially be able to uncover some new insights and solutions to solve the problem. According to Baird et al. (2012), the unrelated thoughts that occur during mind wandering seem to enhance creativity by increasing unconscious associate processing, as predicted by the incubation theory of the relationship between creativity and mind wandering (Ritter and Dijksterhuis 2014). Together, these results suggest that thought content is an important factor underlying the functional consequences of mind wandering.

Third, the results reveal that the interaction effect of mind wandering (nontechnology-related) on knowledge retention is significant. In the context of technology interaction during an IS learning period,
users are required to detect and retain information. Although mind wandering during this technology interaction could potentially lead users to perform poorly and retain less information (Smallwood et al. 2014), we found that mind wandering, if associated with high on-task thought could help users to retain more information about the task. By adapting to task demands that are relevant to attain one’s internal goals, not just adapting to the external goals, will facilitate learning and potentially contributes to enhance knowledge retention (Kaufman 2013). These results confirm the premise that although mind wandering can come with costs, it can be tuned into internally generated content with potential benefits.

Fourth, whereas the interaction effect of mind wandering (technology-related) on knowledge retention is not significant, the direct effect of mind wandering (technology-related) on knowledge retention is negative and significant. However, the direct effect of mind wandering (nontechnology-related) is not significant. One possible explanation is because mind wandering (technology-related) has a distinct psychological profile. Given technology-related content can potentially be triggered by the external needs (e.g., the urge to check an email), it may demand more cognitive resources than nontechnology-related content and in turn, interferes with relevant cues associated with the primary task. Another explanation is that nontechnology-related mind wandering occurs more spontaneously than technology-related mind wandering; thus it requires less cognitive demand than technology-related mind wandering. Together, these results indicate that profiles of thought content must be taken into consideration before making general conclusions about the adaptive nature and consequences of mind wandering (Smallwood and Andrews-Hanna 2013). These results not only support the content regulation hypothesis, but also confirm the decoupling hypothesis—because mind wandering involves a state of decoupled attention, it prevents individuals from encoding information from the first place. Consequently, mind wandering, depending on the content and users’ attentional focus, can hinder knowledge retention. In other words, we argue that the ubiquity of mind wandering may have some functional role, depending on the thought content and the degree of task-related thought activated during the mind wandering periods.

Lastly, our results reveal that creativity is positively correlated with knowledge retention. Knowledge retention is generally viewed as unconscious experiences shaped by conscious experiences (Baars and Gage 2010). On one hand, we first pay attention and are conscious of what we need to learn. On the other hand, we also learn by unconsciously encoding and/or decoding the results of conscious input (Baars and Gage 2010). Unconscious processes themselves have been argued to actively contribute to creativity (Ritter et al. 2012; Ritter and Dijksterhuis 2014). According to the theory of creativity, creativity is a three-step process. In step one, we consciously attend to the problem by thinking and discussing about it. In the second step, we put the problem aside for some time to direct thoughts and attention somewhere else (e.g., mind wandering). This process of unconscious thought is often led to “eureka” moment, in which creative thought enter consciousness. Next, we go back to the conscious state and evaluate the idea (Ritter and Dijksterhuis 2014). Certainly, by creatively working and interacting with technology, we will be able to enhance our knowledge retention as we activate both conscious and unconscious processes to optimize the learning outcomes.

**Practical Implications**

The results of our study offer important practical implications for technology users and IS practitioners. Our findings provide evidence of the significant moderating effect of mind wandering on both creativity and knowledge retention. However, these interaction terms are depending on the thought content of mind wandering, whether it’s technology-related or nontechnology-related. Creativity is one of the most important assets we have to navigate through the fast changing technology world. Many different techniques have been identified to facilitate creative thinking skills, such as set-shifting, brainstorming, etc. (Ritter and Dijksterhuis 2014). The application of mind wandering, however, has not been introduced in the IS field. The results of this study demonstrates that mind wandering (technology-related) can be important for creativity, when it’s associated with high level of task-related thought activities. In other words, mind wandering will contribute to the creativity under the condition that the task-relevant cues have been primarily activated. Applying these findings could, for example, motivate people to be aware of their mind wandering to find creative solutions for an IS problem.

Further, given that we spend a lot of time engaged in mind wandering, we suggest business and IT managers to explore the beneficial aspects of this experience. When users interact with a technology or use a technology to complete their task, mind wandering can be a major detriment to cognitive performance (e.g., our results show that mind wandering (technology-related) has a negative effect on
knowledge retention). However, mind wandering can also enhance knowledge retention with the presence of task-related thought. Drawing upon these results, we propose two practical challenges for technology users: how to optimally balancing mind wandering and task-related thought and how to noticing and correcting mind wandering when it occurs. These can be done by recognizing the content of our attention and determining that this particular content was inconsistent with the intention of completing the task (Smallwood et al. 2008). For example, if the focus of the task at hand is brainstorming needed to generate a list of ideas, then mind wandering should be directed to technology-related content. In contrast, if the primary focus of the technology task is to optimize learning experience, then mind wandering should be directed to nontechnology-related content. These results can also be applied in the health, education, sport, and other domains, across all ages and cultures. Further, we also encourage technology users to engage in mind wandering activities when they work on relatively complex tasks. It can be achieved by simplifying or automatizing the tasks, while simultaneously providing time for breaks (Randall et al. 2014).

Given mind wandering can also be disruptive in nature, it is necessary to identify strategies that can be used to minimize its negative consequences. For example, business and technology managers can encourage individuals to be mindful of their thought contents (Smallwood and Schooler 2015). Meta-awareness trainings may help individuals to curtail episodes of mind wandering. Offering mindfulness programs to IT workers or knowledge workers may encourage them to routinely take notice of the contents of their thoughts and only focus on subject matters relevant to their current task context. Although more research is needed in this area, encouraging people to be aware of their own mind wandering experience may help to minimize its disruptive effects (Smallwood and Schooler 2015).

Limitations and Future Research Directions

Future research can take this study further by addressing several limitations of our study. First, our sample was drawn from undergraduate students. While this sample is relevant to the context of our study, future research can take this investigation further by drawing research subjects from a more diverse population, such as IT practitioners and knowledge workers. Second, this study exclusively focuses on two dimensions of mind wandering—technology-related and nontechnology-related. Although we integrated different contents of thought into nontechnology-related, future research could empirically measure different contents of thought in more details. Further, we only tested the moderating effect of mind wandering. Future research can investigate the effect of other potential moderators, such as self-regulatory activities (Kanfer and Ackerman 1989), working memory capacity (Kane et al. 2007), and task complexity (Randall et al. 2014). Fourth, although the validity of subjective self-reports of mind wandering has been demonstrated in both experimental studies and everyday life experiences (e.g., McVay et al. 2009; Smallwood et al. 2004), our understanding about mind wandering during our interaction with technology can be enhanced by utilizing more advanced neuropsychological tools (e.g., fMRI, eye-tracking devices). Further, the context of this study is limited to a novel task among students (i.e., MS. Access learning). Future research should investigate the phenomena of mind wandering under different types of tasks (e.g., simple tasks, problem tasks, decision tasks, and judgment tasks). Lastly, perceived knowledge retention was measured rather than actual knowledge. To the extent that perceived knowledge is related to actual knowledge, this is not problematic (Williams and Levy 1992). Nevertheless, future research should attempt to measure actual knowledge in different types of technology learning.

Conclusions

This study extends our understanding of the role of mind wandering in a technological setting. To the best of our knowledge, our study is the first to demonstrate the interactions between task-relevant thought and mind wandering in influencing creativity and knowledge retention. We specifically focus on the content of thought during mind wandering by differentiating the thought into two categories—technology-related and nontechnology-related. Our findings suggest that mind wandering (technology-related) moderates the relationship between on-task thought (technology-related) and creativity and mind wandering (nontechnology-related) moderates the relationship between on-task thought (technology-related) and knowledge retention. The results also show that creativity is positively associated with knowledge retention. In sum, this study advances our understanding of the mind wandering phenomena, particularly in the context of our interaction with IS.
References


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Exploring Mind Wandering in a Technological Setting


