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Relationships between mind-wandering and attentional control abilities in young adults and adolescents

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ABSTRACT

Recent findings suggest that mind-wandering—the occurrence of thoughts that are both stimulus-independent and task-unrelated—corresponds to temporary failures in attentional control processes involved in maintaining constant task-focused attention. Studies supporting this proposal are, however, limited by a possible confound between mind-wandering episodes and other kinds of conscious experiences, such as external distractions (i.e., interoceptive sensations and exteroceptive perceptions). In the present study, we addressed this issue by examining, in adolescents and young adults, the relations between tasks measuring attentional control abilities and a measure of mind-wandering that is distinct from external distractions. We observed (1) that adolescents experienced more frequent external distractions, but not more mind-wandering, than young adults during the Sustained Attention to Response Task (SART) and (2) that, in young adults, the influence of external distractions on SART performance was fully accounted for by attentional control abilities, whereas mind-wandering was associated with decreases in SART performance above and beyond what was explained by attentional control abilities. These results show that mind-wandering cannot be entirely reduced to failures in the ability to maintain one's attention focused on task, and suggest that external distractions rather than mind-wandering are due to attentional control failures.

1. Introduction

Mind-wandering refers to the occurrence of stimulus-independent and task-unrelated thoughts (Singer, 1993; Smallwood & Schooler, 2006; Stawarczyk, Majerus, Maj, Van der Linden, & D'Argembeau, 2011; Stawarczyk, Majerus, Maquet, & D'Argembeau, 2011). While reading a book, for instance, it sometimes happens that our mind drifts away from the text and focuses instead on internal thoughts whose content is unrelated to the present situation, like memories or prospective thoughts. Recent research has revealed that mind-wandering represents a substantial part of our daily thinking time (i.e., from 20 to 50%; Kane et al., 2007; Killingsworth & Gilbert, 2010; Song & Wang, 2012), an important part of which is directed towards planning and preparing for future events (Baird, Smallwood, & Schooler, 2011; Song & Wang, 2012; Stawarczyk, Cassol, & D'Argembeau, 2013; Stawarczyk, Majerus, Maj, et al., 2011).

Mind-wandering is commonly associated with decreased performance on the task performed at the moment of its occurrence. For instance, mind-wandering during reading has been consistently associated with decreased text comprehension (McVay & Kane, 2012b; Smallwood, 2011; Unsworth & McMillan, 2013), and the occurrence of mind-wandering during go/no-go tasks has been related to more variable reaction times (RTs) to the go stimuli and an increased rate of errors to the no-go stimuli (Cheyne, Solman, Carriere, & Smilek, 2009; McVay & Kane, 2009, 2012a; Stawarczyk, Cassol, et al., 2013; Stawarczyk, Majerus, Maj, et al., 2011). Another typical finding is that the frequency of mind-wandering is generally high during relatively low-demanding and easy tasks, and gradually decreases with increasing difficulty and task demands (McKiernan, D'Angelo, Kaufman, & Binder, 2006; Smallwood & Schooler, 2006). Together, these findings suggest a close relationship between the occurrence of mind-wandering and attentional control processes (i.e., the domain general ability to maintain one's attention focused on a specific aspect of the environment). The nature of this relationship still remains debated, however.

Two main theories have been proposed to account for the relationship between mind-wandering and attentional processes. On the one hand, the perceptual decoupling theory of mind-wandering (Schooler et al., 2011; Smallwood, 2010; Smallwood & Schooler, 2006) suggests that mind-wandering results from a redirection of attentional resources from the task at hand to the processing and maintenance of internal thoughts (Levinson, Smallwood, & Davidson, 2012). In this proposal, mind-wandering is a resource consuming phenomenon that is more frequent during easier tasks because a larger amount of cognitive resources are available to support internal thoughts in comparison to more difficult tasks (Smallwood & Schooler, 2006). On the other hand,

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for the control failure theory (McVay & Kane, 2010a, 2010b), mind-wandering does not recruit attentional resources; instead, the occurrence of mind-wandering would reflect a temporary breakdown in attentional control processes that are involved in maintaining task-focused attention. According to this view, individuals with low attentional control abilities are more likely to experience mind-wandering because they are less efficient in maintaining their attention on the ongoing task (McVay & Kane, 2009). This theory entails that the lower frequency of mind-wandering during more difficult tasks is due to the fact that higher task demands lead to a continuous recruitment of attentional control processes during task completion preventing the occurrence of mind-wandering (McVay & Kane, 2010b).

The control failure theory of mind-wandering is indirectly supported by the finding that individuals known to have decreased attentional control abilities, like people under the influence of alcohol (Finnigan, Schulze, & Smallwood, 2007; Sayette, Reichle, & Schooler, 2009) or college students who received a diagnosis of attention deficit–hyperactivity disorder during childhood (Hines & Shaw, 1993; Shaw & Giambra, 1993), report experiencing a higher frequency of mind-wandering. Furthermore, several studies have found a negative relationship between working memory capacity, as assessed with complex span tasks (Conway et al., 2005; Redick et al., 2012), and the frequency of mind-wandering sampled during both laboratory tasks (McVay & Kane, 2009, 2012a, 2012b; Unsworth & McMillan, 2013) and daily life activities (Kane, Brown, et al., 2007) that are challenging in terms of attentional demands. Working memory capacity actually measures a domain general attentional control ability that corresponds to the maintenance of goal-relevant information in the focus of attention (Engle & Kane, 2004; Kane, Conway, Hambrick, & Engle, 2007). Individuals with high working memory capacity might thus experience less mind-wandering because they possess better attentional control abilities, which allow them to stay focused on demanding tasks to a larger extent than individuals with low working memory capacity (McVay & Kane, 2010a, 2010b).

A possible limitation of the studies that showed a negative relationship between mind-wandering frequency and working memory capacity is that mind-wandering was operationalized as the occurrence of any task-unrelated thoughts, without consideration of whether or not these thoughts were also stimulus-independent. Indeed, a category of conscious experiences labeled as "current state of being" (defined as "thoughts about being sleepy, hungry, bored, or any other current state") was considered as mind-wandering episodes in these studies (McVay & Kane, 2009, 2010b, 2012a, 2012b; Unsworth & McMillan, 2013). This might be an important issue to take into consideration because a central aspect of the definition of mind-wandering is that the content of these thoughts is unrelated to current sensory input (Schooler et al., 2011; Smallwood, Brown, Baird, & Schooler, 2012). It has been suggested that distractions by directly perceived stimuli might involve different cognitive processes than distractions by internally generated thoughts that do not have a direct referent in the current environment (Friedman & Miyake, 2004; Gilbert, Dumontheil, Simons, Frith, & Burgess, 2007; Lustig, Hasher, & Tonev, 2001). For instance, using latent variable analyses, Friedman and Miyake (2004) showed that tasks in which distractor stimuli are visually presented together with the target stimuli load on a different latent variable than tasks involving the resistance to mental interference resulting from information presented prior to the target stimuli. Furthermore, these two kinds of tasks correlated with different measures of individual differences: the former latent variable was associated with the occurrence of cognitive failures in daily life, while the latter was associated with a general tendency to experience intrusive thoughts (see also Verwoerd, Wessel, & de Jong, 2009; Verwoerd, Wessel, de Jong, Nieuwenhuis, & Huntjens, 2011).

Analyses of task performance have shown that mind-wandering and distractions by sensory input (referred to as "external distractions") are both associated with commission errors and more variable RTs during go/no-go tasks (Stawarczyk, Majerus, Maj, et al., 2011; Stawarczyk, Majerus, Maquet, et al., 2011). However, neuroimaging evidence suggests that these two types of experiences are not equivalent: although both are associated with activity in the default mode network, mind-wandering induces significantly more activation in this network compared to external distractions (Kucyi, Salomons, & Davis, 2013; Stawarczyk, Majerus, Maquet, et al., 2011). External distractions occur when individuals stop being fully focused on a task because of thoughts about exteroceptive perceptions or interoceptive sensations that are unrelated to this task (e.g., being distracted from reading a book because of a sudden phone ring or because one begins to feel hungry), which corresponds to the above mentioned "current state of being" experience. Intriguingly, in the studies that conceptualized mind-wandering as task-unrelated thoughts without taking stimulus-independence into account, the "current state of being" experiences represented around 50% of mind-wandering episodes[1] (e.g., McVay & Kane, 2009, 2012a), and some indirect evidence suggests that these two categories of experiences may be differently related to working memory capacity. Indeed, a recent study has shown that the negative correlation between mind-wandering frequency and working memory capacity is much less consistent when the "current state of being" experiences are not included in the analyses; past-oriented mind-wandering was unrelated to working memory capacity and a significant negative correlation between future-oriented mind-wandering and working memory capacity was only found in one of two samples of participants (McVay, Unsworth, McMillan, & Kane, 2013). This latter study did not examine how "current state of being" experiences are specifically associated with working memory capacity, however, and it thus remains unclear how external distractions and mind-wandering relate to working memory capacity (and attentional control abilities in general) when they are clearly distinguished from one another. From the current state of findings, we cannot dismiss the possibility that previously documented associations between mind-wandering and attentional control measures were actually attributable, at least partially, to the frequency of external distractions.

In the present study, we sought to investigate this issue with the use of thought-probes that clearly distinguish mind-wandering from external distractions (Stawarczyk, Majerus, Maj, et al., 2011) during the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). To measure attentional control abilities, participants carried out a typical complex span tasks and the AX version of the continuous performance task (AX-CPT; Braver et al., 2001), a task that assesses both proactive and reactive attentional control abilities (Braver, 2012; Braver, Gray, & Burgess, 2007; Iselin & DeCoster, 2009). McVay and Kane (2010b) have indeed suggested that these two forms of attentional control might be important in determining the frequency of mind-wandering. Proactive control reflects the sustained and anticipatory maintenance of goal-relevant information in order to enable optimal cognitive performance, which might be crucial for preventing the occurrence of mind-wandering. Reactive control, on the other hand, reflects a transient activation of goal-related information in response to a triggering stimulus and might be involved in the ability to suppress mind-wandering after its occurrence in order to get back on task (McVay & Kane, 2010b). Finally, we not only included young adults in this study, as in most previous studies of mind-wandering, but also adolescents. It has been shown that attentional control abilities are still developing during adolescence (De Luca et al., 2003; Fry & Hale, 1996; Iselin & DeCoster, 2009; Siegel, 1994), making this age group an adequate canditade to examine whether lower and more variable attentional control abilities come along with a higher rate of mind-wandering and external distractions. To the best of our

[1] Interestingly, "current state of being" experiences represented around 25% of the total number of thoughts reported in McVay & Kane, 2009, 2012a, which is similar to the rate of external distractions in our previous studies (e.g., Stawarczyk, Majerus, & D'Argembeau, 2013; Stawarczyk, Majerus, Maj, et al., 2011; Stawarczyk, Majerus, Maquet, et al., 2011).