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

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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

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[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).

knowledge, no study to date has contrasted the frequency of mind-wandering in adolescence and young adulthood.

Our hypotheses were the following: if the occurrence of mind-wandering reflects temporary failures in attentional control abilities (McVay & Kane, 2010a, 2010b) rather than a specific state of attention in which attentional resources are directed to the processing of internal thoughts (Schooler et al., 2011; Smallwood, 2010; Smallwood & Schooler, 2006), then (1) adolescents should experience mind-wandering episodes during the SART to a larger extent than young adults, as the former typically show lower attentional control abilities than the latter (Iselin & DeCoster, 2009); (2) the frequency of mind-wandering should be negatively related to working memory capacity, as well as proactive and reactive attentional control abilities, when mind-wandering is clearly distinguished from external distractions; and (3) the effect of mind-wandering on SART performance should overlap for the most part with the effect of attentional control abilities in multiple regression models, and mind-wandering should therefore not remain an independent predictor of SART performance once the measures of attentional control abilities are taken into account.

2. Methods

2.1. Participants

A total of 164 French-speaking participants from the Belgian general population volunteered to participate in the study. Eighty-seven of these participants (50 women) were young adults. Their age ranged from 19 to 26 years with a mean age of 22.71 years ($SD = 1.93$). The remaining 77 participants (37 women) were adolescents. Their age ranged from 14 to 16 years with a mean age of 14.88 years ($SD = .84$). All participants had normal or corrected to normal vision and audition. The two groups did not differ in terms of anxious [$t(162) = .88$, $p = .38$; Adolescents $= 10.32 \pm 7.24$; Adults $= 9.37 \pm 6.67$] and depressive [$t(162) = .29$, $p = .77$; Adolescents $= 16.19 \pm 7.95$; Adults $= 15.82 \pm 8.72$] symptomatology, respectively assessed with the Beck Anxiety Inventory (BAI) and the Center for Epidemiologic Studies Depression Scale (CES-D) (see Section 2.2.5. for more details on these two scales).[2]

2.2. Tasks and questionnaires

2.2.1. Working memory capacity

Participants completed a computerized version of a listening span task (Delaloye, Ludwig, Borella, Chicherio, & de Ribaupierre, 2008) as a measure of working memory capacity, and hence as an estimate of global attentional control abilities. The listening span is a complex span task in which participants have to judge whether syntactically simple and short sentences are semantically correct (e.g. "Children love chocolate") or not (e.g. "Bananas have pockets") while remembering the last word of each sentence. The present version of the task comprised two parts. In the first part, participants heard 16 sentences wearing headphones and were simply instructed to judge as fast and as accurately as possible whether the sentences were semantically correct or not. Responses were made with button presses and four practice trials with direct feedback on performance were performed before this first part of the task. In the second part, participants were instructed that they would perform the same kind of task as in the first part, but that they would additionally have to remember the last word of each sentence. Participants were told that the sentences would be presented in random sequences of 2, 3, 4, or 5 sentences and that each sequence would be ended by the presentation of a white triangle on black background on the computer screen. The triangle indicated that the ongoing sequence was over and that participants had to orally recall the last word of each sentence of the sequence they just listened to, in their order of presentation. A total of 56 sentences were presented in the second section of the task with four sequences of each length. The presentation of the sequences was predetermined and prevented the succession of two sequences of the same length and of several successive sequences of gradually increasing length, in order to avoid expectancy effects. Half of the sentences were semantically correct, and the number of syllables of the final words to memorize was controlled (i.e., only mono or trisyllabic words). Half of the sentences contained two nouns (as in the two examples above), and half contained one noun (e.g., "One can buy the moon"). Two practice sequences that respectively comprised two and three sentences preceded this second part of the task.

We computed the mean proportion of correctly recalled elements within a sequence, without taking serial order into account as an index of working memory capacity (Conway et al., 2005; Friedman & Miyake, 2004). Finally, as is usually the case with complex span tasks, an 85% accuracy exclusion threshold was used based on performance on the semantic judgment task during the second part of the task, to ensure that the participants were not trading off between processing the sentences and remembering the words (Robert, Borella, Fagot, Lecerf, & De Ribaupierre, 2009). In total, four of the adolescents did not reach this criterion and had to be excluded from the study.

2.2.2. Proactive and reactive attentional control

Participants completed a version of the AX-Continuous Performance Test (AX-CPT; Braver et al., 2001) as a measure of proactive and reactive control. In this task, participants saw letters presented one by one at the center of the screen and were instructed to make a target response with a button press when they were presented with the letter X, but only when it was preceded by the presentation of the letter A (*AX* trials). In every other case (i.e., when presented with any other letter than X or when the letter X was not preceded by an A), participants were required to make a non-target response by pressing another button. The *AX* pairs of letter represented 70% of trials, resulting in a strong expectancy to make a target response to the letter X following the presentation of the letter A. In 10% of trials, however, the letter A was not followed by an X but by another letter (*AY* trial, where Y stands for all non-X letters), and participants were thus required to restrain their automatic tendency to produce a target response following the presentation of the A by using externally activated task-related information (i.e. the non-X letter currently on screen). These trials thus required reactive control to avoid the production of expectancy bias errors (Braver, Satpute, Rush, Racine, & Barch, 2005; Iselin & DeCoster, 2009). Furthermore, in 10% of trials (*BX* trial, where B stands for all non-A letters), the letter X was not preceded by an A. In these cases, responses to the letter X were correctly performed only when the participants actively maintained in mind during the interstimulus interval that the preceding letter was not an A, and thus that the X required an unusual non-target response. These trials therefore required proactive control in order to avoid making perceptual bias errors caused by an excessive reliance on information from the immediate context (i.e., the currently presented X letter; Braver et al., 2005; Iselin & DeCoster, 2009). Finally, the task also comprised 10% of *BY* trials in which neither A or X was presented.

Participants responded to a total of 150 pairs of letters. Letters K and Y were excluded from the task because of their visual similarities with the letter X. Each letter was presented on screen for 500 ms. The interval between two letters of the same pair (e.g., between A and X) was 5000 ms and the interval between two successive pairs was 1000 ms. Participants had up to 1500 ms to respond from the onset of each letter. Responses that were slower than this threshold were not recorded and elicited a short feedback "bloop" sound as a prompt to increase response speed for upcoming letters. It should also be noted that participants

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[2] Descriptive statistics for the BAI, CES-D, Daydreaming Frequency Scale (DDFS), responses to the thought-probes during the SART, as well as the relationship between scores on the DDFS and responses to the thought-probes were previously reported for 63 of the 87 young adults in Stawarczyk et al. (2012); Sample B. All other results regarding the BAI, CES-D, DDFS, and the thought-probes presented here are new and have not been published before.

were not explicitly notified that the letters presented during the task were structured by pairs and were solely asked to respond as fast and as accurately as possible to each presented letter with the above mentioned instructions regarding target and non-target responses. The task was preceded by a practice session of ten trials (seven *AX* trials and one of each kind for *BX*, *AY*, and *BY* trials) that could be started over in case of misunderstanding of the instructions. Participants' performance was assessed by computing two signal detection indices (d'), one for proactive control and one for reactive control. The d' for reactive control (d'-reactive) was computed using *AX* trials hit rate and *AY* trials false alarm rate. The d' for proactive control (d'-reactive) was computed with *AX* trials hit rate and *BX* trials false alarm rate. Only the second letter of each pair was considered for the calculation of both d'. Trials where the first letter of the pair was not correctly performed were excluded from the analyses. A correction factor was applied in the d' computation in cases of a perfect hit rate (1.0) or a null false-alarm rate (0.0); for hit rate, this correction factor was $2^{-(1/N)}$ with $N =$ number of *AX* trials, and for false alarm was $1–2^{-(1/N)}$ with $N =$ number of *BX* or *AY* trials. Seven participants in the young adult group had these correction factors applied for both hit rate on *AX* trials and false alarm rate (either *BX* or *AY* trials).

2.2.3. SART with thought-probes

The version of the SART used in the present study was adapted from to the one used in Stawarczyk, Majerus, Maj, et al. (2011). The SART is a go/no-go task in which performance is highly sensitive to the occurrence of mind-wandering (Hu, He, & Xu, 2012; McVay & Kane, 2009, 2012a; McVay, Meier, Touron, & Kane, 2013; Smallwood et al., 2004; Stawarczyk, Cassol, et al., 2013; Stawarczyk, Majerus, Maj, et al., 2011). It was originally conceived as a measure of attentional lapses although recent findings suggest that other factors come into play to explain SART performance such as speed–accuracy trade-offs (i.e., slowing down RTs to the go stimuli to increase accuracy to the no-go stimuli; Helton, 2009; Helton, Kern, & Walker, 2009; Seli, Cheyne, & Smilek, 2012). In the present version of the task, stimuli (numbers between 1 and 9) were presented sequentially at the center of the screen. Participants were asked to respond as fast and accurately as possible to the numbers and to withhold their response when presented with the number 3 (the target stimulus). The probability of the target stimulus was 11%. The interstimulus interval was 2000 ms, and the duration of each stimulus (target and non-targets) was 500 ms. The task comprised 30 blocks whose duration was either 25, 35, 45, 55 or 65 s. The five last stimuli of each block were always non-targets and were immediately followed by a thought-probe which interrupted the task.

For each probe, participants were asked to characterize the ongoing conscious experience they had just prior to the probe. Four possible choices were provided: (i) on-task reports: the participant's attention and thoughts were fully focused on the task-related stimuli; (ii) task-related interferences reports: the participant experienced thoughts about some task features or about their performance (e.g., thoughts about task duration or about the participant's overall performance); (iii) external distractions reports: the participant's attention was focused on stimuli that were present in the current environment but unrelated to the task at hand (e.g., exteroceptive perceptions or interoceptive sensations). It was explained to the participants that this category comprised all thoughts whose content was focused on current sensory perceptions unrelated to the task at hand, with the origin of these perceptions being either external (e.g., coming from the room) or internal (e.g. bodily sensations). Finally, the last category was (iv) mind-wandering reports: the participant had his/her attention decoupled from the current environment and was experiencing thoughts unrelated to the task at hand (e.g., thoughts about what the participant will do tomorrow).

Several examples of each type of thought were provided to participants and they were then asked to classify ten thoughts in the correct category to ensure that the categories were fully understood before starting the SART. When participants needed further clarification about the distinction between external distractions and mind-wandering, it was further explained that the content of mind-wandering should be unrelated to current perceptions, although in some cases it could be initiated by the current environment. For instance, thinking that one is thirsty and imagining oneself buying a bottle of water after the experiment could both be triggered by the same sensation of thirst but should be rated as an external distraction in the former case (because participants' attention and thoughts were directly focused on the current sensation of thirst and thus their experience cannot be considered as stimulus-independent) and as mind-wandering in the latter case (because this thought involved elements that are not directly perceived and had to be internally generated such as, for instance, the automatic vending machine and the environment outside the testing room). Individuals who took part in a previous study using the same classification reported having no major difficulties to respond to the thought-probes and feeling confident in their answers (Stawarczyk, Majerus, Maj, et al., 2011). In the present study, each time participants reported mind-wandering to the probes, another question appeared on screen asking participants to rate the personal importance of the thought they had just reported, on a seven-point Likert scale ranging from 1 (not important at all) to 7 (very important). Data regarding this latter question will not be further analyzed here because how the personal importance of thoughts could influence their relationships with attentional control abilities was beyond the scope of the present study.

2.2.4. General fluid intelligence

Given the close relationship between attentional control abilities and general fluid intelligence (Engle & Kane, 2004; Kane, Conway, Hambrick, & Engle, 2007), participants also completed the Standard Progressive Matrices (Raven, Raven, & Court, 1998). The test consists of five sets, each comprising 12 items of increasing difficulty. For each item, participants are asked to identify, among 6 or 8 possibilities, the missing element that completes a visual pattern. Participants were given 10 min to complete the even-numbered items of each set (for a similar procedure, see Unsworth, Redick, Lakey, & Young, 2010). Participants' score was the raw number of correct responses made during the imparted time.

2.2.5. Questionnaires

Participants also completed three questionnaires. The first was the CES-D (French version, Fuhrer & Rouillon, 1989; original version, Radloff, 1977), which is frequently used to assess depressive symptomatology in non-clinical population. It comprises 20 items assessing for the presence of depressive symptoms in the past week with reference to a four points Likert scale ranging from 0 (never, rarely: less than one day) to 3 (frequently, all the time: between 5 and 7 days). The CES-D has been validated for use in adolescent populations (Chabrol, Montovany, Chouicha, & Duconge, 2002). Cronbach's alphas were respectively .89 and .82 in the present study for adults and adolescents. The second questionnaire was the BAI (original version, Beck, Epstein, Brown, & Steer, 1988; French version, Freeston, Ladouceur, Thibodeau, Gagnon, & Rhéaume, 1994), which is used to assess anxiety in adults during the last seven days and comprises 21 items. Respondents are asked to rate how much they have been affected by certain anxiety symptoms in the past week on a four point Likert scale ranging from 0 (not at all) to 3 (severely). The BAI has also been validated for use with adolescents (Osman et al., 2002). Cronbach's alpha for this scale in the present study was .82 for both adults and adolescents. The third questionnaire was the Daydreaming Frequency Scale (DDFS; original version, Singer & Antrobus, 1970; French version, Stawarczyk, Majerus, Van der Linden, & D'Argembeau, 2012) which is used to assess the frequency of mind-wandering in daily life and comprises 12 items rated on a five point Likert scale ranging from 1 to 5.

2.3. Procedure

Participants were tested individually and were first asked for demographic information. They then completed the tasks and questionnaires in the following order: the Raven's progressive matrices (10–15 min), the AX-CPT (20–25 min), the French listening span (15–20 min), the SART with thought-probes (40–45 min), and finally the DDFS, CES-D and BAI (5–10 min). The total experiment lasted from approximately 90 to 115 min and the participants could take a small break between some of the tasks if they wished.

3. Results

3.1. Group comparisons

We first computed a series of Student's *t*-tests to examine whether young adults and adolescents differed in terms of SART performance, responses to the thought-probes, proactive and reactive attentional control, working memory capacity, and general fluid intelligence. Results of these analyses are shown in Table 1. Regarding SART performance, adolescents were slower and had more variable RTs to the non-target stimuli, and they also committed more errors to the target stimuli. As expected, adolescents showed lower and more variable performance on measures of proactive and reactive attentional control, working memory capacity, and general fluid intelligence. It is important to note, however, that the frequency of mind-wandering episodes reported during the SART was equivalent for young adults and adolescents. Young adults even reported *more* mind-wandering than adolescents on the DDFS. Regarding the other responses to the thought-probes, young adults reported being fully focused on task to a larger extent than adolescents, whereas adolescents reported more frequent external distractions; the two groups did not differ on the frequency of task-related interferences.

Next, we examined whether mind-wandering and external distractions impaired SART performance to the same extent in young adults and adolescents. To do so, we analyzed the RTs (means and CVs) to the five last non-targets of each block (Kam et al., 2011; Seli, Cheyne, & Smilek, 2013; Stawarczyk, Majerus, Maj, et al., 2011) as a function of the responses given to the probes, using a series of 2 (group) × 4 (probe response) mixed-design Analyses of Variance (ANOVAs). We also used a 2 × 4 ANOVA to analyze the proportion of correct target responses within each block, as a function of the responses given to the probes. For each measure (means and CVs of RTs for the non-targets, and accuracy to the targets), a single average score was computed per participant for each of the four kinds of thought-probe responses. As shown in panel A of Fig. 1, the ANOVA for mean RTs revealed main effects of group [$F(1,131) = 7.96$; $p = .006$; $\eta_p^2 = .06$] and probe response [$F(3,393) = 3.37$; $p = .02$; $\eta_p^2 = .03$], but no significant interaction effect [$F(3,393) = 1.49$; $p = .22$; $\eta_p^2 = .01$]. Planned comparisons revealed that participants were faster when they reported being fully focused on task compared to when they experienced mind-wandering and external distractions [$F(1,131) = 8.72$; $p = .004$; $\eta_p^2 = .06$], and that mean RTs did not differ between the two latter kinds of probe responses [$F(1,131) = .05$; $p = .82$; $\eta_p^2 < .001$]. As shown in panel B, the ANOVA performed on CVs also revealed main effects of group [$F(1,131) = 34.03$; $p < .001$; $\eta_p^2 = .21$] and probe response [$F(3,393) = 8.99$; $p < .001$; $\eta_p^2 = .06$], but no significant interaction effect [$F(3,393) = 2.35$; $p = .07$; $\eta_p^2 = .02$]. Planned comparisons showed that RTs were more variable when participants reported mind-wandering and external distractions than when they reported being fully focused on task [$F(1,131) = 20.69$; $p < .001$; $\eta_p^2 = .14$]; there was also a trend for RTs to be more variable preceding mind-wandering than external distraction reports [$F(1,131) = 3.86$; $p = .051$; $\eta_p^2 = .03$]. Finally, as shown in panel C, the ANOVA performed on target accuracy revealed significant main effects of group [$F(1,131) = 35.71$; $p < .001$; $\eta_p^2 = .21$] and probe response [$F(3,393) = 32.15$; $p < .001$; $\eta_p^2 = .20$], and again no significant interaction effect [$F(3,393) = 1.63$; $p = .18$; $\eta_p^2 = .01$]. Planned comparisons showed that participants committed less errors during blocks when they reported that they were fully focused on task than when they reported mind-wandering and external distractions [$F(1,131) = 62.96$; $p < .001$; $\eta_p^2 = .32$], and target accuracy did not differ between the two latter kinds of reports [$F(1,131) = 1.47$; $p = .23$; $\eta_p^2 = .01$].

In sum, the results of these ANOVAs show that participants' performance on the SART was worse when they experienced mind-wandering and external distractions compared to when they were fully focused on task (see also; Stawarczyk, Majerus, Maj, et al., 2011). The degree to which performance was affected by mind-wandering and external distractions was equivalent for adolescents and young adults.

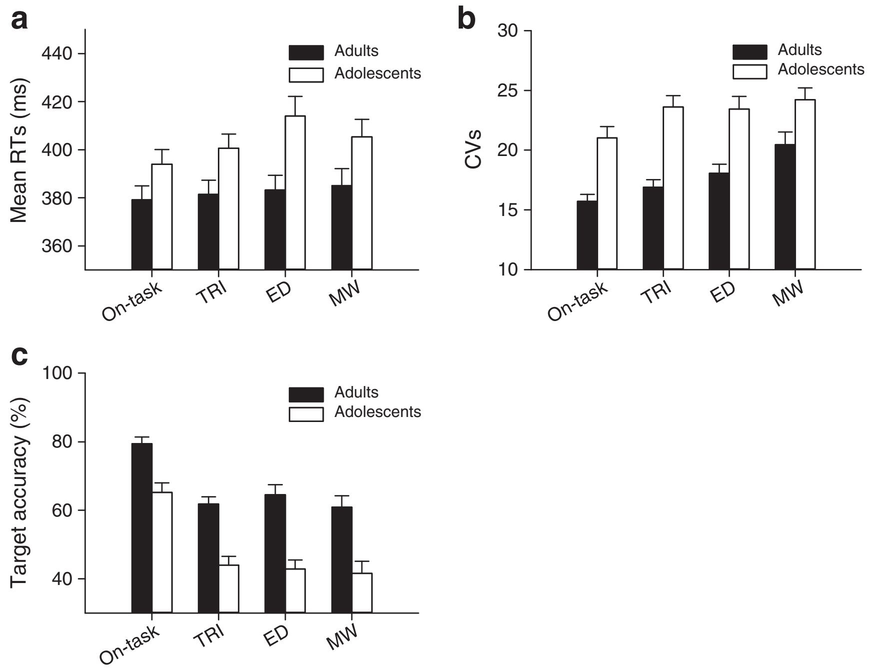
Table 1
Comparisons between young adults and adolescents.

	Mean score (standard deviation)		$t(162)$	p	Cohen's d
	Adolescents	Young adults			
SART target accuracy (%)	50.28 (17.57)	68.41 (15.52)	−7.02	<.001	1.10
SART non-target RT (ms)	395 (45)	377 (46)	2.47	.01	.40
SART non-target CV	31.88 (8.94)	24.53 (7.50)	5.72	<.001	.90
% On-task reports	31.43 (20.32)	38.47 (21.67)	−2.14	.03	.34
% TRI reports	26.49 (16.33)	27.74 (15.01)	−.51	.61	.08
% ED reports	24.85 (16.19)	16.63 (10.80)	3.86	<.001	.61
% MW reports	17.23 (12.96)	17.16 (16.76)	.03	.98	.005
DDFS	40.29 (8.61)	42.94 (7.73)	−2.08	.04	.33
AX-CPT d'-proactive	2.28 (.79)	3.02 (.85)	−5.78	<.001	.91
AX-CPT d'-reactive	2.22 (.80)	3.09 (.69)	−7.39	<.001	1.18
WMC	.85 (.09)	.90 (.06)	−4.75	<.001	.67
Raven's matrices	20.10 (3.53)	23.18 (3.37)	−5.72	<.001	.90

Note: RT = reaction time; CV = coefficient of variation of RTs; TRI = task-related interference; ED = external distraction; MW = mind-wandering; DDFS = Daydreaming Frequency Scale; WMC = working memory capacity.

3.2. Correlation analyses

Next, we performed correlation analyses to examine the relationships between the different variables. These analyses were performed separately for the two groups of participants. As shown in Table 2, the correlations between SART performance and thought-probe responses revealed that mind-wandering reports were associated with lower performance (more target errors and a larger variability of RTs for non-targets) in young adults, whereas reports of being fully focused on task showed the opposite pattern of associations (they were related to less RT variability and fewer errors to the target stimuli). External distraction reports were associated with more target errors. These results confirm that individual differences in SART performance are related to mind-wandering and external distraction frequency (Stawarczyk, Majerus, Maj, et al., 2011). The analyses for the adolescent group (see Table 3) revealed only two significant correlations, which showed that more frequent on-task reports were associated with fewer errors to the target stimuli and that more frequent mind-wandering reports were associated with a higher variability of RTs for the non-target stimuli. Interestingly, correlations between the DDFS and responses to the thoughts probes were nearly identical in the two groups: the frequency of mind-wandering in daily life was associated with more reports of mind-wandering during the SART and fewer reports of being focused on task, but was not significantly associated with task-related interferences and external distractions. These results suggest that adolescents properly followed the instructions regarding the thought-probes. As DDFS scores were unrelated to all the other measures under investigation here, they will not be analyzed further.



Note: bars represent the standard error on the mean; RTs = reaction times; CVs = coefficients of variation of RTs; TRI = task-related interference; ED = external distraction; MW = mind-wandering.

Fig. 1. SART performance according to the responses given to the thought-probes for the two groups of participants. Note: bars represent the standard error on the mean; RTs = reaction times; CVs = coefficients of variation of RTs; TRI = task-related interference; ED = external distraction; MW = mind-wandering.

Next, we examined the relationships between proactive and reactive attentional control abilities, working memory capacity, and fluid intelligence. Results were consistent across the two groups (see Tables 2 and 3) and showed that all variables significantly correlated with each other, except that reactive attentional control was not significantly correlated with fluid intelligence in the adult group.

Finally, we examined whether the responses to the thought-probes and the measures of SART performance that were related to these

Table 2
Correlation matrix for the young adult group.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. % on-task	*.87*												
2. % TRIs	−.41 $p < .001$	*.73*											
3. % EDs	−.56 $p < .001$	.007 $p = .95$	*.63*										
4. % MW	−.56 $p < .001$	−.37 $p = .001$	.08 $p = .47$	*.86*									
5. SART acc.	.45 $p < .001$	.04 $p = .70$	−.28 $p = .009$	−.44 $p < .001$	*.84*								
6. SART CV	−.27 $p = .01$	−.01 $p = .91$	.09 $p = .38$	.31 $p = .004$	−.34 $p = .001$	*.94*							
7. SART RTs	−.12 $p = .28$	.12 $p = .25$	.06 $p = .58$	<.001 $p = .99$	.05 $p = .63$	.51 $p < .001$	*.97*						
8. WMC	.33 $p = .002$	−.09 $p = .43$	−.33 $p = .002$	−.14 $p = .19$	.41 $p < .001$	−.32 $p = .003$	−.15 $p = .16$	*.67*					
9. Raven	.22 $p = .04$	.005 $p = .96$	−.06 $p = .57$	−.25 $p = .02$	.32 $p = .003$	−.17 $p = .11$	−.09 $p = .42$	.39 $p < .001$	*.72*				
10. *d′* proact.	.27 $p = .01$	−.04 $p = .70$	−.16 $p = .13$	−.21 $p = .06$	.38 $p < .001$	−.25 $p = .02$	−.22 $p = .04$	.29 $p = .006$	.23 $p = .04$				
11. *d′* react.	.38 $p < .001$	−.09 $p = .39$	−.24 $p = .02$	−.26 $p = .02$	.53 $p < .001$	−.16 $p = .15$	−.07 $p = .54$	.29 $p = .006$	−.18 $p = .10$	.63 $p < .001$			
12. Att. comp.	.42 $p < .001$	−.08 $p = .48$	−.28 $p = .009$	−.30 $p = .005$	.58 $p < .001$	−.31 $p = .003$	−19 $p = .09$	.70 $p < .001$	.63 $p < .001$	.76 $p < .001$	.74 $p < .001$		
13. DDFS	−.23 $p = .03$	−.08 $p = .43$	.10 $p = .36$	.31 $p = .003$	−.17 $p = .12$	.07 $p = .51$	−.19 $p = .09$	.03 $p = .80$	.004 $p = .97$	.04 $p = .70$	−.001 $p = .95$	.02 $p = .83$	*.88*

Note: Italicized values on the diagonal reflect Cronbach's alpha for each measure as a reliability estimate (when applicable); alphas were calculated over task blocks for the measures of SART performance as well as responses to the thought-probes and over items for the other variables; TRIs = task-related interferences; EDs = external distractions; MW = mind-wandering; SART acc. = accuracy to the target stimuli; SART CV = coefficients of variation of RTs for the non-target stimuli; SART RTs = mean RT for the non-target stimuli; WMC = working memory capacity; Att. comp. = Attentional composite z-score of AX-CPT, WMC and Raven's matrices performances; DDFS = Daydreaming Frequency Scale.

Table 3
Correlation matrix in the adolescent group.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. % on-task	*.72*												
2. % TRIs	−.40 $p < .001$	*.78*											
3. % EDs	−.49 $p < .001$	−.33 $p = .003$	*.79*										
4. % MW	−.43 $p < .001$	−.20 $p = .07$	−.05 $p = .65$	*.75*									
5. SART acc.	.29 $p = .01$	−.17 $p = .14$	−.09 $p = .44$	−.13 $p = .27$	*.84*								
6. SART CV	−.03 $p = .83$	−.05 $p = .67$	−.19 $p = .09$	.27 $p = .02$	−.12 $p = .32$	*.93*							
7. SART RTs	.10 $p = .38$	.007 $p = .95$	−.13 $p = .25$	−.005 $p = .97$	.30 $p = .009$	.34 $p = .002$	*.95*						
8. WMC	.13 $p = .26$	−.02 $p = .86$	−.06 $p = .63$	−.11 $p = .35$	.31 $p = .006$	.03 $p = .79$	−.25 $p = .03$	*.79*					
9. Raven	−.09 $p = .45$	.15 $p = .20$	−.008 $p = .94$	−.04 $p = .73$	.13 $p = .25$	.07 $p = .55$	−.04 $p = .73$	.33 $p = .003$	*.71*				
10. d' proact.	.10 $p = .38$	.05 $p = .67$	.002 $p = .98$	−.22 $p = .052$	.47 $p < .001$	−.32 $p = .005$	−.19 $p = .09$	.38 $p = .001$	.26 $p = .02$				
11. d' react.	.04 $p = .71$	.04 $p = .70$	.03 $p = .77$	−.17 $p = .15$	.55 $p < .001$	−.42 $p < .001$	−.05 $p = .64$	.36 $p = .001$	.28 $p = .01$	.59 $p < .001$			
12. Att. comp.	.06 $p = .58$	.08 $p = .51$	−.01 $p = .93$	−.18 $p = .11$	.50 $p < .001$	−.22 $p = .055$	−.19 $p = .11$	.71 $p < .001$	.65 $p < .001$	.77 $p < .001$	.77 $p < .001$		
13. DDFS	−.27 $p = .02$	.04 $p = .75$	.08 $p = .48$	.27 $p = .02$	.14 $p = .21$	.22 $p = .054$	.08 $p = .49$	.05 $p = .65$	.15 $p = .21$	−.12 $p = .31$	−.009 $p = .43$	−.004 $p = .97$	*.87*

Note: Italicized values on the diagonal reflect Cronbach's alpha for each measure (when applicable) as a reliability estimate; alphas were calculated over task blocks for the measures of SART performance as well as responses to the thought-probes and over items for the other variables; TRIs = task-related interferences; EDs = external distractions; MW = mind-wandering; SART acc. = accuracy to the target stimuli; SART CV = coefficients of variation of RTs for the non-target stimuli; SART RTs = mean RT for the non-target stimuli; WMC = working memory capacity; Att. comp. = Attentional composite z-score of AX-CPT, WMC and Raven's matrices performances; DDFS = Daydreaming Frequency Scale.

responses (i.e., CVs and target accuracy) were related to proactive and reactive attentional control abilities, working memory capacity, and fluid intelligence. Furthermore, given the intercorrelations between the different cognitive tasks, we also computed an attentional composite Z-score (combining proactive and reactive attentional control abilities, working memory capacity, and fluid intelligence) that is free of the measurement error associated with each single task (Conway et al., 2005). Results showed that none of the four kinds of thought-probe responses was related to the different measures of cognitive abilities in the adolescent group (see Table 3). In young adults (see Table 2), mind-wandering was related to lower reactive attentional control and fluid intelligence. Furthermore, external distractions were related to lower reactive attentional control and working memory capacity, and reports of being fully focused on task were related to better proactive and reactive attentional control, working memory capacity, and fluid intelligence. These three kinds of responses to the thought-probes were also significantly related to the attentional composite Z-score (positively for on-task reports and negatively for mind-wandering and external distraction reports). Regarding SART performance, accuracy to the target stimuli significantly correlated with all measures of cognitive abilities in both groups of participants, with the exception of fluid intelligence for adolescents. RTs variability correlated to proactive and reactive attentional control in adolescents, and with proactive attentional control and working memory capacity in young adults. RTs variability was also correlated with the attentional composite Z-score in young adults and this association was nearly significant in the adolescent group ($p = .055$).

Together, these results partially support the prediction stemming from the control failure theory that the frequency of mind-wandering should be related to proactive and reactive attentional control abilities, as well as working memory capacity. In the young adult group, mind-wandering frequency was indeed significantly related to reactive attentional control, fluid intelligence, and the attentional composite Z-score. On the other hand, however, the measures of cognitive abilities were unrelated to the frequency of mind-wandering in the adolescent group. These results suggest that mind-wandering is more closely tied to attentional control abilities in young adulthood than in adolescence.

3.3. Variance partitioning analyses

As the results of the correlational analyses partly supported the predictions of the control failure theory of mind-wandering, we further explored the association between mind-wandering frequency, external distractions, SART performance and attentional control abilities. We used variance partitioning methods (e.g., Chuah & Maybery, 1999; Cowan et al., 2005; Unsworth, Redick, Heitz, Broadway, & Engle, 2009) to examine the shared and unique contribution of mind-wandering, attentional abilities and external distractions to SART performance. Variance partitioning attempts to allocate the overall R^2 of a particular criterion variable (here accuracy to the target stimuli and variability of RTs to the non-target stimuli of the SART) into portions that are shared and unique to a set of predictor variables (mind-wandering, external distractions, and the attentional composite Z-score for target accuracy; mind-wandering and the attentional composite Z-score for RTs variability). These portions of the overall R^2 are obtained by carrying out a series

Table 4
R^2 values for regression analyses predicting SART accuracy for various predictor variables in the young adult group.

Predictor variables	Adjusted R^2	F	p
1. MW, EDs, AC	.41	20.73	<.001
2. MW, EDs	.24	14.42	<.001
3. MW, AC	.40	29.55	<.001
4. EDs, AC	.33	22.47	<.001
5. MW	.19	20.68	<.001
6. EDs	.07	7.15	.009
7. AC	.33	42.56	<.001

Note: MW = mind-wandering; EDs = external distractions; AC = Attentional composite z-score of AX-CPT, WMC and Raven's matrices performances.

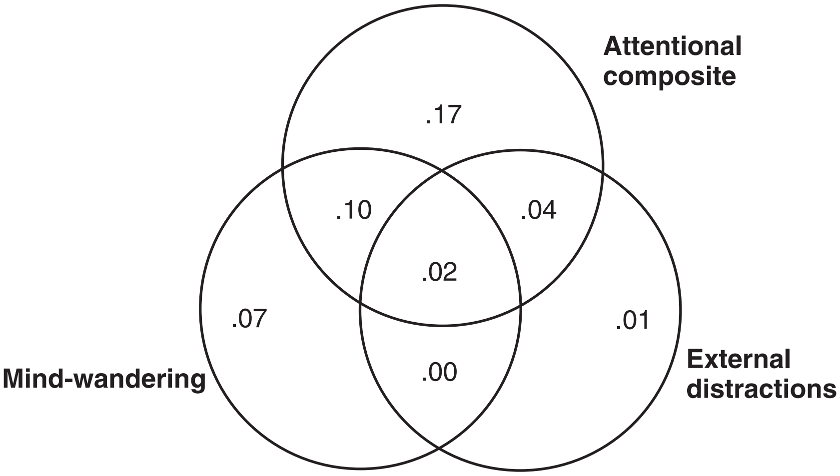


Fig. 2. Venn diagram displaying the variance in target accuracy during the SART accounted for by mind-wandering frequency, external distractions frequency, and the attentional composite z-score for the adult group.

of regression analyses from different combinations of the predictor variables (Unsworth et al., 2009).

First, Table 4 shows that 41% of the variance in target accuracy during the SART in young adults was accounted for by the three predictor variables. Furthermore, as shown in Fig. 2, mind-wandering remained a significant predictor of SART accuracy beyond and above what was explained by the attentional composite Z-score and external distractions [$t(83) = -3.40$; $p = .001$], explaining an additional 7% of the variance. On the other hand, external distractions were not an independent performance of accuracy to the target stimuli, explaining only 1% of additional variance beyond the two other variables [$t(83) = -1.49$; $p = .14$]. As recent findings (Seli, Jonker, Cheyne, & Smilek, 2013) have demonstrated that SART accuracy is a more direct measure of attentional failures after controlling for mean RTs (which reflect the way speed–accuracy trade-offs are handled), we also computed similar regression analyses with mean RTs as an additional independent variable. The inclusion of this variable did not change the significance of the results regarding mind-wandering, external distractions, and the attentional composite Z-score.

Second, Table 5 shows that mind-wandering and the attentional composite Z-score accounted for 13% of the variance in RTs variability in the young adult group. As shown in Fig. 3, mind-wandering significantly explained an additional 4% of the variance beyond and above attentional abilities [$t(84) = 2.19$; $p = .03$]. It should be noted that external distractions were not included in this analysis because they were not significantly correlated with the variability of RTs during the SART ($r = .09$; $p = .38$). Adding this variable did not change the significance of the results regarding mind-wandering and the attentional composite Z-score.

Finally, Table 6 shows that mind-wandering and the attentional composite Z-score accounted for 8% of the variance in RTs variability in the adolescent group. As shown in Fig. 4, mind-wandering significantly explained an additional 4% of the variance beyond attentional abilities [$t(74) = 2.07$; $p = .04$]. Similarly to the analyses performed in the young adult group, external distractions were not included in this analysis because they were not significantly correlated with the variability of RTs during the SART ($r = -.19$; $p = .09$). Again, adding this variable did not change the significance of the results regarding mind-wandering and the attentional composite Z-score.

Table 5
R^2 values for regression analyses predicting SART variability of RTs for various predictor variables in the young adult group.

Predictor variables	Adjusted R^2	F	p
1. MW, AC	.13	7.23	.001
2. MW	.08	8.73	.004
3. AC	.09	9.22	.003

Note: MW = mind-wandering; AC = Attentional composite z-score of AX-CPT, WMC and Raven's matrices performances.

4. Discussion

The purpose of present study was to further examine the proposal that the occurrence of mind-wandering corresponds to temporary breakdowns in the cognitive processes involved in maintaining constant task-focused attention (the control failure theory; McVay & Kane, 2010a, 2010b). To test this proposal, we sampled the occurrence of mind-wandering in a group of young adults and a group of adolescents using the SART with thought-probes. Importantly, and contrary to previous studies (McVay & Kane, 2009, 2010a, 2012a, 2012b; Unsworth & McMillan, 2013), mind-wandering episodes were clearly distinguished from external distractions (i.e., exteroceptive perceptions or interoceptive sensations that are unrelated to the task at hand). A battery of cognitive tasks that assessed working memory capacity, general fluid intelligence, as well as reactive and proactive attentional control abilities was also administered. We tested the following predictions stemming from the control failure theory: if mind-wandering corresponds to attentional control failures, then (1) adolescents should experience more frequent mind-wandering than young adults, as the former typically show lower and more variable attentional control abilities than the latter; (2) mind-wandering frequency should be negatively related to the measures of attentional control abilities; and (3) the effect of mind-wandering on SART performance should overlap for the most part with the effect of attentional control abilities, such that mind-wandering should not be an independent predictor of SART performance when attentional control abilities are included into multiple regression models. Our results only provided partial support for the second prediction and revealed several important findings that call into question the control failure view of mind-wandering.

First, despite showing (as expected) lower SART performance (Carriere, Cheyne, Solman, & Smilek, 2010) and attentional control abilities (De Luca et al., 2003; Fry & Hale, 1996; Iselin & DeCoster, 2009; Siegel, 1994), adolescents reported rates of mind-wandering that were comparable to those of young adults during the SART. These results, together with the findings that mind-wandering is unaffected or even tends to decrease in older adults (Einstein & McDaniel, 1997; Giambra, 1989, 1993; Jackson & Balota, 2012; Krawietz, Tamplin, & Radvansky, 2012; McVay, Meier, Touron, & Kane, 2013), show that mind-wandering frequency is not necessarily higher in populations

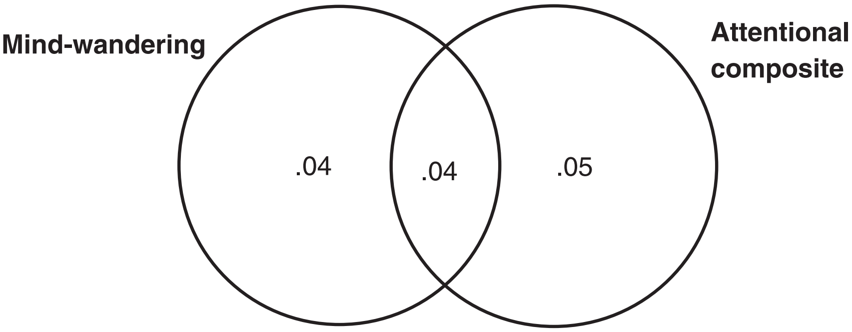


Fig. 3. Venn diagram displaying the variance in RTs variability to the non-target during the SART accounted for by mind-wandering frequency and the attentional composite z-score for the adult group.

who present lower attentional control abilities. Interestingly, however, we found that adolescents reported being fully focused on the SART less frequently and experienced a higher rate of external distractions than young adults. In other words, adolescents do indeed seem to have more difficulty than young adults to stay focused on task (as could be expected from their lower attentional control abilities and SART performance), yet this does not relate to increased mind-wandering episodes but instead to distractions from current task-irrelevant environmental stimuli and sensations.

Second, correlational and regression analyses did not support some central tenets of the attentional control failure theory of mind-wandering. In adolescents, neither mind-wandering nor the other kinds of reports of conscious experiences were related to proactive and reactive attentional control, working memory, and fluid intelligence. In young adults, reactive attentional control abilities and fluid intelligence, but not working memory capacity and proactive attentional control, were related to mind-wandering frequency. We also found that mind-wandering frequency was significantly related to an attentional composite Z-score (combining the four measures of attentional abilities) that is free of the measurement error associated with each task (Conway et al., 2005). This latter finding fits with the proposal that mind-wandering is associated with attentional control failures (Kane & McVay, 2012; McVay & Kane, 2010b). However, mind-wandering frequency remained an independent predictor of SART accuracy and RT variability beyond and above the attentional composite Z-score in the variance partitioning analysis. These results thus suggest that, although attentional control abilities and mind-wandering frequency are related, mind-wandering cannot be entirely reduced to failures in the ability to maintain one's attention focused on task.

Interestingly, our data further suggest that external distractions more closely correspond to attentional control failures than mind-wandering, at least in young adults. Indeed, we found that external distractions were also related to the attentional composite Z-score and, once this variable was taken into account into the variance partitioning analysis, the influence of external distractions on SART accuracy was not significant. As mentioned in the Introduction, it is likely that the sampling of mind-wandering episodes was contaminated by the inclusion of external distractions in previous studies that showed a negative relationship between working memory capacity and mind-wandering frequency (McVay & Kane, 2009, 2010a, 2012a, 2012b; Unsworth & McMillan, 2013). The present findings suggest that (at least part of) this relationship resulted from the mixing of mind-wandering with external distractions in the same response category. When mind-wandering and external distractions are clearly distinguished from one another, as in the current study, it seems that only the latter kind of experience can be entirely accounted for in terms of temporary breakdowns in attentional control processes.

Table 6
R^2 values for regression analyses predicting SART variability of RTs for various predictor variables in the adolescent group.

Predictor variables	Adjusted R^2	F	p
1. MW, AC	.08	4.13	.02
2. MW	.06	5.67	.02
3. AC	.04	3.81	.05

Note: MW = mind-wandering; AC = Attentional composite z-score of AX-CPT, WMC and Raven's matrices performances.

Our finding that mind-wandering explains SART performance beyond attentional control abilities can be interpreted in terms of the attentional decoupling theory of mind-wandering (Schooler et al., 2011; Smallwood, 2010, 2013; Smallwood & Schooler, 2006). This theory proposes that mind-wandering does not represent attentional failures but rather a redirection of attentional resources from the task at hand to the processing and maintenance of internal thoughts, resulting in a state of perceptual decoupling (see also Smilek, Carriere, & Cheyne, 2010). In line with this view, recent EEG data (Barron, Riby, Greer, & Smallwood, 2011) have for instance shown that individuals who experienced more mind-wandering during a task showed a diminished cortical response to task-irrelevant stimuli (for a recent review on this topic, see Kam & Handy, 2013). The theoretical view that mind-wandering is a specific state of decoupled attention from sensory information (rather than merely attentional lapses) is in line with the present finding that mind-wandering is associated with specific decreases in SART performance above and beyond what is explained by attentional control abilities. Furthermore, this view can also account for the significant correlation between mind-wandering and attentional control abilities observed in the present study, as well as for the finding that some of the variance of SART performance was shared between the attentional composite Z-score and mind-wandering frequency. Indeed, although the presence of mind-wandering (and thus perceptual decoupling) reflects more than attentional control failures, this does not exclude the possibility that the occurrence of mind-wandering could be triggered in the first place by temporary breakdowns in task-focused attention (Smallwood, 2013). Future research focusing specifically on the occurrence of mind-wandering rather than on its overall frequency should be conducted to assess this proposal (e.g., by using algorithms that can predict in real time when participants start to experience mind-wandering based on variations in task performance and/or physiological indices; Bastian & Sackur, 2013; Franklin, Smallwood, & Schooler, 2011).

The influence of current concerns needs also be considered when interpreting the independent part of SART performance variance explained by mind-wandering (Klinger, 1971, 2009, 2013). In their original proposal, McVay & Kane (2010b; see also Kane & McVay, 2012) suggested that, independent of attentional control failures, heightened current concerns might also be the cause of more frequent mind-wandering episodes. According to this view, the relationship between mind-wandering frequency and SART performance might thus be more fully explained by taking into account both attentional control abilities and current concerns. Whether the influence of current

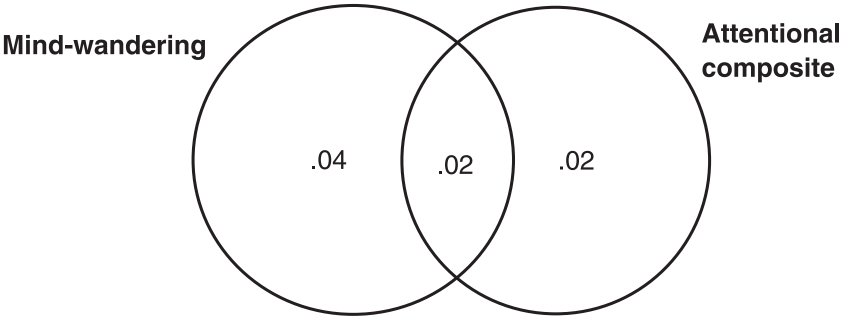


Fig. 4. Venn diagram displaying the variance in RTs variability to the non-target during the SART accounted for by mind-wandering frequency and the attentional composite z-score for the adolescent group.

concerns on the occurrence of mind-wandering is truly independent of attentional control failures (or at least partly independent) remains to be determined, however. It has for instance been demonstrated that priming unfulfilled goals typically interfere with later task performances that require executive attentional control abilities (Masicampo & Baumeister, 2011a, 2011b). Thus, although our results may be explained by the influence of current concerns, further studies examining how current concerns interact with attentional control abilities should be conducted to clearly determine whether the respective influences of these two variables on mind-wandering frequency are indeed independent, as suggested by McVay and Kane (2010b).

A third interpretation of the present findings would be that mind-wandering has a negative impact on task-specific processes involved in SART performance that are independent from attentional control abilities (e.g., speed–accuracy trade-off). As mentioned in the Methods sections, performance on the SART is multiply-determined (Helton, 2009; Helton et al., 2009; Seli et al., 2012) and a recent study has shown that SART accuracy is more strongly related to attentional lapses after controlling for speed–accuracy trade-offs (considered as being reflected by mean RTs; Seli, Jonker, Cheyne, & Smilek, 2013). Although controlling for mean RTs did not change the results of the regression analyses on SART accuracy in the present study, further research should examine whether the present finding are reproducible with other tasks and different versions of the SART (e.g., versions that solely emphasize response accuracy rather than both response times and accuracy; Seli et al., 2012). Such studies would allow us to determine whether the independent influence of mind-wandering on task-performance found in the present study represents a domain-general feature of mind-wandering (i.e., perceptual decoupling) rather than being specifically related to the present version of the SART.

At a more general level, it should be noted that the present results do not contradict the view that there is a domain general attentional ability involved in maintaining task-focused attention, and that working memory capacity might be an accurate marker of this ability (Engle & Kane, 2004; Kane, Conway, Hambrick, & Engle, 2007). Indeed, reports of being fully focused on task were more frequent in young adults than adolescents and, contrary to the other kinds of conscious experiences, these reports consistently correlated with all measures of attentional control abilities, general fluid intelligence, and the attentional composite Z-score in the adult group. These results add to the neuroimaging findings that reports of being focused on task are associated with larger activity in brain regions involved in the top-down maintenance of task-related attention (i.e., the dorsal lateral prefrontal cortex and anterior inferior parietal cortex; Hasenkamp, Wilson-Mendenhall, Duncan, & Barsalou, 2012; Stawarczyk, Majerus, Maquet, et al., 2011). We therefore suggest that on-task reports might be a better marker of the domain general ability to maintain task-focused attention than mind-wandering is, at least in young adults.

It should also be reminded that the present study is one of the first to examine mind-wandering and related ongoing conscious experiences in an adolescent sample. Although the results of the analyses involving thought-probe responses in this age-group were generally in line with those found in the young adult group (i.e., impaired SART performance prior off-task reports, satisfactory internal consistency, as well as significant correlations between the different categories of thought-probe responses and with the DDFS), an absolute certainty that the reports made to the thought-probes correspond to the individuals' actual experiences can never be reached (McVay & Kane, 2010a). Therefore, although promising, our results should nonetheless be considered carefully and future studies should be conducted to further examine the behavioral correlates and validity of ongoing conscious experience reports, particularly in younger age groups given the paucity of mind-wandering research in these populations (for preliminary findings, see French, Zentall, & Bennett, 2001; Mrazek, Phillips, Franklin, Broadway, & Schooler, 2013).

To conclude, the present results only partially support the attentional control failure theory of mind-wandering, according to which the occurrence of mind-wandering episodes reflect temporary breakdowns in attentional control process (McVay & Kane, 2010a, 2010b), and are more supportive of the view that mind-wandering is a state of perceptual decoupling in which attentional resources are redirected from the task at hand to the processing and maintenance of internal thoughts (Schooler et al., 2011; Smallwood, 2010; Smallwood & Schooler, 2006). Importantly, however, these results do not contradict the view that there is a domain general ability to maintain one's attention focused on task and that working memory capacity is an accurate measure of this ability (Engle & Kane, 2004; Kane, Conway, Hambrick, & Engle, 2007). The present findings suggest that mind-wandering frequency cannot be entirely reduced to this domain-general ability for attentional control and that reports of being fully focused on task, and possibly external distractions, might be more adequate subjective markers of attentional control abilities.

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References

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

Barron, E., Riby, L. M., Greer, J., & Smallwood, J. (2011). Absorbed in thought: the effect of mind wandering on the processing of relevant and irrelevant events. *Psychological Science*, *22*, 596–601.

Bastian, M., & Sackur, J. (2013). Mind wandering at the fingertips: Automatic parsing of subjective states based on response time variability. *Frontiers in Psychology*, *4*, 573.

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology*, *56*, 893–897.

Braver, T. S. (2012). The variable nature of cognitive control: A dual mechanisms framework. *Trends in Cognitive Sciences*, *16*, 106–113.

Braver, T. S., Barch, D.M., Keys, B.A., Carter, C. S., Cohen, J.D., Kaye, J. A., et al. (2001). Context processing in older adults: Evidence for a theory relating cognitive control to neurobiology in healthy aging. *Journal of Experimental Psychology: General*, *130*, 746–763.

Braver, T. S., Gray, J. R., & Burgess, G. C. (2007). Explaining the many varieties of working memory variation: Dual mechanisms of cognitive control. In A. R. A. Conway, C. Jarrold, M. J. Kane, A. Miyake & J. N. Towse (Eds.), *Variation in working memory* (pp. 76–106). New York, NY: Oxford University Press; US.

Braver, T. S., Satpute, A.B., Rush, B. K., Racine, C. A., & Barch, D.M. (2005). Context processing and context maintenance in healthy aging and early stage Dementia of the Alzheimer's type. *Psychology and Aging*, *20*, 33–46.

Carriere, J. S., Cheyne, J. A., Solman, G. J. F., & Smilek, D. (2010). Age trends for failures of sustained attention. *Psychology & Aging*, *25*, 569–574.

Chabrol, H., Montovany, A., Chouicha, K., & Duconge, E. (2002). Study of the CES-D on a sample of 1,953 adolescent students. *Encephale*, *28*, 429–432.

Cheyne, J. A., Solman, G. J. F., Carriere, J. S. A., & Smilek, D. (2009). Anatomy of an error: A bidirectional state model of task engagement/disengagement and attention-related errors. *Cognition*, *111*, 98–113.

Chuah, Y. M., & Maybery, M. T. (1999). Verbal and spatial short-term memory: Common sources of developmental change? *Journal of Experimental Child Psychology*, *73*, 7–44.

Conway, A.R., Kane, M. J., Bunting, M. F., Hambrick, D., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, *12*, 769–786.

Cowan, N., Elliott, E. M., Scott Saults, J., Morey, C. C., Mattox, S., Hismjatullina, A., et al. (2005). On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes. *Cognitive Psychology*, *51*, 42–100.

De Luca, C. R., Wood, S. J., Anderson, V., Buchanan, J. -A., Proffitt, T. M., Mahony, K., et al. (2003). Normative data from the Cantab. I: Development of executive function over the lifespan. *Journal of Clinical & Experimental Neuropsychology: Official Journal of the International Neuropsychological Society*, *25*, 242–254.

Delaloye, C., Ludwig, C., Borella, E., Chicherio, C., & de Ribaupierre, A. (2008). The Reading Span as a measure of working memory capacity: Norms based on a French speaking population of 775 younger and older adults. *European Review of Applied Psychology/Revue Europeenne de Psychologie Appliquee*, *58*, 89–103.

Einstein, G. O., & McDaniel, M.A. (1997). Aging and mind wandering: Reduced inhibition in older adults? *Experimental Aging Research*, *23*, 343–354.

Engle, R. W., & Kane, M. J. (2004). Executive Attention, Working Memory Capacity, and a Two-Factor Theory of Cognitive Control. In B. H. Ross (Ed.), *The psychology of learning and motivation: Advances in research and theory, Vol. 44* (pp. 145–199). New York, NY: Elsevier Science; US.

Finnigan, F., Schulze, D., & Smallwood, J. (2007). Alcohol and the wandering mind: A new direction in the study of alcohol on attentional lapses. *The Journal of Endocrine Genetics*, *6*, 189–199.

Franklin, M. S., Smallwood, J., & Schooler, J. W. (2011). Catching the mind in flight: Using behavioral indices to detect mindless reading in real time. *Psychonomic Bulletin & Review*, *18*, 992–997.

Freeston, M., Ladouceur, R., Thibodeau, N., Gagnon, F., & Rhéaume, J. (1994). L'inventaire d'anxiété de Beck: Propriétés psychométriques d'une traduction française. *L'Encephale: Revue de Psychiatrie Clinique Biologique et Therapeutique*, *20*, 47–55.

French, B. F., Zentall, S. S., & Bennett, D. (2001). Short-term memory of children with and without characteristics of attention deficit hyperactivity disorder. *Learning and Individual Differences*, *13*, 205–225.

Friedman, N.P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General*, *133*, 101–135.

Fry, A. F., & Hale, S. (1996). Processing speed, working memory, and fluid intelligence: Evidence for a developmental cascade. *Psychological Science*, *7*, 237–241.

Fuhrer, R., & Rouillon, F. (1989). La version française de l'échelle CES-D (Center for Epidemiologic Studies-Depression Scale). Description et traduction de l'échelle d'autoévaluation. *Psychiatrie et Psychobiologie*, *4*, 163–166.

Giambra, L. M. (1989). Task-unrelated thought frequency as a function of age: A laboratory study. *Psychology and Aging*, *4*, 136–143.

Giambra, L. M. (1993). The influence of aging on spontaneous shifts of attention from external stimuli to the contents of consciousness. *Experimental Gerontology*, *28*, 485–492.

Gilbert, S. J., Dumontheil, I., Simons, J. S., Frith, C. D., & Burgess, P. W. (2007). Comment on "Wandering minds: The default network and stimulus-independent thought". *Science*, *317*, 43 (author reply 43).

Hasenkamp, W., Wilson-Mendenhall, C. D., Duncan, E., & Barsalou, L. W. (2012). Mind wandering and attention during focused meditation: A fine-grained temporal analysis of fluctuating cognitive states. *NeuroImage*, *59*, 750–760.

Helton, W. S. (2009). Impulsive responding and the sustained attention to response task. *Journal of Clinical and Experimental Neuropsychology*, *31*, 39–47.

Helton, W. S., Kern, R. P., & Walker, D. R. (2009). Conscious thought and the sustained attention to response task. *Consciousness and Cognition: An International Journal*, *18*, 600–607.

Hines, A.M., & Shaw, G. A. (1993). Intrusive thoughts, sensation seeking, and drug use in college students. *Bulletin of the Psychonomic Society*, *31*, 541–544.

Hu, N., He, S., & Xu, B. (2012). Different efficiencies of attentional orienting in different wandering minds. *Consciousness & Cognition*, *21*, 139–148.

Iselin, A. -M. R., & DeCoster, J. (2009). Reactive and proactive control in incarcerated and community adolescents and young adults. *Cognitive Development*, *24*, 192–206.

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

Kam, J. W., Dao, E., Farley, J., Fitzpatrick, K., Smallwood, J., Schooler, J. W., et al. (2011). Slow fluctuations in attentional control of sensory cortex. *Journal of Cognitive Neuroscience*, *23*, 460–470.

Kam, J. W., & Handy, T. C. (2013). The neurocognitive consequences of the wandering mind: A mechanistic account of sensory-motor decoupling. *Frontiers in Psychology*, *4*, 725.

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

Kane, M. J., Conway, A. R. A., Hambrick, D. Z., & Engle, R. W. (2007). Variation in working memory capacity as variation in executive attention and control. In A. R. A. Conway, C. Jarrold, M. J. Kane, A. Miyake & J. N. Towse (Eds.), *Variation in working memory* (pp. 21–46). New York, NY: Oxford University Press; US.

Kane, M. J., & McVay, J. C. (2012). What mind wandering reveals about executive-control abilities and failures. *Current Directions in Psychological Science*, *21*, 348–354.

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

Klinger, E. (1971). *Structure and functions of fantasy.* New York: Wiley.

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

Klinger, E. (2013). Goal Commitments and the content of thoughts and dreams: Basic principles. *Frontiers in Psychology*, *4*, 415.

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

Kucyi, A., Salomons, T. V., & Davis, K. D. (2013). Mind wandering away from pain dynamically engages antinociceptive and default mode brain networks. *Proceedings of the National Academy of Sciences of the United States of America*, *110*, 18692–18697.

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

Lustig, C., Hasher, L., & Tonev, S. T. (2001). Inhibitory control over the present and the past. *European Journal of Cognitive Psychology*, *13*, 107–122.

Masicampo, E. J., & Baumeister, R. F. (2011). Consider it done! Plan making can eliminate the cognitive effects of unfulfilled goals. *Journal of Personality & Social Psychology*, *101*, 667–683.

Masicampo, E. J., & Baumeister, R. F. (2011). Unfulfilled goals interfere with tasks that require executive functions. *Journal of Experimental Social Psychology*, *47*, 300–311.

McKiernan, K. A., D'Angelo, B. R., Kaufman, J. N., & Binder, J. R. (2006). Interrupting the "stream of consciousness": An fMRI investigation. *NeuroImage*, *29*, 1185–1191.

McVay, J. C., & Kane, M. J. (2009). Conducting the train of thought: Working memory capacity, goal neglect, and mind wandering in an executive-control task. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *35*, 196–204.

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

McVay, J. C., & Kane, M. J. (2010a). Adrift in the stream of thought: The effects of mind wandering on executive control and working memory capacity. In A. Gruszka, G. Matthews & B. Szymura (Eds.), *Handbook of individual differences in cognition: Attention, memory, and executive control* (pp. 321–334). New York, NY: Springer Science+Business Media; US.

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

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

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

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

Mrazek, M.D., Phillips, D. T., Franklin, M. S., Broadway, J. M., & Schooler, J. W. (2013). Young and restless: Validation of the Mind-Wandering Questionnaire (MWQ) reveals disruptive impact of mind-wandering for youth. *Frontiers in Psychology*, *4*, 560.

Osman, A., Hoffman, J., Barrios, F. X., Kopper, B.A., Breitenstein, J. L., & Hahn, S. K. (2002). Factor structure, reliability, and validity of the Beck Anxiety Inventory in adolescent psychiatric inpatients. *Journal of Clinical Psychology*, *58*, 443–456.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*, 385–401.

Raven, J. C., Raven, J. E., & Court, J. H. (1998). *Manual for Raven's Progressive Matrices and Vocabulary Scales.* Oxford, UK: Oxford Psychologists Press.

Redick, T. S., Broadway, J. M., Meier, M. E., Kuriakose, P.S., Unsworth, N., Kane, M. J., et al. (2012). Measuring working memory capacity with automated complex span tasks. *European Journal of Psychological Assessment*, *28*, 164–171.

Robert, C., Borella, E., Fagot, D., Lecerf, T., & De Ribaupierre, A. (2009). Working memory and inhibitory control across the life span: Intrusion errors in the Reading Span Test. *Memory & Cognition*, *37*, 336–345.

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). 'Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, *35*, 747–758.

Sayette, M.A., Reichle, E. D., & Schooler, J. W. (2009). Lost in the sauce: The effects of alcohol on mind wandering. *Psychological Science*, *20*, 747–752.

Schooler, J. W., Smallwood, J., Christoff, K., Handy, T. C., Reichle, E. D., & Sayette, M.A. (2011). Meta-awareness, perceptual decoupling and the wandering mind. *Trends in Cognitive Sciences*, *15*, 319–326.

Seli, P., Cheyne, J. A., & Smilek, D. (2012). Attention failures versus misplaced diligence: Separating attention lapses from speed–accuracy trade-offs. *Consciousness & Cognition*, *21*, 277–291.

Seli, P., Cheyne, J. A., & Smilek, D. (2013). Wandering minds and wavering rhythms: Linking mind wandering and behavioral variability. *Journal of Experimental Psychology: Human Perception & Performance*, *39*, 1–5.

Seli, P., Jonker, T. R., Cheyne, J. A., & Smilek, D. (2013). Enhancing SART validity by statistically controlling speed–accuracy trade-offs. *Frontiers in Psychology*, *4*, 265.

Shaw, G., & Giambra, L. M. (1993). Task-unrelated thoughts of college students diagnosed as hyperactive in childhood. *Developmental Neuropsychology*, *9*, 17–30.

Siegel, L. S. (1994). Working memory and reading: A life-span perspective. *International Journal of Behavioral Development*, *17*, 109–124.

Singer, J. L. (1993). Experimental studies of ongoing conscious experience. *Ciba Foundation Symposium*, *174*, 100–122.

Singer, J. L., & Antrobus, J. S. (1970). *Imaginal process inventory.* New York: City University of New York.

Smallwood, J. (2010). Why the global availability of mind wandering necessitates resource competition: Reply to McVay and Kane (2010). *Psychological Bulletin*, *136*, 202–207.

Smallwood, J. (2011). Mind-wandering while reading: Attentional decoupling, mindless reading and the cascade model of inattention. *Language and Linguistics Compass*, *5*, 63–77.

Smallwood, J. (2013). Distinguishing how from why the mind wanders: A process-occurrence framework for self-generated mental activity. *Psychological Bulletin*, *139*, 519–535.

Smallwood, J., Brown, K., Baird, B., & Schooler, J. W. (2012). Cooperation between the default mode network and the frontal-parietal network in the production of an internal train of thought. *Brain Research*, *1428*, 60–70.

Smallwood, J., Davies, J. B., Heim, D., Finnigan, F., Sudberry, M., O'Connor, R., et al. (2004). Subjective experience and the attentional lapse: Task engagement and disengagement during sustained attention. *Consciousness and Cognition: An International Journal*, *13*, 657–690.

Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin*, *132*, 946–958.

Smilek, D., Carriere, J. S., & Cheyne, J. (2010). Out of mind, out of sight: Eye blinking as indicator and embodiment of mind wandering. *Psychological Science*, *21*, 786–789.

Song, X., & Wang, X. (2012). Mind wandering in Chinese daily lives—An experience sampling study. *PLoS ONE*, *7*, e44423 (Electronic Resource).

Stawarczyk, D., Cassol, H., & D'Argembeau, A. (2013). Phenomenology of future-oriented mind-wandering episodes. *Frontiers in Psychology*, *4*, 225.

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

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

Stawarczyk, D., Majerus, S., Maquet, P., & D'Argembeau, A. (2011). Neural correlates of ongoing conscious experience: Both task-unrelatedness and stimulus-independence are related to default network activity. *PLoS ONE*, *6*, e16997 (Electronic Resource).

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

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

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

Unsworth, N., Redick, T. S., Lakey, C. E., & Young, D. L. (2010). Lapses in sustained attention and their relation to executive control and fluid abilities: An individual differences investigation. *Intelligence*, *38*, 111–122.

Verwoerd, J., Wessel, I., & de Jong, P. J. (2009). Individual differences in experiencing intrusive memories: The role of the ability to resist proactive interference. *Journal of Behavior Therapy and Experimental Psychiatry*, *40*, 189–201.

Verwoerd, J., Wessel, I., de Jong, P. J., Nieuwenhuis, M. M., & Huntjens, R. J. (2011). Pre-stressor interference control and intrusive memories. *Cognitive Therapy and Research*, *35*, 161–170.