Mind-wandering: phenomenology and function as assessed with a novel experience sampling method

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Abstract

Mind-wandering refers to the occurrence of thoughts whose content is both decoupled from stimuli present in the current environment and unrelated to the task being carried out at the moment of their occurrence. The core of this phenomenon is therefore stimulus-independent and task-unrelated thoughts (SITUTs). In the present study, we designed a novel experience sampling method which permitted to isolate SITUTs from other kinds of distractions (i.e., irrelevant interoceptive/exteroceptive sensory perceptions and interfering thoughts related to the appraisal of the current task). In Experiment 1, we examined the impact of SITUTs on the performance of the Sustained Attention to Response Task (SART; a Go/No-Go task). Analyses demonstrated that SITUTs impair SART performance to the same extent as irrelevant sensory perceptions. In Experiment 2, we further examined SITUTs in order to assess the possible functions of mind-wandering. We observed that the content of most of reported SITUTs refers to the anticipation and planning of future events. Furthermore, this "prospective bias" was increased when participants' attention had been oriented toward their personal goals before performing the SART. These data support the view that an important function of mind-wandering relates to the anticipation and planning of the future.

Keywords: mind-wandering; distractions; phenomenology; personal goals; prospective thoughts; experience sampling

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1. Introduction

An important feature of the human mind resides in its propensity to spontaneously generate thoughts when some of its resources are left idle (Antrobus, Singer, Goldstein, & Fortgang, 1970; Christoff, Gordon, & Smith, in press; Giambra, 1995; Klinger, 1990, 2009; Pope & Singer, 1978; Scerbo, Bliss, Freeman, Mikulka, & Schultz Robinson, 2005; Singer, 2003; Smallwood, 2009; Smallwood & Schooler, 2006). For instance, when performing boring or redundant activities, it is relatively frequent that our mind drifts away from the current task and wanders towards memories, future plans, personal concerns and other thoughts whose content is not the direct reflection of our immediate stimulus environment. The core characteristic of such thoughts, generally labeled as mind-wandering (Smallwood, 2009; Smallwood & Schooler, 2006) or daydreams (Klinger, 1990; Singer, 1975), is that their content is both decoupled from stimuli present in the current environment (i.e., they are stimulus-independent; Antrobus, 1968; Teasdale, et al., 1995; Teasdale, Proctor, Lloyd, & Baddeley, 1993) and unrelated to the activity being carried out at the time of their occurrence (i.e., they are task-unrelated; Giambra, 1989, 1995; Scerbo, et al., 2005). They can therefore be broadly defined as “stimulus-independent and task-unrelated thoughts” (abbreviated here as SITUTs).

Research suggests that SITUTs are concomitant with almost every kind of activity, occurring (albeit with reduced frequency) even when highly resource consuming tasks are performed (Antrobus, et al., 1970; Smallwood, Fishman, & Schooler, 2007) and representing on average between 10% and 30% of our daily thinking time (Kane, et al., 2007; Klinger, 1990). It has been proposed that SITUTs depend, at least in part, on the same cognitive resources as (and thus compete with) task-related processing, as they generally impair performance on the task being carried out at the moment of their appearance (Antrobus, et al., 1970; Smallwood, 2009, 2010; Smallwood, Fishman, et al., 2007; Smallwood & Schooler, 2006). Mind-wandering has, for instance, been linked to decreased text comprehension (Schooler, Reichle, & Halpern, 2004; Smallwood, McSpadden, & Schooler, 2008) and to higher variability of reaction times and increased number of errors in Go/No-Go tasks (McVay & Kane, 2009). However, the results of many studies are still debated and may be subject to problems of interpretation because of the specific methods used to assess the occurrence of mind-wandering (e.g., Christoff, Gordon, Smallwood, Schooler, & Smith, 2009; Gilbert, Dumontheil, Simons, Frith, & Burgess, 2007; Mason, et al., 2007a, 2007b). In this study, we present and validate a novel experience sampling method that assesses the occurrence mind-wandering episodes in a more rigorous way, and use this new method to further investigate the function and phenomenology of SITUTs.

Currently, the most commonly used method to assess mind-wandering consists of probing the subjects' conscious experience at random intervals while performing various cognitive tasks (i.e., the thought-probe method; Giambra, 1995; Smallwood & Schooler, 2006). Typically, probes interrupt tasks requiring sustained externally-driven attention (e.g., reading tasks or signal detection tasks; Smallwood, Fishman, et al., 2007) and participants are instructed to report whether they were totally focused on the proposed task just before the interruption (i.e., on-task or stimulus-dependent reports, depending on which aspect of SITUTs is emphasized by the study) or whether they were distracted by task-unrelated conscious experiences (or stimulus-independent conscious experiences). In some studies (e.g., Teasdale, et al., 1995; Teasdale, et al., 1993), participants simply have to say what they had in mind at the moment of the thought-probe and the experimenters later classify the reports as reflecting on-task (or stimulus-dependent) or off-task (or stimulus-independent) conscious experiences. Whether self-reported or judged by the experimenter, off-task (or stimulus-independent) reports are considered to reflect the presence of mind-wandering episodes (e.g., Forster & Lavie, 2009; Giambra, 1995; Mason, et al., 2007b; McKiernan, D'Angelo, Kaufman, & Binder, 2006; Smallwood, McSpadden, & Schooler, 2007).

However, as illustrated in Figure 1, distractions occurring during tasks requiring sustained focused attention to the external environment can originate not only from SITUTs but also (1) from interfering thoughts related to the appraisal of the current task, such as, for instance, wondering when the task will end or thoughts about one's overall performance (i.e., task-related interferences, abbreviated here as TRIs; Matthews, Joyner, Gililand, Campbell, & Faulconner, 1999; Smallwood, Baracaia, Lowe, & Obonsawin, 2003; Smallwood, Davies, et al., 2004), and (2) from exteroceptive and interoceptive perceptions caused by irrelevant stimuli, such as noises, hunger, thirst and so forth (i.e., external distractions, abbreviated here as EDs; Forster & Lavie, 2008a, 2008b; Lustig, Hasher, & Tonev, 2001; Unsworth, Redick, Lakey, & Young, 2010). The dichotomous division of conscious experiences into on-task and off-task (or stimulus-dependent and stimulus-independent) does not permit to clearly distinguish between these different categories (Christoff, et al., 2009; Gilbert, et al., 2007; Mason, et al., 2007a, 2007b). As shown in Figure 1, TRIs, EDs, SITUTs, and being fully focused on the current task can all be conceptualized along two dimensions: "task-relatedness" and "stimulus-dependency." If the classification of ongoing conscious experiences is limited to on-task and off-task reports, EDs and SITUTs may be mixed in the same category. Similarly, if the division of conscious experiences is confined to stimulus-dependent or stimulus-independent reports, there is a risk for TRIs and SITUTs to be pooled together. This lack of precision of typical thought-probes is problematic as, currently, little is known about the precise nature of distractions caused by SITUTs versus EDs or TRIs.

Insert Figure 1 about here

In the present study, we used the conceptualization of conscious experiences based on the stimulus-dependency and task-relatedness dimensions described in Figure 1 to develop a novel kind of thought-probes that clearly distinguishes SITUTs from other classes of distractions (i.e., EDs and TRIs). These new probes permitted us to determine in Experiment 1 whether SITUTs still affect task performance when they are rigorously separated from other kinds of distractions, and also to directly assess the similarities and differences between SITUTs, EDs, and TRIs in terms of their impact on task performance.

In spite of their negative impact on current task performance, SITUTs may nevertheless serve a variety of useful functions. Daydreams and mind-wandering episodes have notably been supposed to be involved in the maintenance of an ongoing sense of identity, in emotion regulation, creative thinking, self-entertainment during boring activities, or maintaining arousal in situations of poor environmental stimulation (for reviews, see Antrobus, et al., 1970; Gold & Cundiff, 1980; Klinger, 1999). Furthermore, several authors have emphasized the potential importance of SITUTs in problem solving and planning for the future (Bar, 2007, 2009; Bar, Aminoff, Mason, & Fenske, 2007; Binder, et al., 1999; Buckner & Vincent, 2007; Singer, 1966; Smallwood & Schooler, 2006). For example, discussing the possible function of daydreams, Binder and colleagues (1999, p. 85) suggested that "[...] by storing, retrieving, and manipulating internal information, we organize what could not be organized during stimulus presentation, solve problems that require computation over long periods of time, and create effective plans governing behavior in the future." Mind-wandering episodes may thus be more than simple attentional lapses and consist in a redirection of cognitive resources away from the ongoing task and towards the processing of personal goals and concerns (Christoff, et al., 2009; Smallwood, 2010; Smallwood & Schooler, 2006). Yet, to date, very few empirical studies have directly focused on the possible functions of SITUTs

(Smallwood, 2009) and the evidence for their possible role in anticipating and planning future events, notably through the processing of personal goals and concerns, is inconsistent.

In a recent study, Smallwood, Nind, and O'Connor (2009) have suggested that the content of mind-wandering episodes mainly involves thoughts about the future. Using the above-mentioned thought-probe method, these authors found that off-task thoughts were more frequently oriented toward the future than toward the past and concluded that mind-wandering was characterized by a "prospective bias." However, other laboratory studies reported roughly equivalent proportions of past- versus future-oriented off-task thoughts (Fransson, 2006; Mason, et al., 2007a, 2007b). Some studies using thought sampling in daily life situations also reported that future- and past-oriented daydreams did not differ in prevalence (Klinger, 1990). It is possible that this discrepancy among findings originates, at least in part, from the lack of precision in the method used to assess SITUTs (see above)—the future-oriented function of mind-wandering might have been concealed by the mix-up of other conscious experiences with SITUTs. For example, it might be that, in the absence of probes offering the possibility to report TRIs, some past and future thoughts that do not fit the typical definition of mind-wandering were mixed with SITUTs (e.g., reflecting upon past errors committed during the task or thinking about the end of the task).

This possibility was explored in Experiment 2. We adapted the newly validated experience sampling method of Experiment 1 to precisely assess the content of each reported SITUT. Notably, in addition to the temporal orientation of these thoughts (Miles, Karpinska, Lumsden, & Macrae, 2010; Smallwood, Nind, et al., 2009), we also examined their perceived functions. To our knowledge, this is the first study to assess this aspect of SITUTs and we were particularly interested in contrasting the frequency of SITUTs involved in preparing for the future with the frequency of SITUTs perceived as being aimless daydreams or involved in other functions (e.g, maintaining arousal or providing pleasant feelings; for reviews, see

Antrobus, et al., 1970; Gold & Cundiff, 1980; Klinger, 1999). Furthermore, we also explored whether the content of SITUTs can be manipulated experimentally. We reasoned that if an important function of SITUTs is to plan the future through the processing of personal goals and concerns (Christoff, et al., 2009; Smallwood, 2010; Smallwood & Schooler, 2006), then the occurrence of SITUTs involved in preparing for upcoming events should be influenced by conditions that increase people's attention to their personal goals. Some previous research has shown that mind-wandering can be influenced by mood induction procedures (Seibert & Ellis, 1991; Smallwood, Fitzgerald, Miles, & Phillips, 2009) or by confronting participants to threatening stressful events before performing a cognitive task (e.g., Antrobus, Singer, & Greenberg, 1966; Horowitz, 1975). However, no study to date has attempted to manipulate pre-task circumstances to specifically influence the prospective bias of mind-wandering.

2. Experiment 1

In this experiment, we aimed at better characterizing SITUTs by implementing a novel experience sampling procedure. As developed in the Introduction, this method is based on a classification of ongoing conscious experiences into four categories along two dimensions: "task-relatedness" and "stimulus-dependency" (see Figure 1). Using this novel experience sampling procedure, we first examined whether SITUTs still negatively affect task performance when they are rigorously distinguished from other classes of distractions (i.e., EDs and TRIs). Furthermore, we assessed the similarities and differences between these three types of conscious experiences in terms of their impact on task performance. Finally, we also examined whether factors that are known to increase the frequency of off-tasks reports, namely the time spent on a task (Cunningham, Scerbo, & Freeman, 2000; McVay & Kane, 2009; Smallwood, Davies, et al., 2004) and the duration of between-probe task blocks

(Giambra, 1995; Smallwood, O'Connor, Sudbery, & Obonsawin, 2007; Smallwood, Obonsawin, & Reid, 2003), have similar effects on SITUTs, EDs and TRIs.

The newly designed experience sampling method described above (see Figure 1) was combined with the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997), a Go/No-Go task developed to measure lapses in effortful sustained attention. The first study that combined the SART with thought-probes had been conducted by Smallwood and colleagues (2004). Since then, several findings have demonstrated that off-task reports impair performance on the SART, which is mainly reflected by a larger amount of errors and increased variability in RTs (McVay & Kane, 2009). However, no study to date has attempted to investigate the specific impact of SITUTs relative to other kinds of distractions on SART performance.

2.1. Methods

2.1.1. Participants

A total of 98 students or acquaintances of students from the University of Geneva volunteered to participate in the study (76 women, 22 men). Their age ranged from 18 to 30 years, with a mean age of 22.73 years (*SD* = 3.26). Individuals with medical disorders, neurological disorders, psychiatric disorders or history of medication/substance use were excluded from the experiment. All subjects had normal or corrected to normal vision and audition.

2.1.2. Materials

The version of the SART used in this study was adapted from Smallwood, Beach, Schooler and Handy (2008). It was implemented on a PC-compatible computer interfaced with a 14-inch SVGA color monitor using E-Prime software version 1.0 (Schneider, Eschman, & Zuccolotto, 2002). Participants were seated in front of the computer screen so that their eyes were approximately 70 cm from the display. The response keys were located on a standard keyboard.

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 the 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. All participants signaled the presence of each non-target number via a manual finger press on the spacebar. Within each block of trials, target and non-target probability was pre-randomized, with the constraints that (1) a minimum of one and a maximum of three targets were presented during each block, (2) for blocks including two or three targets, targets were separated by at least one non-target event, (3) the first stimulus of each block was a non-target (initial stimuli of each block were considered as buffer items and were not analyzed further) and (4) the last five stimuli of each block (i.e., stimuli presented just before the thought-probe) were non-targets. Thirty blocks were administered to each participant. Durations of each block were 25, 35, 45, 55 or 65 seconds, and there were six blocks of each length. Six higher order blocks comprising one block of each length were constructed. Order of the five blocks within each higher order block was pre-randomized. Across the 30 blocks, 540 numbers (both targets and non-targets) were presented for a total duration of 22 minutes and 30 seconds.

Each block was 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, according to the two dimensions “task-relatedness” and “stimulus-dependency” described above (Figure 1). Four possible choices were thus provided, each being associated with a specific response key: (1) Task-related and stimulus-dependent experience (i.e., on-task reports): the participant’s attention and thoughts are fully focused on the task-related stimuli (i.e., the numbers); (2) Task-related and stimulus-independent experience (i.e., TRIs reports): the participant experiences thoughts about the task that are not directly related to the numbers presented on the screen and, thus, that do not help him/her to have the best possible performance on the current ongoing trials (e.g., thoughts about task duration or about the participant’s overall performance); (3) Task-unrelated and stimulus-dependent experience (EDs reports): the participant’s attention is focused on stimuli that are present in the current environment but unrelated to the task at hand (e.g., exteroceptive perceptions, such as noises, the luminance, the temperature or others features of the current environment or interoceptive sensations, such as feeling thirsty, tired or other physical sensations); (4) Task-unrelated and stimulus-independent experience (i.e., SITUTs reports): the participant has his/her attention decoupled from exteroceptive/interoceptive perceptions caused by irrelevant stimuli and is experiencing thoughts unrelated to the task at hand (e.g., thoughts about what the participant did last evening, about what he/she needs to do this evening or about what significant others could be doing now). Responses to thought-probes were self-paced, which gave participants the possibility to consult, if needed, an instruction sheet where a written description of the four possible conscious experiences under investigation in this study was provided. After responding to each probe during the SART, a short text was displayed on the screen asking participants to press the spacebar to continue the task.

In order to ensure that the participants correctly understood the instructions regarding the different possibilities of responses to the thought-probes, ten written statements describing possible thought contents were read aloud one by one by the experimenter. These statements comprised three examples of TRIs, three examples of EDs, and four examples of SITUTs (two directed toward the past and two directed toward the future). Participants were asked to classify each statement in the correct category and were told that they could use the instruction sheet if they wanted. In case of a mistake, the experimenter corrected the participants before reading the next statement. Participants also performed a short training session of the SART (ten numbers, two targets, and two thought-probes). Finally, participants were told that they should be as honest and sincere as possible when reporting what they had in mind at the moment preceding the interruptions of the SART by the probes.

2.1.3. Procedure

All participants were tested individually in a quiet, well-lightened room. At the end of the SART, the participants were asked whether they had had any difficulties to respond to the thought-probes and they were invited to rate the overall quality of their responses to these probes using a 7-point Likert scale (-*3 = very bad, +3 = very good*).

2.2. Results

2.2.1. SART performance and probe reports

Mean response time (RT) on the SART for non-targets was 348 ms (*SD* = 44). Response withholding accuracy for targets was 59.47 % (*SD* = 17.54). Regarding thought-probes, participants reported being fully focused on the SART for 27.28 % (*SD* = 19.44) of probes, TRIs for 30.34 % (*SD* = 11.43) of probes, EDs for 20.78 % (*SD* = 10.78) of probes, and SITUTs for 21.6 % (*SD* = 15.14) of probes. The mean score of the scale assessing the subjective quality of the responses to thought-probes was 1.91 (*SD* = 0.84) with no rating below zero, indicating that participants felt relatively confident in their responses to the probes.

2.2.2. Behavioral validation of probe reports

First, we examined the impact of the four types of reports on RTs for the five non-target stimuli preceding each probe. A 2 (task-relatedness) × 2 (stimulus-dependency) repeated measures ANOVA was performed on mean RTs. Mean values and standard deviations are detailed in Table 1. We observed a main effect of task-relatedness [$F(1,97) = 5.11$; $p < 0.05$; partial $\eta^2 = 0.05$], indicating that RTs for trials preceding task-unrelated reports (i.e., EDs and SITUTs) were slower than RTs preceding task-related reports (being fully focused on the task and TRIs). The main effect of stimulus-dependency [$F(1,97) = 0.79$; $p = 0.38$; partial $\eta^2 < 0.01$] and the interaction effect were not significant [$F(1,97) = 0.18$; $p = 0.67$; partial $\eta^2 < 0.01$]. A second ANOVA was conducted on the variability of RTs (as assessed by the standard deviation of RTs): we observed a main effect of task-relatedness [$F(1,97) = 25.37$; $p < 0.01$; partial $\eta^2 = 0.21$], a main effect of stimulus dependency [$F(1,97) = 5.38$; $p < 0.05$; partial $\eta^2 = 0.05$], and a significant interaction between the two factors [$F(1,97) = 9.97$; $p < 0.01$; partial $\eta^2 = 0.09$]. The interaction indicated that stimulus-dependent and task-related reports (being fully focused on the task) were preceded by more stable RTs than the three other types of reports (all ps < 0.05); there was no significant difference between SITUTs, EDs, and TRIs.

We also examined the effect of the four types of reports on response accuracy, by performing a 2 (task-relatedness) × 2 (stimulus-dependency) repeated measures ANOVA on the number of errors to the targets. Mean values and standard deviations are detailed in Table 1. The ANOVA demonstrated a main effect of task-relatedness [$F(1,97) = 36.12$; $p < 0.01$;

partial $\eta^2 = 0.27$], a main effect of stimulus dependency [$F(1,97) = 29.84$; $p < 0.05$; partial $\eta^2 = 0.24$], and a significant interaction [$F(1,97) = 32.91$; $p < 0.01$; partial $\eta^2 = 0.25$]. Stimulus-dependent and task-related reports (being fully focused on the task) were preceded by fewer errors to the targets than the three other classes of reports (all *p*s < 0.05); there was no significant difference between SITUTs, EDs, and TRIs.

Insert Table 1 about here

Correlation analyses were also performed to assess the relationship between reports of the four kind of conscious experiences and the global performance on the SART (mean RT, standard deviation of RTs, and proportion of correct responses to the target stimuli). Results of these analyses are presented in Table 2. A higher number of reports of being fully focused on the task was related to better performance on the SART (less variability in RTs for non-targets and fewer errors to the targets), whereas a higher number of reports of SITUTs and EDs was associated with increased variability in RTs and more errors to the targets. TRIs were not significantly related to global performance on the SART. Mean RTs for non-targets showed no significant correlation with the frequency of reports of the different classes of conscious experiences investigated here.

Insert Table 2 about here

2.2.3. Effect of time on task on probe responses

In order to examine the impact of time on task on the distribution of responses to thought-probes, the SART was divided in two equal parts (15 probes). An index of the effect of time on probe responses was calculated for each of the four kinds of reports according to the following formula: number of reports for the second half of the SART – number of reports for the first half of the SART. A 2 (task-relatedness) X 2 (stimulus-dependency) repeated measures ANOVA was performed on this index. As illustrated in Figure 2, we observed a main effect of task-relatedness [$F(1,97) = 38.23$; $p < 0.01$; partial $\eta^2 = 0.28$], indicating a shift from task-related reports to task-unrelated reports with time on task. A main effect a stimulus-dependency was also demonstrated [$F(1,97) = 5.09$; $p < 0.05$; partial $\eta^2 = 0.05$], indicating a shift from stimulus-dependent to stimulus-independent reports with time on task. The interaction effect was not significant [$F(1,97) = 0.39$; $p = 0.54$; partial $\eta^2 < 0.01$]. Examination of the 95% confidence intervals showed that the index of the effect of time on probe responses was significantly different from zero for reports of being fully focused on the SART (-1.89, -0.76), for EDs (0.20, 1.13), and for SITUTs (0.66, 1.61), but not for TRIs (-1.02, 0.08). These results indicate that the frequency of EDs and SITUTs increased with time on task, whereas reports of being fully focused on the SART decreased.

Insert Figure 2 about here

2.2.4. Effect of blocks duration on probe responses

In order to examine the impact of block duration on the distribution of responses to thought-probes, an index of the effect of block duration on probe responses was calculated for each of the four kinds of reports according to the following formula: (number of reports for

22-trial blocks + number of reports for 26-trial blocks) – (number of reports for 10-trial blocks + number of reports for 14-trial blocks). A 2 (task-relatedness) × 2 (stimulus-dependency) repeated measures ANOVA was performed on this index. As illustrated in Figure 3, we observed a main effect of task-relatedness [$F(1,97) = 14.74$; $p < 0.01$; partial $\eta^2 = 0.13$], indicating a shift from task-related reports to task-unrelated reports with increasing block duration. A main effect of stimulus-dependency was also demonstrated [$F(1,97) = 6.62$; $p < 0.05$; partial $\eta^2 = 0.06$], indicating a shift from stimulus-dependent to stimulus-independent reports with increasing block duration. The interaction effect was also significant [$F(1,97) = 6.51$; $p < 0.05$; partial $\eta^2 = 0.06$], indicating that the effect of block duration was especially marked for task-related and stimulus-dependent reports (being fully focused on the task; see Figure 3). Examination of the 95% confidence intervals showed that the index of the effect of block duration on probe responses was significantly different from zero for reports of being fully focused on the SART (-1.51, -0.59), for EDs (0.03, 0.77), and for SITUTs (0.03, 0.81), but not for TRIs (-0.21, 0.60). These results indicate that the frequency of EDs and SITUTs increased with block duration, whereas reports of being fully focused on the SART decreased.

Insert Figure 3 about here

2.3. Discussion

Experiment 1 demonstrates that SITUTs are associated with an increased variability of RTs and diminished response accuracy during the SART. These results are consistent with previous studies that focused on the impact of attentional lapses on task performance (e.g., Cheyne, Solman, Carriere, & Smilek, 2009; McVay & Kane, 2009; Unsworth, et al., 2010) and further demonstrate that SITUTs are directly linked to decreased performance on the current task, even when they are carefully distinguished from other distracting conscious experiences (i.e., EDs and TRIs). Furthermore, the frequency of SITUTs increased with both time on task (Cunningham, et al., 2000; McVay & Kane, 2009; Smallwood, Davies, et al., 2004) and block duration (Giambra, 1995; Smallwood, O'Connor, et al., 2007; Smallwood, Obonsawin, et al., 2003). These results regarding SART performance thus provide a behavioral validation of the novel experience sampling method proposed in this study to assess the presence of SITUTs.

The results further demonstrate that EDs are also related to decreased performance on the SART, as measured by intra-individual variability in RTs and error rate to the target stimuli. Importantly, the analyses show that SITUTs and EDs have a similar impact on task performance. Moreover, the frequency of reports of these two classes of conscious experiences increased with block duration and time on task, whereas the frequency of reports of being fully focused on the SART decreased. This experiment thus demonstrates that thoughts that do not refer to stimuli present in the current environment (SITUTs) and irrelevant sensory perceptions (EDs) can have similar consequences in terms of task performance. On the other hand, the results show that TRIs differ from EDs and SITUTs. Like these two latter classes of conscious experiences, TRIs were associated with decreased performance in blocks for which they were reported (decreased accuracy to the target stimuli and increased variability in RTs). However, contrary to SITUTs and EDs, the total number of these thoughts did not correlate with the global SART performance. Furthermore, the frequency of TRIs was not influenced by time on task and block duration, whereas the frequency of SITUTs and EDs increased with both variables. These results indicate that TRIs do not behave like SITUTs and EDs, which demonstrates the importance of using more precise thought-probes to distinguish conscious experiences according to both the “task-relatedness” and “stimulus-dependency” dimensions.

3. Experiment 2

Experiment 1 demonstrated that SITUTs negatively affect performance on the SART (Robertson, et al., 1997), even when they are carefully distinguished from other kinds of distracting conscious experiences (i.e., EDs and TRIs). If the novel measure of SITUTs implemented in this study really reflects the core of mind-wandering, then these thoughts should be sensitive to variables supposed to characterize mind-wandering. This hypothesis was tested in Experiment 2, by exploring the content and sensitivity of SITUTs with respect to the anticipation and planning of the future. A number of studies indeed suggest that mind-wandering serves a variety of useful functions, including the preparation for future events through the processing of personal goals and concerns (Bar, 2007, 2009; Bar, et al., 2007; Binder, et al., 1999; Buckner & Vincent, 2007; Singer, 1966; Smallwood & Schooler, 2006). In Experiment 2, we reasoned that if an important function of SITUTs is to plan the future, then (1) the content of most SITUTs reported during the SART should be oriented towards the future and (2) the occurrence of future-oriented SITUTs should be influenced by conditions that increase participants’ attention to personal goals before engaging in the SART.

In order to precisely assess the content of each reported SITUT, we combined the thought-probes method used during the SART (see Experiment 1) with an adaptation of the Memory Characteristics Questionnaire (Johnson, Foley, Suengas, & Raye, 1988). This questionnaire permitted us not only to assess the temporal orientation of SITUTs (Miles, et al., 2010; Smallwood, Nind, et al., 2009) but also their perceived functions. With regards to this latter aspect of SITUTs, we were particularly interested in contrasting future-oriented functions, which refer to planning, decision making (i.e., behavioral intention; Sheeran, 2002; Webb & Sheeran, 2006) and the re-appraisal of previous situations (i.e., counterfactual thinking; Barbey, Krueger, & Grafman, 2009; Epstude & Roese, 2008; Smallman & Roese, 2009), with other functions that have also been attributed to SITUTs (e.g, maintaining arousal or providing pleasant feelings; for reviews, see Antrobus, et al., 1970; Gold & Cundiff, 1980; Klinger, 1999). We expected that future-oriented SITUTs (either temporally or functionally) would be more frequent than other kinds of SITUTs, showing a "prospective bias" (Smallwood, Nind, et al., 2009). Furthermore, we reasoned that if an important function of SITUTs is to prepare for future events through the processing of personal goals and concerns, then priming these personal goals and concerns should influence the number of future-oriented SITUTs experienced during the SART. Therefore, we expected that the number of future-oriented SITUTs would be further increased when participants' attention had been drawn to currently relevant personal goals before completing the SART (i.e., by writing an essay about this particular topic), in comparison to a control baseline condition matched in length and difficulty but that did not involve the activation of personal goals (i.e., writing an essay about a familiar itinerary).

3.1. Methods

3.1.1. Participants

A total of 53 students from the University of Liège volunteered to participate in the study. Their age ranged from 19 to 29 years, with a mean age of 23.35 years (*SD* = 2.41). Individuals with medical disorders, neurological disorders, psychiatric disorders or history of medication/substance use were excluded from the experiment. All subjects had normal or corrected to normal vision and audition. Participants were randomly assigned either to the personal goal (PG) condition or to a baseline condition (mental navigation, MN) (see below). Seven participants (six of whom were from the PG group) were later removed from the study because they reported, after the test session, having guessed that one of the purposes of the study was to explore whether writing about personal goals or familiar routes had an impact on the subsequent SART and, more specifically, on their responses to thought-probes. The criterion for removing these subjects was a score above 4 on a 7-point Likert scale ranging from 1 "I had no idea that the essay writing task had this purpose" to 7 "I completely guessed that the essay writing task had this purpose." Of the 46 remaining participants, 23 (16 women, 7 men) were in the PG group and 23 (17 women and 6 men) were in the MN group. Mean ratings on the "guessing" scale indicated that these participants had no idea about the real purpose of the study, and the two groups did not differ in this respect [$t(44) = 1.29$, $p = 0.2$; PG = 1.71 ± 0.91; MN = 1.39 ± 0.78]. The two groups did not differ in terms of age [$t(44) = -1.23$, $p = 0.23$; PG = 22.91 ± 2.45 years; MN = 23.78 ± 2.35 years] and essay writing time [$t(44) = -1.33$, $p = 0.19$; PG = 954.57 ± 219.06 seconds; MN = 1040.17 ± 217.57 seconds].

3.1.2. Materials

Writing task. Before completing the SART, participants engaged in a writing task designed to draw their attention either to personal goals or to a topic unrelated to personal goals. This writing task was adapted from a procedure previously used to investigate "possible selves" (Hoyle & Sherrill, 2006) and to manipulate the content of dreams (Langens, 2006). Participants in the personal goal (PG) condition were asked to take some minutes to think about their future and to write a one page essay in which they described one or two of their most important current personal projects, as well as the steps that need to be taken for reaching them (see the Appendix for detailed instructions). Participants in the baseline (mental navigation, MN) condition were asked to describe in detail the itinerary from the building where the experiment took place to a well-known location in the center of Liège. As with the experimental condition, this baseline condition involved planning processes, but the mental contents activated referred to familiar driving routes rather than personal goals (see the Appendix for detailed instructions). A recent meta-analysis of neuroimaging studies (Spreng, Mar, & Kim, 2009) has demonstrated that these two kinds of tasks activate largely overlapping brain regions, suggesting that they involve, for the most part, highly similar cognitive processes. However, a notable difference was that MN lacked activation in the medial prefrontal cortex, an area well known to support self-related processes (D'Argembeau, et al., 2005; Gusnard, Akbudak, Shulman, & Raichle, 2001), including the processing of personal goals (D'Argembeau, et al., 2010). The MN and PG conditions used in this study thus appear to involve highly similar cognitive processes, except for their relevance to the individual's current goals which was the key dimension of interest in this study[1].

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[1]Although it was not our main purpose, we had initially thought that it would be interesting to include another control condition consisting in priming past goals that are no longer relevant to the individual. Therefore, we conducted a pilot study in which we asked 22 participants (8 men and 14 women) to write a one page essay about an important personal goal that they had accomplished in the past and that is currently completed. Participants had no difficulty in writing the essay (indeed, redaction times were similar as in the two other writing conditions). However, subsequent ratings indicated that they described past goals that still had important implications for their current and future life; the mean rating was 5.41 (SD = 1.65) on a seven-point Likert scale ranging from 1 (*not at all important*) to 7 (*very important*). Only two participants gave a rating below 4 (*moderately important*). Retrospectively, this finding is not particularly surprising given that an important function of autobiographical memory may be to provide a means to check on progress with current goals, and that people typically have difficulty in accessing past personal knowledge that is no longer relevant to their current goals and concerns (Conway, 2005, 2009). Considering the results of this pilot study, it appeared to us that priming past goals would not be an appropriate control condition for our purpose, as the past goals being primed would also be relevant to participants' current goals and concerns.

SART with thought-probes. This task was similar to the one used in Experiment 1. The only difference concerned the short text displayed on the screen after the responses to the probes. When the participants provided a (4) rating (i.e., SITUTs report), the text display reminded them to write a description of the thought they were experiencing. There was no time limitation for this part of the task. Before the task, participants were told that their descriptions should be detailed enough to allow them to clearly remember after the task what they were thinking about. In order to diminish the discomfort that some individuals could experience when sharing personal thoughts (Klinger, Murphy, Ostrem, & Stark-Wroblewski, 2005), the participants were also told that they could describe their thoughts by noting down key-words if they wanted, the important point being that they could remember which thought these words referred to. No mention was made about the thought questionnaires at this point of the task.

Thought Characteristics Questionnaire. This kind of self-report questionnaire is derived from the Memory Characteristics Questionnaire created by Johnson and colleagues (1988). It is usually used to asses phenomenological characteristics of thoughts sampled in daily life (e.g., Berntsen & Jacobsen, 2008; D'Argembeau, Renaud, & Van der Linden, 2011; Klinger & Cox, 1987) but has also been recently used to assess the features of involuntary memories occurring during vigilance tasks (Schlagman & Kvavilashvili, 2008).

In the present study, participants were asked to report the characteristics of SITUTs at the end of the SART rather than on-line. This choice was made because the on-line assessment of SITUTs content might have led participants to guess more easily the real purpose of the writing task. Some previous studies have examined the differences between on-line versus retrospective assessments of thought features and found no major discrepancy between these two kinds of procedures (Hurlburt, Lech, & Saltman, 1984; Hurlburt & Melancon, 1987). In addition, retrospective assessments of the frequency of mind-wandering episodes with questionnaires such as the Thinking Content component of the Dundee Stress Scale Questionnaire (Matthews, et al., 1999) correlate strongly with online reports of off-task thoughts (Smallwood, Baracaia, et al., 2003; Smallwood, O'Connor, Sudberry, Haskell, & Ballantyne, 2004). These results indicate that participants can remember their thoughts and mind-wandering episodes at the end of a task and demonstrate the reliability of retrospective measures of thoughts' characteristics.

For each thought, the following characteristics were assessed: (1) visual imagery (*1 = not at all visual, 7 = completely visual*), (2) inner speech (*1 = not at all, 7 = totally*), (3) the voluntary aspect of thought occurrence (*1 = not at all, 7 = totally*), (4) the fact that this thought belonged to a structured succession of thoughts, such as in problem solving (*1 = not at all, 7 = totally*), (5) the fact that its content was realistic and plausible (*1 = not at all, 7 = totally*), (6) the fact that its content was related to the participant's current goals (*1 = not at all, 7 = totally*), (7) the fact that its content was of importance to the participant's life (*1 = not at all, 7 = totally*), (8) its repetitive aspect in daily life (*1 = never occurs in daily life, 7 = occurs very often in daily life*) and (9) its affective content *(-3 = very negative, +3 = very positive*). Participants were also asked to categorize each thought according to its temporal orientation: (1) past, (2) present, (3) future or (4) no precise temporal orientation. For past and future SITUTs, participants were also asked to specify the temporal distance of their thoughts by choosing between six different categories: SITUTs referring to (1) the present day, (2) the past/next seven days, (3) the past/next month, (4) a time period between the past month and the past year / between the next month and the next year, (5) a time period more than one year away in the past/future and (6) I can't say. Finally, subjects were asked to specify the main function of each thought, using seven response categories. Three of these categories referred to possible future-oriented functions: (1) to make a decision/solve a problem, (2) to plan something, (3) to re-appraise a situation. Three other categories referred to others functions that are not particularly future-oriented: (4) to make the participant feel better, (5) to keep the participant aroused, and (6) another non-listed function (in which case, participants were asked to specify what the function was). Finally, the last possibility was (7) thought with no apparent function. Thoughts classified under the three future-oriented functions (i.e., "decision making", "planning" and "re-appraisal of situation") were subsequently pooled into one group and thoughts classified under the three non-future-oriented functions (i.e., "feeling better", "arousal" and "other non-listed function") were pooled into another group for statistical analyses.

At the end of the questionnaire participants were asked whether they had any difficulties to rate the features of their SITUTs and were invited to rate the overall quality of their retrospective evaluations using a 7-point Likert scale (*-3 = very bad, +3 = very good*). Participants reported that the overall quality of the phenomenological evaluations of their SITUTs on the thought-questionnaires was rather high, with a mean score of 2.09 (*SD* = 0.78) and no rating below zero, indicating that participants made their judgments with a reasonable degree of confidence.

3.1.3. Procedure

Participants were tested individually in a quiet, well-lightened room. As a cover story, they were told that they would be taking part in a study examining the relationship between the features of their own mental representations and their tendency to maintain attention on a task. They were told that they would have to carry out two different tasks assessing each of these aspects. The two tasks (the essay writing task presumably assessed features of mental representations and the SART assessed the ability to maintain attention) were then described in detail (see above). Participants then carried out the short training session for the SART. After these training blocks, participants performed the essay writing task which was immediately followed by the SART. After the SART, subjects were instructed to assess each of their SITUTs using the Thought Characteristics Questionnaire. For the first thought, each dimension of the questionnaire was explained to the participants.

At the end of the experiment, the real purpose of the essay writing task was explained to the participants (i.e., to investigate whether the writing task would influence the content of thoughts during the SART) and they were given the 7-point Likert scale which assessed the extent to which they had guessed the real purpose of the essay writing task. In total, the whole session lasted about 75 minutes.

3.2. Results

3.2.1. Effects of mindset induction on global SART performance and probe responses

To assess whether writing about personal goals had an impact on the responses made to the probes, as well as on the SART performance (as assessed by mean RT, standard deviation of RTs and response accuracy to the target stimuli), independent samples *t*-tests were conducted. As shown in Table 3, no difference was found between the two groups. These results indicate that writing about personal goals did not influence the performance on the SART nor the distribution of responses given to the probes.

Insert Table 3 about here

3.2.2. Effects of mindset induction on SITUTs characteristics

We first examined descriptions of SITUTs reported by both groups of participants and computed the number of thoughts that directly involved thinking back to the specific personal goal(s) or itinerary that participants had described in their essay. Only two SITUTs (from two different participants) involved thinking back to the specific personal goal(s) that had been previously described (i.e., less than 1% of the total number of SITUTs reported in the PG condition) and only one SITUT involved thinking back to the itinerary that had been previously described (i.e., less than 1% of the total number of SITUTs reported in the MN condition). In addition, no SITUT referred to the content of the statements that the participants classified during training.

Next, we examined whether the temporal orientation of SITUTs differs as a function of mindset induction condition. A 2 (group) × 4 (temporal orientation) mixed ANOVA was performed on the number of reported thoughts. As illustrated in Figure 4, this analysis demonstrated a main effect of temporal orientation [$F(3,132) = 16.54$; $p < 0.01$; partial $\eta^2 = 0.27$], indicating that future-oriented SITUTs were more frequent than SITUTs with other temporal orientations (i.e., past and present) and SITUTs with no precise temporal orientation. The main effect of group was not significant [$F(1,44) = 0.98$; $p = 0.33$; partial $\eta^2 = 0.02$] but there was a significant interaction between group and temporal orientation, [$F(3,132) = 3.15$; $p < 0.05$; partial $\eta^2 = 0.07$]. A planned comparison indicated that future-oriented SITUTs were more frequent in the PG group than in the MN group [$F(1,44) = 5.09$; $p < 0.05$; partial $\eta^2 = 0.10$]; there was no difference between the two groups for other temporal orientations. In summary, these results indicate that most SITUTs are temporally oriented toward the future and that this “prospective bias” is enhanced when participants had thought about their personal goals before completing the task.

Insert Figure 4 about here

The same analysis was performed on the reported future-oriented *function* of SITUTs. A main effect of function was observed [$F(2,88) = 17.26$; $p < 0.01$; partial $\eta^2 = 0.28$], indicating that thoughts classified under the “future-oriented functions” category were more frequent than thoughts classified under other functions or classified as aimless daydreams. No main effect of group was demonstrated [$F(1,44) = 1.18$; $p = 0.28$; partial $\eta^2 = 0.03$] but the interaction was close to statistical significance [$F(2,88) = 2.92$; $p = 0.06$; partial $\eta^2 = 0.06$]. A planned comparison indicated that SITUTs with a future-oriented function were significantly more frequent in the PG group than in the MN group [$F(1,44) = 5.57$; $p < 0.05$; partial $\eta^2 = 0.11$]; there was no difference between the two groups for other functions. In summary, these results indicate that most SITUTs are perceived as having future-oriented functions, and that this is even more the case when participants had thought about their personal goals before completing the SART.

Insert Figure 5 about here

Next, to examine the temporal distance of SITUTs, a 2 (group) × 5 (temporal distance) mixed ANOVA was performed on the number of past and future SITUTs. Because of the very low number of SITUTs belonging to the “no precise temporal distance” category, they were not included in the present analysis. As illustrated in Figure 6, this analysis revealed a main effect of temporal distance [$F(4,176) = 28.45$; $p < 0.01$; partial $\eta^2 = 0.39$], indicating that SITUTs related to the present day were more frequent than SITUTs belonging to other temporal distance categories. No main effect of group was demonstrated [$F(1,44) = 1.74$; $p =$

0.19; partial η^2 = 0.04] and the interaction effect was not significant either [$F(4,176) = 1.78$; $p = 0.14$; partial η^2 = 0.04].

Insert Figure 6 about here

Mean scores and standard deviations on each of the phenomenological dimensions assessed by the Thought Characteristics Questionnaires, as well as results of the independent samples *t*-tests conducted on these measures, are reported in Table 4. No difference was found between the two groups. It is worth noting that the mean scores for the voluntary aspect of SITUTs occurrence and their sequential aspect (i.e., the fact that the SITUT belonged to structured sequence of thoughts, like reasoning or problem solving) were rather low (note that on the Likert scales, a score of four corresponded to moderately intentional and sequential SITUT), indicating that most of the reported SITUTs were rather spontaneous. It can also be noted that the content of SITUTs was mostly very realistic with a mean score above six out of seven.

Insert Table 4 about here

3.3 Discussion

In Experiment 2, we used the novel experience sampling method developed in Experiment 1 to further investigate the function and phenomenology of SITUTs. Following previous suggestions that an important function of mind-wandering is to plan the future (Bar, 2007, 2009; Bar, et al., 2007; Binder, et al., 1999; Buckner & Vincent, 2007; Singer, 1966;

Smallwood & Schooler, 2006), we hypothesized (1) that the content of most SITUTs reported during the SART should be oriented towards the future, and (2) that the occurrence of future-oriented SITUTs should be influenced by conditions that increase participants' attention to personal goals before engaging in the SART. The results of Experiment 2 are consistent with these hypotheses. In both groups of participants, future-oriented SITUTs were more frequent than SITUTs with other temporal orientations (or SITUTs without precise temporal orientation), and SITUTs related to future-oriented functions (i.e., SITUTs related to decision making, planning, or reevaluation of situations) were more frequent than SITUTs serving other functions or without any function. Furthermore, future-oriented SITUTs (both temporally and functionally) were more frequent for participants who had previously thought about their personal goals than for participants who had thought about a familiar itinerary. These findings indicate that there is a general tendency for SITUTs to be oriented towards the future, and that this prospective bias (Smallwood, Nind, et al., 2009) is increased when participants' attention had been directed towards their personal goals before performing the SART. A descriptive analysis of the phenomenological dimensions of SITUTs further indicated that they mainly consisted in realistic and involuntary future thoughts about practical plans/concerns related to the present day (e.g., thinking about an appointment in the next hours, about possible leisure activities for the end of the day or about work that need to be done before tomorrow).

4. General discussion

The present study introduces a novel experience sampling method to study mind-wandering based on a conceptualization of ongoing conscious experiences along two dimensions: "task-relatedness" and "stimulus dependency." This new method permits to clearly distinguish mind-wandering (i.e., stimulus-independent and task-unrelated thoughts; SITUTs) from irrelevant exteroceptive and interoceptive perceptions (i.e., external distractions; EDs) and interfering thoughts related to the appraisal of the current task (i.e., task-related interferences; TRIs). Experiment 1 provides a behavioral validation of this novel experience sampling method, demonstrating that SITUTs are associated with an increased variability of RTs and diminished response accuracy during the SART. In Experiment 2, we further investigated the phenomenology and possible functions of SITUTs. We reasoned that if the novel measure of SITUTs implemented in this study really reflects the core of mind-wandering, then these thoughts should be sensitive to variables supposed to characterize mind-wandering, such as their role in anticipating and planning the future. In line with this hypothesis, the results of Experiment 2 show that most SITUTs are oriented towards the future (both temporally and functionally), and that this "prospective bias" is further increased when participants' attention had been previously oriented toward their personal goals.

In most previous studies that have investigated mind-wandering using thought-probes, participants were simply instructed to report whether they were totally focused on the task or whether they were distracted by task-unrelated (or stimulus-independent) conscious experiences, and the latter was considered to reflect the occurrence of mind-wandering episodes (e.g. Forster & Lavie, 2009; Giambra, 1989, 1995; Mason, et al., 2007b; McKiernan, et al., 2006; Smallwood, McSpadden, et al., 2007). A limit of this dichotomous classification is that reports of true mind-wandering episodes (here referred to as SITUTs) may be mixed with reports of other distracting conscious experiences, such as irrelevant exteroceptive and interoceptive perceptions (EDs) and interfering thoughts related to the appraisal of the current task (TRIs). Consequently, the link between mind-wandering and task performance is still debated, notably because the decreased performance that is associated with "off-task" reports may be due to EDs rather than SITUTs (Christoff, et al., 2009; Gilbert, et al., 2007; Mason, et al., 2007a, 2007b). In this context, the results of the current study demonstrate the importance of using more precise thought-probes that clearly distinguish SITUTs from other classes of distractions (i.e., EDs and TRIs). In Experiment 1, we show that SITUTs are associated with an increased variability of RTs and diminished response accuracy during the SART, even when they are carefully distinguished from other distracting conscious experiences (i.e., EDs and TRIs). Furthermore, Experiment 1 demonstrates that SITUTs and EDs negatively affect SART performance to a comparable extent (in terms of intra-individual variability of RTs and accuracy to the target stimuli), and that both increase in frequency with block duration and time on task. On the other hand, TRIs show a different pattern of results: these thoughts are not related to global performance on the SART and their frequency is unaffected by time on task and block duration. These results thus highlight the importance of using more precise thought-probes to distinguish conscious experiences according to both task-relatedness and stimulus-dependency.

The association between diminished performance on the SART and reports of SITUTs/EDs might suggest that participants reported task-unrelated conscious experiences not because they were truly experiencing SITUTs and EDs at the end of the block (i.e., at the moment of the thought-probe), but rather to “justify” their poor performance during that block. We nonetheless believe that this is not the case and that the subjective reports made by our participants are reliable for several reasons. First, if reports of SITUTs and EDs were post-hoc justifications for mistakes committed during the task, then one would expect this kind of reports to decrease in conditions where participants commit fewer errors. However, it is the opposite effect that is typically observed, with the frequency of task-unrelated reports during a task actually decreasing as the difficulty of the task increases (e.g., McKiernan, et al., 2006; Teasdale, et al., 1995). Second, the ecological validity of the thought-probe method has been demonstrated in a recent study (McVay, Kane, & Kwapil, 2009). These authors showed that participants who report more task-unrelated conscious experiences during the SART are also more likely to report off-task thoughts when beeped at random intervals in their daily life. There is no reason to believe that such a relationship between laboratory and real-life reports should exist if task-unrelated reports during the SART were made by the participants simply to justify their poor performance in this task. Finally, Experiment 2 shows that the specific content of SITUTs can be experimentally manipulated, which again argues against the view that they simply reflect post-hoc justifications of poor task performance. For these reasons, we believe that the reports made by our participants to the thought-probes can be reasonably trusted (for another review on the validity of thought-probe reports, see McVay & Kane, 2010a).

Although the present results show that SITUTs and EDs have a similar impact on task performance, the underlying processes might be different in the two cases. The appearance of these two kinds of distracting conscious experiences has been linked to failures in executive functioning (McVay & Kane, 2009, 2010b; Unsworth, et al., 2010), and more specifically inhibitory processes (Lustig, et al., 2001). However, inhibition is not a unitary cognitive process (e.g., Friedman & Miyake, 2004; Harnishfeger, 1995; Nigg, 2000) and it might be that the occurrence of SITUTs and EDs are related to different subcomponents of inhibition. There is evidence that intrusive thoughts are specifically related to the "resistance to proactive interference" subcomponent of inhibition (i.e., the ability to resist memory intrusions from information that was previously relevant to the task but has since become irrelevant; Friedman & Miyake, 2004; Verwoerd, Wessel, & de Jong, 2009). Although this issue remains to be investigated in detail, it is likely that EDs are related to other subcomponents of inhibition (e.g., "resistance to distractor interference"). Future studies could use the novel thought-probes method developed in this study in order to test this hypothesis.

A possible interpretation for the differences between TRIs versus SITUTs and EDs is that the former corresponds, at least in part, to attempts to optimize the speed by accuracy trade-off during the SART. Indeed, RTs and errors to the target stimuli in the SART are strongly negatively related (e.g., Robertson, et al., 1997; Smilek, Carriere, & Cheyne, 2010), and several findings indicate that participants commonly slow down the speed of their RTs during this task in order to commit fewer errors to the target stimuli (e.g., Helton, 2009; Helton, Kern, & Walker, 2009). It is therefore possible that participants consciously reflected upon their performance during the SART (hence the occurrence of TRIs) in order to adjust the speed of their RTs and commit fewer errors to the upcoming targets. Thus, even if TRIs are associated with decreased performance at the moment of their occurrence, they might nevertheless help to prevent subsequent mistakes by inducing a more adjusted and careful mode of response. This might explain why, in the end, reports of TRIs did not correlate with the global performance on the SART.

In addition to providing a behavioral validation of our novel thought-probes method, the current findings demonstrate that this method is sensitive to variables supposed to characterize mind-wandering, such as its role in anticipating and planning the future (Bar, 2007, 2009; Bar, et al., 2007; Binder, et al., 1999; Buckner & Vincent, 2007; Singer, 1966; Smallwood & Schooler, 2006). Experiment 2 indeed shows that most of the SITUTs reported by the participants are temporally oriented towards the future, which is consistent with previous research indicating that mind-wandering is characterized by a prospective bias (Smallwood, Nind, et al., 2009). Importantly, we also found that most SITUTs are perceived as fulfilling future-oriented functions, such as planning, decision making (i.e., behavioral intention; Sheeran, 2002; Webb & Sheeran, 2006), and the re-appraisal of situations (i.e., counterfactual thinking; Barbey, et al., 2009; Epstude & Roese, 2008; Roese, 1994). These results thus indicate that most SITUTs involve attempts to anticipate and prepare for what might occur, especially in the near future. In addition, Experiment 2 also demonstrates that the occurrence of these future-oriented SITUTs increases when participants' attention had been oriented to their personal goals before performing the SART. To our knowledge, this is the first study to demonstrate that the temporal direction of mind-wandering can be experimentally manipulated by varying pre-task circumstances, and the findings thus provide new evidence that mind-wandering is not a random mental phenomenon but might instead play a key role in the management of personal goals.

To conclude, the present study is the first to both clearly distinguish the core of mind-wandering (i.e., SITUTs) from other distracting conscious experiences (i.e., EDs and TRIs) and to precisely examine the content and function of reported mind-wandering episodes. Results of the two experiments presented here illustrate the paradoxical nature of mind-wandering: although SITUTs impair task performance at the moment of their occurrence, they are more than simple attentional lapses and may play a key role in anticipating and planning future events. This study thus supports the proposal that SITUTs are not the mere reflection of failures in executive control processes (McVay & Kane, 2009, 2010b) but should rather be considered as the consequence of a redirection of cognitive resources away from the ongoing task and toward the processing of internal information linked to personal goals and concerns (Christoff, et al., 2009; Smallwood, 2010; Smallwood & Schooler, 2006).

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Appendix

Instructions for the writing task

Personal goals

We are going to ask you to take some minutes to think about your future. We would like you to write an essay of about one page in length in which you describe in detail how you imagine your future. More specifically, we ask you (1) to describe things you would like to achieve in the future that are most important for you at the moment (your projects), (2) to explain why it is important for you to achieve these projects, and (3) to specify the necessary steps for achieving these projects (what you will have to do to reach these goals, the possible difficulties that you could encounter, and so on). These projects can relate to various domains of life (school/work, romantic/family life, leisure activities, and so forth). You can describe a single project in detail or describe two projects, the important point being that you describe the most important project(s) you would like to achieve and that you indicate the three elements mentioned above for every project. Try to be as sincere as possible.

Mental navigation

We are going to ask you to take some minutes to think about and mentally represent a particular itinerary. We would like you to write an essay of about one page in length in which you describe in detail the itinerary from the Psychology department building to the place Saint-Lambert. More specifically, we ask you (1) to describe the various elements you have to take (e.g., roads, squares, bridges, traffic circles, etc.) or next to which you pass (buildings, etc.), (2) to specify the directions to be taken (to the left, to the right, etc.) and (3) to describe exactly the location of the place Saint-Lambert at which you arrive. You can take the route you wish, the important point being that you describe the three elements mentioned above in detail. Try to be as accurate as possible.

Table 1: Mean performance for each block of the SART according to the response given to the though-probes

	Mean RTs for the 5 last non-targets	Mean SDs for the 5 last non-targets	Mean percentages of errors to the targets
On-task reports	349 (45)	51 (16)	25.98 (22.69)
TRIs reports	351 (49)	59 (22)	45.34 (21.50)
EDs reports	357 (57)	63 (27)	49.22 (23.48)
SITUTs reports	358 (56)	63 (26)	47.78 (22.28)

Note: Standard deviations from the mean are presented in brackets. SDs: standard deviations; TRIs: task-related interferences; EDs: external distractions; SITUTs: stimulus-independent and task-unrelated thoughts. Mean RTs and mean SDs are presented in msec.

Table 2: Correlations between SART performance and the percentages of responses of each kind made to the thought-probes

	Accuracy for targets	Mean RT for non-targets	Mean SD for non-targets
% On-task reports	0.42**	-0.02	-0.31**
% TRIs reports	-0.15	-0.11	-0.07
% EDs reports	-0.40**	-0.08	0.20*
% SITUTs reports	-0.23*	0.14	0.33**

Note:

*: Correlation significant at the 0.05 level (two-tailed).

**: Correlation significant at the 0.005 level (two-tailed).

SD: standard deviation; TRIs: task-related interferences; EDs: external distractions; SITUTs: stimulus-independent and task-unrelated thoughts.

Table 3: Mean performance on the SART, mean percentages of responses of each kind to the thought-probes for the two groups of participants, and results of the independent samples *t*-tests comparing these mean scores

SART performance and thought-probe responses	Mean score (standard deviation)		*t* scores	*p*
	PG group	MN group		
RTs for non-targets	347 (37)	358 (27)	-1.09	0.28
SDs for non-targets	78 (19)	77 (22)	0.05	0.96
% accuracy for targets	63.99 (16.09)	67.54 (13.18)	-0.82	0.42
% on-task reports	26.09 (11.49)	29.71 (19.90)	-0.76	0.45
% TRIs reports	29.71 (10.05)	33.77 (14.95)	-1.08	0.29
% EDs reports	22.46 (9.11)	17.97 (9.57)	1.63	0.11
% SITUTs reports	21.74 (11.80)	18.55 (9.94)	0.99	0.33

Note: SDs: standard deviations; TRIs: task-related interferences; EDs: external distractions; SITUTs: stimulus-independent and task-unrelated thoughts; PG: personal goals; MN: mental navigation. RTs and SDs for non-targets are presented in msec. Value of *dl* for each of the *t*-test is 44.

Table 4: Mean scores of the phenomenological dimensions of SITUTs for the two groups of participants and results of the independent student *t*-tests comparing these mean scores

Phenomenological dimensions	Mean score (standard deviation)		*t* scores	*p*
	PG group	MN group		
Visual imagery	4.35 (1.23)	4.09 (1.4)	0.69	0.5
Inner speech	3.81 (1.57)	4.23 (1.64)	-0.89	0.38
Intentional aspect	2.57 (0.88)	2.38 (0.88)	0.75	0.46
Sequential aspect	3.08 (1.16)	3.05 (1.17)	0.11	0.91
Realism	6.21 (0.74)	6.34 (0.69)	-0.61	0.55
Relat. to personal goals	3.72 (1.42)	3.91 (1.5)	-0.44	0.66
Importance	4.07 (1.21)	3.7 (1.21)	1.05	0.3
Repetitive aspect	3.69 (1.57)	2.95 (1.19)	1.81	0.08
Affective valence	0.62 (1.25)	0.19 (0.88)	1.34	0.19

Note: PG: personal goals; MN: mental navigation. All mean scores range from 1 to 7 except for the affective valence dimension the range of which goes from -3 to +3. Value of *dl* for each of the *t*-test is 44.

Figure 1: Conceptual division of ongoing conscious experiences occurring during tasks requiring sustained externally driven attention according to their "stimulus-dependency" and "task-relatedness" dimensions.

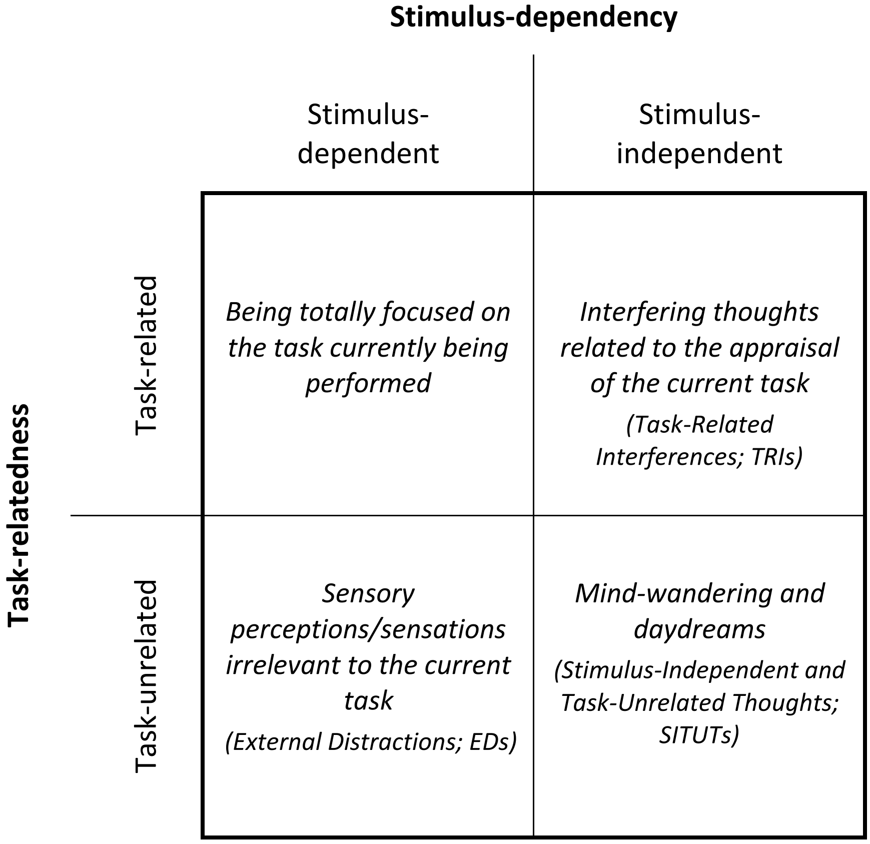
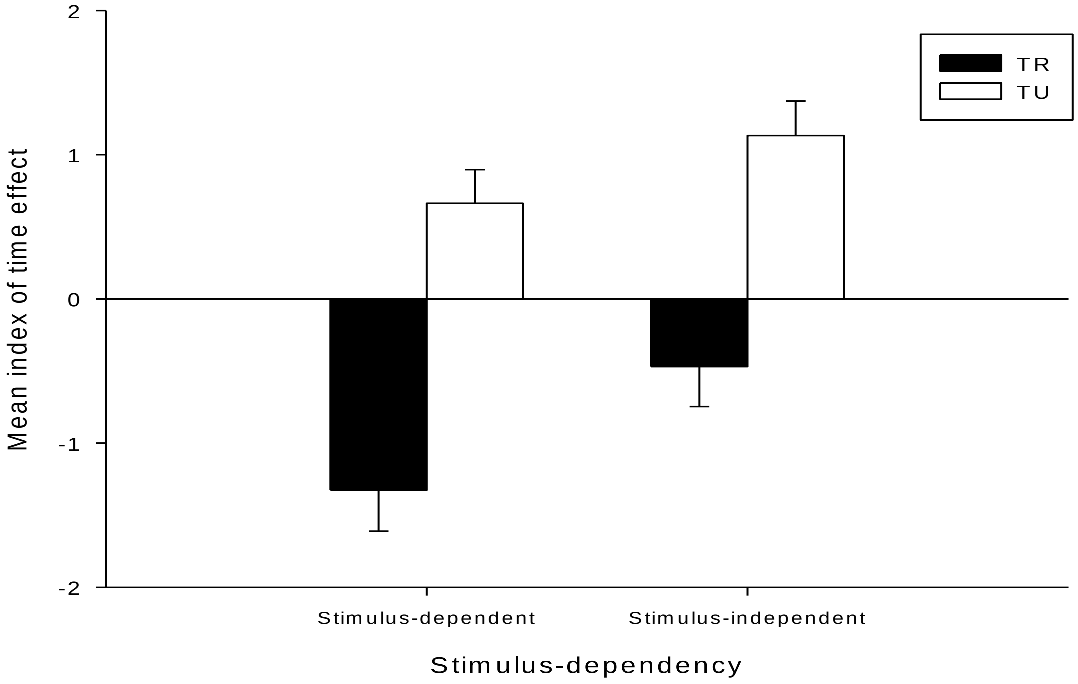
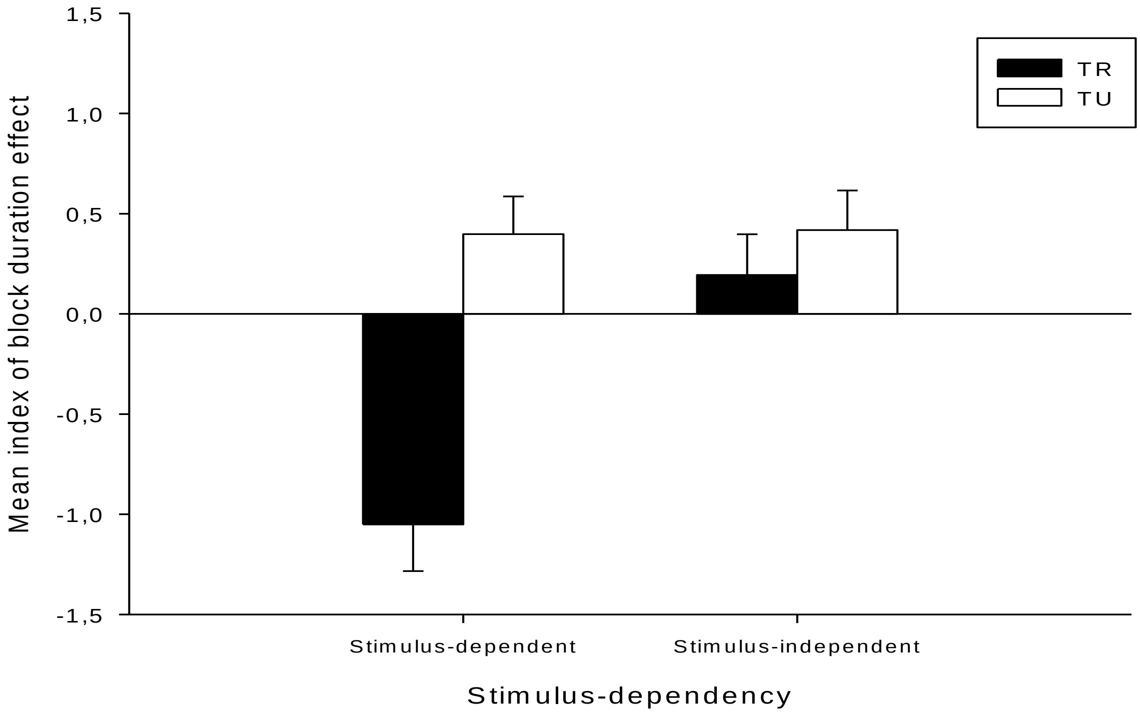


Figure 2: Influence of time on task on thought-probes reports



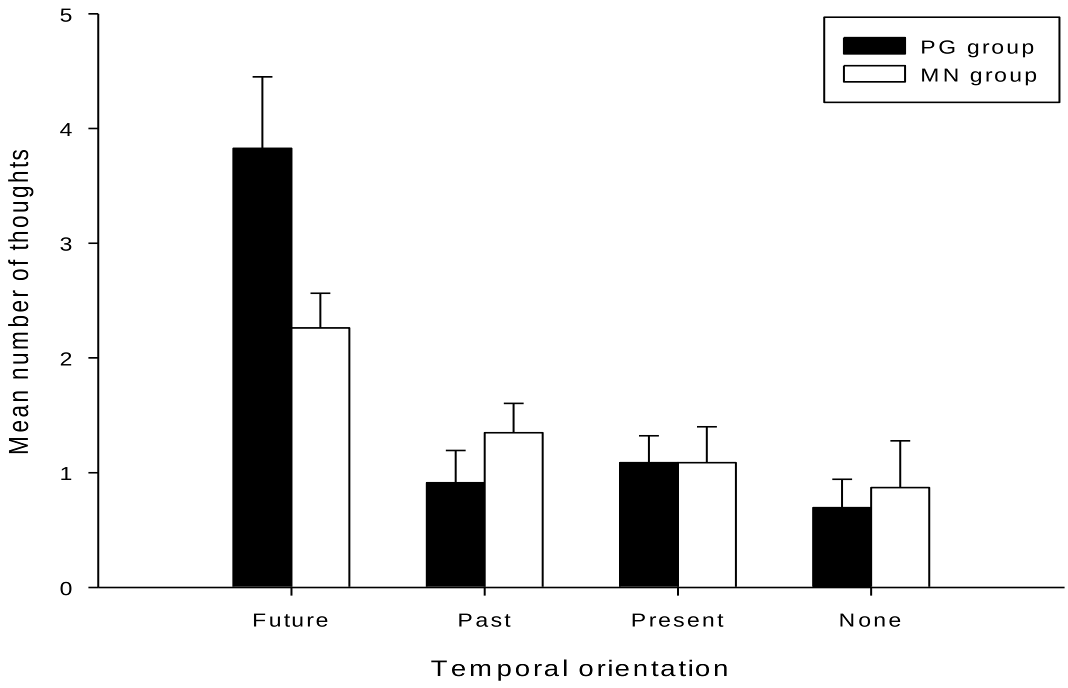
Note: bars represent standard error on the mean. TR: Task-related; TU: Task-unrelated.

Figure 3: Influence of block duration on thought-probes reports



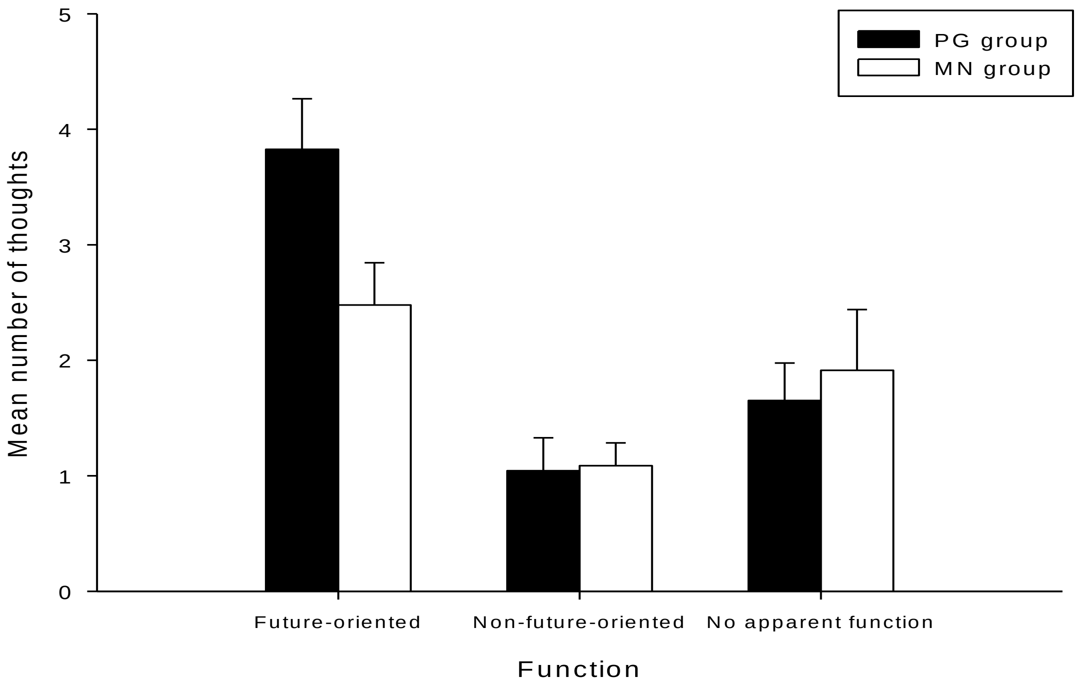
Note: bars represent standard error on the mean. TR: Task-related; TU: Task-unrelated.

Figure 4: Distribution of SITUTs according to their temporal orientation



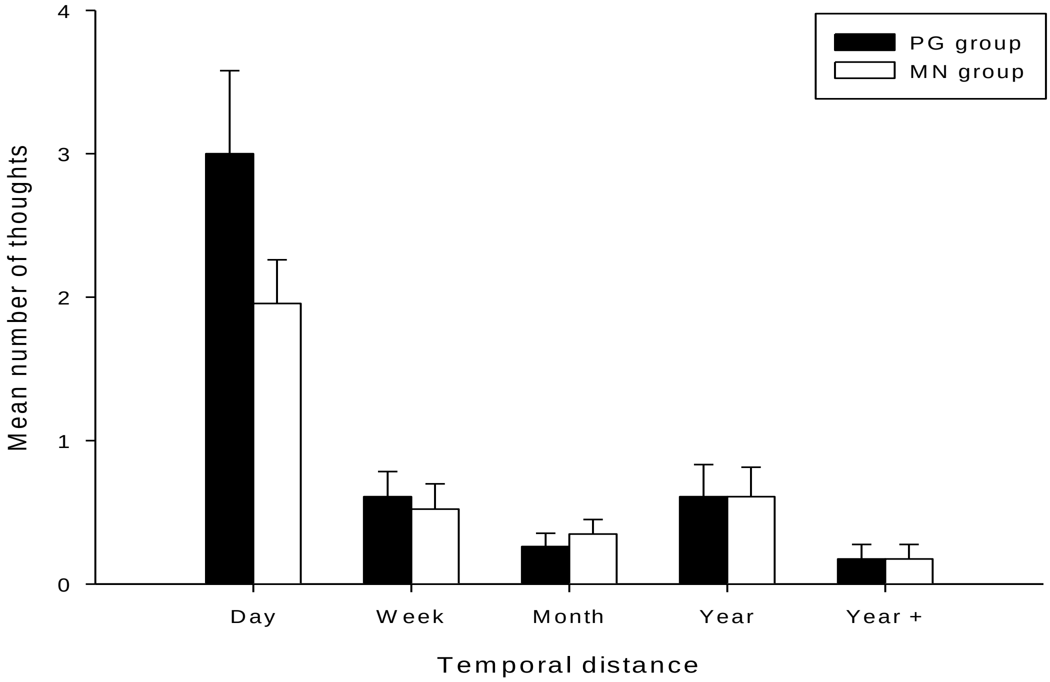
Note: bars represent standard error on the mean. PG: personal goals; MN: mental navigation.

Figure 5: Distribution of SITUTs according to their attributed function



Note: bars represent standard error on the mean. "Future-oriented functions" represent the sum of thoughts attributed to the "planning", "decision making" and "re-evaluation of situations" functions. "Non-future-oriented functions" represent the sum of thoughts attributed to the "arousal", "feeling better" and "other non-listed functions" categories. PG: personal goals; MN: mental navigation.

Figure 6: Distribution of past and future SITUTs according to their temporal distance



Note: bars represent standard error on the mean. Day: SITUTs pertaining to the present day. Week: SITUTs pertaining to the past/next seven days. Month: SITUTs pertaining to the past/next month. Year: SITUTs pertaining to the past/next year. Year +: SITUTs pertaining to more than one year in the past/future. PG: personal goals; MN: mental navigation.