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Self-reflection and the temporal focus of the wandering mind

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ABSTRACT

Current accounts suggest that self-referential thought serves a pivotal function in the human ability to simulate the future during mind-wandering. Using experience sampling, this hypothesis was tested in two studies that explored the extent to which self-reflection impacts both retrospection and prospection during mind-wandering. Study 1 demonstrated that a brief period of self-reflection yielded a prospective bias during mind-wandering such that participants' engaged more frequently in spontaneous future than past thought. In Study 2, individual differences in the strength of self-referential thought — as indexed by the memorial advantage for self rather than other-encoded items — was shown to vary with future thinking during mind-wandering. Together these results confirm that self-reflection is a core component of future thinking during mind-wandering and provide novel evidence that a key function of the autobiographical memory system may be to mentally simulate events in the future.

1. Introduction

In the bestselling novel *The Time Traveler's Wife* (Niffenberg, 2003), the male protagonist — *Henry DeTamble* — has a genetic disorder that causes him to travel physically through time to periods of the past or future with personal significance (e.g., the childhood home of his wife). While the laws of physics currently prohibit time travel, we are nevertheless able to revisit the past or simulate the future using a quite straightforward ability — imagination. Such prospective thinking involves a constellation of brain regions including the hippocampus and areas of frontal cortex (Buckner, 2010; Schacter & Addis, 2007b; Schacter, Addis, & Buckner, 2008) and is adaptive because it permits the imaginer to "pre-experience" situations that have yet to occur and alter subsequent behavior if necessary (Bar, 2009; Boyer, 2008; Gilbert & Wilson, 2007; Wheeler, Stuss, & Tulving, 1997). In addition, the ability to locate autobiographical events in their correct temporal context enables a coherent and stable personal identity to be developed (Tulving, 1985).

While past and present events are represented by a combination of perceptual and memorial details, several lines of evidence suggest that the ability to simulate future outcomes is a construction based on previous autobiographical (i.e., personal) knowledge (Buckner, 2010; Gilbert & Wilson, 2007; Schacter & Addis, 2007a). First, both autobiographical memory and prospection emerge at around the same age (Suddendorf & Busby, 2003). Second, patients with problems remembering events from their personal past also have difficulties in imagining what they are likely to do in the future (e.g., Klein, Rozendal, & Cosmides, 2002). Finally, neuroimaging studies show overlapping brain activation when individuals remember events from the past and imagine experiences that have yet to occur (Addis, Pan, Vu, Laiser, & Schacter, 2009).

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It is commonly argued that the primary purpose of mental time travel (Suddendorf & Corballis, 1997, 2007) and indeed the memorial system (e.g. Bar, 2007, Gilbert & Wilson, 2007; Schacter & Addis, 2007a) is to ensure the continued existence of the organism by using imagination to look forward rather than backwards in time. Consistent with this hypothesis, participants spend significant time engaged in future related thought under laboratory conditions (Smallwood, Nind & O'Connor 2009; Smallwood & O'Connor, in press) and in daily life (D'Argeambeau, Renaud, & Van der Linden, 2009). If the primary function of the autobiographical memory system is to mentally simulate the future, it is possible that the process of self reflection would be more strongly associated with the engagement of prospective thought during mind-wandering than it would with thoughts of the past.

The current set of studies examined two issues regarding the hypothesized role of self-memory in prospective thought. If the self is especially important to thoughts of the future, then making self-memories salient (e.g., by asking participants to answer self-referential autobiographical questions) should increase the frequency that prospective thoughts arise during mind-wandering. To this end, Study 1 required participants to rate whether a set of trait adjectives applied to one of several referents (i.e., self, best friend and the UK prime minister, see Rogers, Kuiper, & Kirker, 1977), thereby creating a task context that varied the applicability of self-reflection (Kelley et al., 2002; Rogers et al., 1977; Symons & Johnson, 1997). Following this procedure, we examined whether those individuals who engaged in self-reflection reported more future than past-oriented thoughts during periods of spontaneous mind-wandering than those who did not. In Study 2, we considered whether individual differences in the memorial advantage to self-relevant information (known as the self-reference effect (SRE) (Rogers et al., 1977) moderated the emergence of this effect (i.e., larger SRE = greater prospection). In both experiments, experience sampling was used to assess the momentary occurrence of future and past thought during mind-wandering.

2. Study 1

In Phase 1, undergraduate students from a UK university were told that they were going to perform a brief personality test ('Self' condition, $n = 15$), a survey of social networks ('Best Friend' condition, $n = 15$) or a political survey ('Gordon Brown' condition, $n = 15$).[1] All participants in the Gordon Brown condition were familiar with his identity as he was the UK prime minister at the time of testing. One person from each referent condition was excluded for performing below chance on one or other task. Participants in all three conditions were then shown a sequence of 32 trait adjectives (from Anderson, 1968) on a computer screen and asked to decide whether these adjectives did or did not apply to the condition-specific referent (i.e., self, best friend or Gordon Brown). The identity of the referent was displayed on the computer screen throughout the task and the specific instructions for each condition were identical. Each word list contained an equal number of positive and negative adjectives and the lists were rotated across conditions. Order of adjectives within each list was randomized. Stimulus presentation was self-paced. An additional control group ($n = 13$) did not perform any personality survey, only Phase 2 of the experiment. The mean age of the sample was 20.3 ($SE = .7$) and seventeen participants were male.

The second phase of the experiment required participants to complete two tasks that have previously been shown to vary in their propensity for future thinking (Smallwood, Nind et al., 2009). One was a Working Memory (WM) task that required individuals to monitor a stream of numbers (the digits 1–8), presented in black ink and appearing at fixation. Randomly interspersed with the number presentation were targets (a colored '?') that cued participants to report whether the previous digit was odd or even by means of a mouse click. Stimulus presentation rate was 1 item every 1000 ms (followed by 1500 ms fixation cross) and the stimuli were presented in five blocks each with a quasi-random order of presentation. The second task was a Choice Reaction Time (CRT) task in which participants viewed a similar stream of black digits appearing on screen, this time monitoring for the presence of a colored digit. On presentation of a colored digit, they were asked to report whether the presented stimulus was odd or even. All features of stimulus presentation were identical to the WM task. In both tasks a total of 156 non-targets and 25 targets were presented. Previous work demonstrated that future thinking was more prevalent in the CRT than in the WM task (Smallwood, Nind et al., 2009) a finding that Study 1 sought to replicate.

Participants' mind-wandering was assessed by presentation of ten experience sampling probes (five in each task). These probes were presented visually on a computer screen and prompted participants to report whether their current thoughts pertained to the task/here and now, a personal event in the future or a personal event in the past. Participants responded with the keyboard using the first letter of each experience. Participants were explicitly instructed to reserve the category of future/past thoughts for personal events unrelated to the current task. Following completion of these tasks, participants were thanked, debriefed and dismissed.

2.1. Results

Analysis of variance (ANOVA) yielded no significant effect of Referent [$F(2, 36) = 1.88$, $p = .169$, $\eta^2 = .09$] showing that participants did not differ in their assignment of character traits to the three referents (*Self*, *Best Friend*, or *Gordon Brown*). A mixed-model ANOVA conducted on the accuracy data, with Referent included as a between-participants factor and Task

[1] It is possible that different introductory screens for the three conditions may have subtly influenced the mind set of individuals as they performed the task. While this bias may have enhanced the effectiveness of the manipulations, as the adjectives and the specific instructions were identical across conditions, it would not alter the conclusion that self-memories are central to prospective thought.

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Table 1
Means (M) and standard errors (SE) for the proportion of past and future thoughts across the different referent conditions in Study 1.

Referent	Task	Temporal focus of mind-wandering			
		Future		Past	
		M	*SE*	*M*	*SE*
Self	WM	0.36	0.06	0.14	0.06
	CRT	0.50	0.09	0.10	0.05
Best friend	WM	0.17	0.07	0.18	0.06
	CRT	0.44	0.09	0.18	0.05
Gordon Brown	WM	0.18	0.07	0.19	0.06
	CRT	0.33	0.09	0.18	0.05
No Pre task	WM	0.23	0.07	0.30	0.06
	CRT	0.32	0.10	0.35	0.05

[*CRT/WM*] as a repeated measures factor, revealed only a main effect of Task [$F(1, 55) = 25.35$, $p < .001$, $\eta^2 = .31$], indicating that accuracy was lower in the WM than the CRT task. Analysis of RT yielded no significant effects.

Table 1 presents the experience sampling data. These data were analyzed using a mixed-model ANOVA with the repeated measures factors of Temporal Focus [*future* or *past*] and Task [*CRT* or *WM*], and the between-participants factor of Referent [*Self*, *Best friend*, *Gordon Brown*, or *Control]*. A main effect of Temporal Focus was observed [$F(1, 51) = 9.75$, $p < .005$, $\eta^2 = .16$] indicating that future thought [$M = .32$ ($SE = .03$)] was more common than past thought [$M = .20$ ($SE = .02$)]. A Temporal Focus X Task interaction also emerged [$F(1, 51)$ 8.65, $p < .005$, $\eta^2 = .14$] replicating previous findings (Smallwood, Fitzgerald, Miles, & Phillips, 2009) that future thought is more common than past thought during the CRT task ($p < .01$) but not the WM task and that future thought is more common in CRT than WM task ($p < .001$, see Fig. 1, left hand panel). We also observed a Referent X Temporal focus interaction [$F(3, 51) = 4.07$, $p < .01$, $\eta^2 = .19$, see Fig. 1, right hand panel]. Further analysis indicated that, following thinking about themselves, participants reported more future than past-oriented thoughts in the entire experimental session [$p < .01$]. While the best friend condition yielded a marginally significant effect in the same direction [$p = .07$], neither the Gordon Brown nor the control condition differed in the reported incidence of retrospection and prospection [$p = .3$ for both comparisons]. Finally, the 3-way interaction between Task, condition and temporal focus was non-significant [$F(3, 51) = .60$, $p = .61$, $\eta^2 = .03$] indicating that the main effects of Task (CRT/WM) and Referent (Self, Best friend, Gordon Brown & No Pre task) both led to independent changes in future thinking. The relative independence of the effects of task and condition are illustrated by the fact that at least 10% more future thoughts were reported in the CRT than in the WM task in each condition (see Table 1) despite varying in the size of the prospective bias measured across the testing session as a whole (Fig. 1, Panel B).

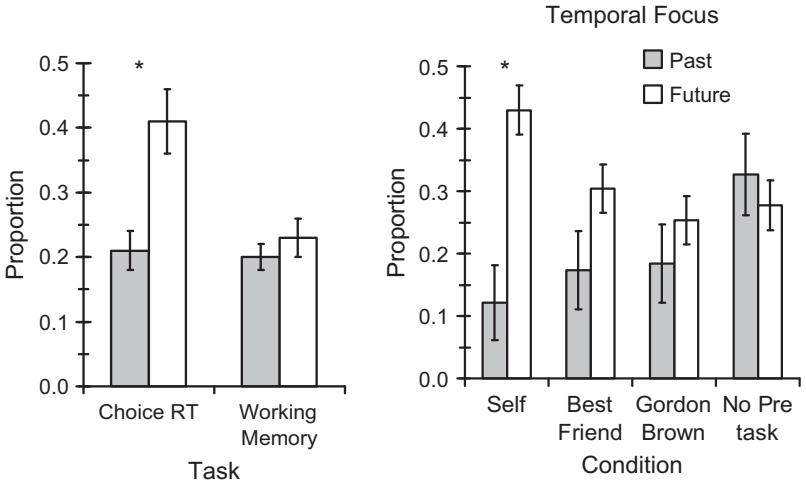

Fig. 1. Study 1. *Left hand panel*. Analysis indicated a significant effect of task on the temporal focus of mind-wandering. Participants reported more future thought in the Choice RT task (CRT) than the Working Memory task (WM). Moreover, greater future than past thought was reported in the CRT but not in the WM task. This suppression of future thinking by the WM load suggests that this task may involve shared processes with future thought. *Right hand panel*. Analysis also indicated an effect of the pre-task on the temporal focus of mind-wandering. Across the entire testing session, participants who reported more future than past thought following the self-condition ($p < .01$). This overall prospective bias approached significance for the best friend condition but was non-significant for both Gordon Brown and the control condition. In both panels the error bars indicate one standard error of the mean. * Indicates significant differences ($p < .01$).

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2.2. Discussion

The findings of Study 1 showed that if self-reflection is engaged prior to performing a laboratory task, attention exhibited a general tendency to focus on the future rather that the past during episodes of mind-wandering. Specifically across the entire experimental session, retrieval of self-relevant knowledge resulted in participants reporting more episodes of prospection than retrospection during periods of off-task mental activity. Interestingly, prior reflection on one's best friend produced a similar, albeit only a marginally significant effect. Such a finding is perhaps unsurprising given intimate representational linkages between self and best friend (Aron, Aron, Tudor, & Nelson, 1991; Aron & Fraley, 1999). Indeed, when thinking about a close friend, one may routinely retrieve memories in which self also features (i.e., "I know John is generous as he bought me a yacht for my birthday"), a situation that is possible but less likely to arise when Gordon Brown is the target of interest. Future work may benefit from investigating whether tasks that systematically vary on their involvement of autobiographical information (either directly or indirectly) lead to parametric changes in future thinking.

In addition, Study 1 replicated the suppression of future thinking by a working memory load observed by Smallwood, Nind et al. (2009), Experiment 1). This reduction in future thinking in the WM task may occur because of involvement of control processes involved in the generation and maintenance of streams of autobiographical future thought. Further support for the involvement of some form of controlled processing in future thought comes from a recent neuroimaging study by Spreng, Stevens, Chamberlain, Gilmore, and Schacter (2010) who documented that the generation of autobiographical plans (such as "How to get out of debt") involves co-operation between elements of the default mode network (Raichle et al., 2001) and a fronto-parietal attentional control system (Vincent, Kahn, Snyder, Raichle, & Buckner, 2008).

Having demonstrated that self-reflection triggers a bias to future-oriented mind-wandering, Study 2 considered whether the magnitude of this effect is linked to stable individual differences in the memorial advantage for self-referenced information.

3. Study 2

Participants in Study 2 completed a trait-ascription task in which they were asked to consider two referents (i.e., self and a familiar other), a manipulation that leads to superior recall for items referenced to self in memory (the self-reference effect, SRE) Following this task, participants performed the CRT task (from Study 1) with experience sampling probes before finally completing a surprise memory test for the items presented in the trait-ascription task. We anticipated that future thinking would increase with the strength of self-reflection. Specifically, participants who displayed the strongest SRE (i.e., memory-for-self > memory-for-other) would be most likely to entertain thoughts of the future than past during periods of mind-wandering. To establish any impact that thought probes may exert on the SRE, a separate group of control participants received no probes and at points when probes would have occurred were given the chance to rest. Finally, to rule out any influence of SRE-dependent changes in mood—a factor previously implicated by mind-wandering studies (Smallwood, Fitzgerald et al., 2009; Smallwood & O'Connor, in press; Smallwood, O'Connor, Sudbery & Obonsawin, 2007)—a measure of participants' mood was also included.

3.1. Methods

70 undergraduate participants from a US university completed the study (Mean age = 20.5 (*SE* = .8), 28 males). In the first phase, participants were told that they were going to perform a personality test (i.e., Self-referent condition) and a political survey (i.e., Other-referent condition). In both conditions, they were shown a list of the trait adjectives used in Study 1 and were asked to consider these traits with reference to either themselves ($n = 16$) or the current US president ($n = 16$) (e.g., *'Are you tidy?*' '*Is George Bush calm?*"). The order of presentation of referents and trait lists were counterbalanced across participants. The subsequent recognition test was not mentioned during this phase of the study. Phase 2 of the experiment involved the CRT task described in Study 1, with the following modifications. Instead of thought probes, participants in the no-probe condition were given the opportunity to rest before continuing with the task. Second, in Study 2 the experience sampling probes offered the additional category of 'no temporal time period' to reflect the possibility that some thoughts were not tied to a particular temporal window. At the end of the CRT task, participants provided an indication of their mood using a 5-point Likert scale, ranging from 1 (very negative) to 5 (very positive). The final phase of Study 2 required participants to complete a surprise recognition-memory task, indicating whether presented trait adjectives were 'old' or 'new' using the left and right mouse buttons. Sixty-four stimuli were presented during the recognition phase and half of the items were new. Order of stimuli was randomized and stimulus presentation was self-paced.

3.2. Results

Across the sample post task mood was close to the mid point 2.9 (SE = .08). The correct recognition scores (corrected for guessing) for self and other encoding conditions separated into those individuals who did or did not receive probes is presented in the left hand panel of Fig. 2. A paired samples *t*-test indicated that trait adjectives were seen as more applicable to self [$M = 14.5$ ($SE = .35$)] than to George Bush [$M = 10.8$ ($SE = .35$), $t(69) = -7.9$, $p < .001$], and memory accuracy was superior

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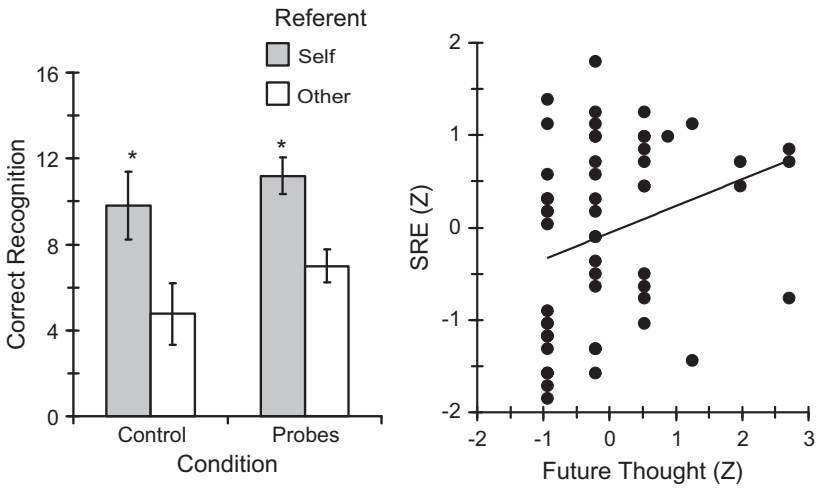

Fig. 2. Study 2. *Left hand panel.* The size of the self-reference effect (SRE) did not vary with whether individuals received probes or were instead give the opportunity to rest. This indicates that the probing did not lead to gross changes in the SRE. The error bars indicate one standard error of the mean. *Right hand panel.* The scatter plot indicates the relationship between the SRE and the amount of future thinking during mind-wandering. Those individuals who showed a large memorial advantage to self encoded items also engaged in the greatest future thoughts in the period between encoding and recognition. * Indicates significant differences ($p < .01$).

for self [$M = 10.9$ ($SE = .67$)] than other [$M = 6.2$ ($SE = .62$), $t(69) = 5.35$, $p < .001$] consistent with the standard SRE (Rogers et al., 1977). No effect of condition [probe vs. rest breaks] was observed on the SRE [$p = .3$] with both groups showing a memory advantage following self-referential encoding (in both cases $p < .01$, see Fig. 2, left hand panel).

The General Linear Model was used to estimate the relationship between past and future focus during the CRT task and the magnitude of the SRE in a more systematic manner. This analysis had a single within participant factor of referent with two levels [Self/Bush]. The probability of future and past thoughts were entered as separate continuous independent variables. This analysis indicated a Referent X Future thinking interaction [$c1, 52) = 4.79$, $p < .05$, $\eta^2 = .08$]. No similar interaction was observed due to past thought [$F(1, 52) = 0.05$, $p = .94$, $\eta^2 = .01$]. Future thought showed a weak positive association with items referred to Self [$r = .20$, $p = .13$], a weak negative association with those associated with Bush [$r = -19$, $p = .17$] and a statistically robust relationship to the SRE [$r = .29$, $p = .05$]. By contrast, Past related thought was not associated with retrieval in any form [Self, $r = .09$, $p = 38$, Other, $r = .08$, $p = .48$ and the SRE, $r = .015$, $p = .9$]. This analysis indicates that individual differences in the size of the memorial advantage associated with self-relevant material was positively associated with the amount of future thinking that took place in the period between encoding and retrieval. The relationship between the SRE advantage and future thinking is displayed in the scatter plot (Fig. 2, right hand panel). Finally, analysis indicated that the size of the memorial advantage to was non-significant when the amount of future and past thought was controlled for [$F(1, 52) = 2.16$, $p = .15$, $\eta^2 = .04$] indicating the scope of the memorial advantage for self-relevant information was entirely accounted for by the extent of future focused mind-wandering that occurred.

We also explored whether the relationship between future thought and self-memory could be due to mood. Mood was not significantly associated with the SRE ($r = .11$, $p = .37$) or with future thought ($r = -.03$, $p = .78$). Further analysis indicated that controlling for mood did not appreciably alter the association between the SRE and future thought [$F(1, 52) = 4.87$, $p < .05$, $\eta^2 = .09$].

3.3. Discussion

Study 2 demonstrated that individual variation in the size of the SRE was positively associated with the incidence of future-oriented thought during the mind-wandering state. This analysis lends further support to the link between self-reflection and prospection during periods of off-task mental activity.

4. General discussion

Whereas the fictional character Henry DeTamble's time travelling was to personally relevant periods of either the past or future, the current data suggest that the relationship between self-referential thought and the focus of mind-wandering is temporally asymmetric. Study 1 demonstrated that a period of self-reflection increased the likelihood that future rather than past-related events would come to mind during periods of spontaneous off-task thought. Study 2 showed that individual differences' in the magnitude of the SRE was associated with the amount of future thought that occurred during mind-wandering. This propensity to simulate the future rather than dwell on the past following self-reflection is consistent with the

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viewpoint that the most obvious benefits of spontaneous thought to the individual emerge when people look forward rather than backward in time (Suddendorf & Corballis, 1997, 2007).

Several features of our results allow alternative interpretations to be ruled out. First, because the period of self-reflection occurred prior to the experimental task, a simple account of our data based on remembering events from the earlier session would favor an increase in retrospective thought; instead, we observed that autobiographical memory was especially associated with future thought. The current results, therefore, rule out the more obvious hypothesis that self-memories prime further thoughts of past and instead support the idea that a core function of autobiographical memory system is the anticipation of events that may yet occur. Second, relative to rest breaks, thought probes yielded no difference in the size of the SRE indicating that thought sampling per se did not artificially alter the SRE. This indicates that the results do not arise from gross changes in the memory for self-relevant information that could have occurred due to thought sampling. Finally, Study 2 suggested that the association between SRE and future thought was not a result of participants' mood; however it is possible that other measures of mood such as the Positive and Negative Affective Schedule (Watson, Clark, and Tellegen, 1988) would have yielded different results. While this question requires further research, it is worth noting that a recent study demonstrated that inducing negative mood (as assessed by two different mood measures one of which was the PANAS) increased mental time travel to the past (Smallwood & O'Connor, in press). This result suggests that if mood does play a direct role in the process by which self-memories underlie future thought it would seem unlikely to be unhappiness.

While such alternatives fail to capture key features of our results, the hypothesis that self-referential thought is a core feature of prospective thinking provides a simple and parsimonious account of the observed data. There are at least two reasons why self-reflection may favor future-oriented mental time travel over thoughts of the past. One possibility is that self-reflection simply influences the temporal locus that mental time travel takes. Such a viewpoint gains support from the suggestion that a major function of the memory system is to simulate the future (e.g. Bar, 2007). Alternatively, perhaps self-reflection triggers imaginative thought (Hassabis, Kumaran, & Maguire, 2007) and that the advantages that future thinking can bring motivates individuals to mind-wander about the future. Both of these possibilities are consistent with the demonstration of a common network of brain regions that support imaginative thought regardless of whether it is focused on the past or the future (Addis et al., 2009). One important task for future research will be to disambiguate quite how self-reflection and autobiographical processes more generally impacts the various mental contents that emerge when the mind wanders.

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