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The role of personal goals in auto-noetic experience when imagining future events

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Abstract

Although auto-noetic experience—a sense of mental time travel—has been considered as the hallmark of episodic future thinking, what determines this subjective feeling is not yet fully understood. Here, we investigated the role of autobiographical knowledge by manipulating the relevance of imagined events for personal goals. Participants were asked to imagine three types of events (goal-related future events, experimenter-provided future events, and atemporal events) and to assess various characteristics of their mental representations. The results showed that the three types of events were represented with similar levels of detail and vividness. Importantly, however, goal-related future events were associated with a stronger auto-noetic experience. Furthermore, auto-noetic experience was significantly predicted by the importance of imagined events for personal goals. These findings suggest that the subjective feeling of pre-experiencing one's personal future in part depends on the extent to which imagined events can be placed in an autobiographical context.

Keywords: episodic future thinking; goals; auto-noetic consciousness; mental time travel; autobiographical memory; phenomenological characteristics.

1. Introduction

The capacity to mentally simulate events that might happen in one's personal future—often referred to as episodic future thinking—has attracted growing interest in the past few years, probably due to the increasing recognition of its importance in the regulation of human behavior (Schacter, 2012; Seligman, Railton, Baumeister, & Sripada, 2013; Suddendorf & Corballis, 2007; Szpunar, 2010). Findings from cognitive, neuropsychological, and neuroimaging research have shown that episodic future thoughts are created based on informational components provided by episodic and semantic memory (i.e., specific past experiences and general knowledge about the world and the self), and multiple cognitive processes are engaged to retrieve, select, and assemble relevant pieces of information (for reviews, see D'Argembeau, 2015; Irish & Piguet, 2013; Klein, 2013; Schacter et al., 2012). These representational systems and cognitive processes are supported by a distributed set of brain regions, involving frontal, parietal, and temporal areas (Benoit & Schacter, 2015; Stawarczyk & D'Argembeau, 2015).

Despite these significant advances in understanding how future event representations are formed, the hallmark of episodic future thinking—the subjective sense of “pre-experiencing” a future event (Atance & O'Neill, 2001; Klein, 2016; Suddendorf & Corballis, 2007; Szpunar, 2011; Tulving, 2005)—remains somewhat mysterious. What gives us the subjective feeling that an event currently represented in our minds refers to something that might happen in our personal future rather than, say, a mere fantasy? According to Tulving (1985, 2002, 2005), the sense of navigating a personal future is a manifestation of autonoetic consciousness, defined as “a form of consciousness that allows individuals to apprehend their subjective experiences throughout time, and to perceive the present moment as both a

continuation of their past and as a prelude to their future” (Tulving, 2002, p. 315).¹ On this view, episodic future thinking does not only involve the mental simulation of specific events (based on information stored in memory), but also the capacity to locate imagined events at subjective times other than the present (Szpunar, 2011; Tulving, 2005). It is the combination of these two components—event simulation and auto-noetic consciousness—that would give rise to the feeling of mental time travel (Klein, 2016). The precise conditions under which this subjective experience emerges are not fully understood, however.

A few studies have started to explore this question by examining factors that are predictive of the qualities of subjective experience during episodic future thinking—an experimental phenomenological approach (Johnson, 1988). In most of these studies, auto-noetic consciousness is assessed by asking participants to rate their feeling of experiencing imagined events and feeling of travelling forward in time.² D’Argembeau and Van der Linden (2004) manipulated the emotional valence and temporal distance of imagined events. It was found that participants reported greater auto-noetic feelings and more vivid mental representations when imagining positive rather than negative, and temporally close rather than distant, future events (see also Berntsen & Bohn, 2010; Rasmussen & Berntsen, 2013). Szpunar and McDermott (2008) investigated the influence of the familiarity of contextual settings in which imagined future events take place. The results showed that future events imagined in familiar settings (e.g., at home) were rated as more detailed and were associated with stronger feelings of pre-experience and mental time travel than events imagined in unfamiliar settings (e.g., in the jungle) (see also Robin & Moscovitch, 2014).

Arnold, McDermott, and Szpunar (2011a) reported similar findings, and further showed that

¹ A variety of terms has been proposed to refer to consciousness of subjective time, including auto-noetic consciousness or auto-noesis (Tulving, 2005), chronesthesia (Tulving, 2002), and temporal consciousness (Dalla Barba & Boissé, 2010). Although there are subtle differences between these concepts, they all involve the capacity to apprehend the temporal dimension of one’s experiences. Here we use the term auto-noetic consciousness because it is most frequently used in the field of episodic memory and future thinking.

² These two dimensions derive from the idea that auto-noetic consciousness involves both a “self” aspect (representing an experience as one’s own) and a notion of subjective time (representing an experience as referring to a time other than the present) (Tulving, 2002, 2005).

the effect of temporal distance on the subjective qualities of mental representations was at least partly due to differences in the familiarity of imagined settings.

Looking at patterns of relations between various characteristics of episodic future thoughts, D'Argembeau and Van der Linden (2012) found that the familiarity of imagined contents (i.e., location and persons/objects) was a significant predictor of the subjective vividness of mental representations, which in turn predicted auto-noetic experience. Interestingly, however, auto-noetic feelings were not entirely explained by the subjective vividness of represented contents. Another variable that independently predicted auto-noetic experience was the goal-relevance of imagined events: future events that were more related to personal goals were associated with greater feelings of pre-experience and mental time travel. The role of personal relevance in auto-noetic experience is also suggested by studies showing that the degree to which people report feelings of pre-experience and mental time travel when imagining future events is related to individual differences in future time perspective (i.e., a general concern for the future, including a focus on planning and future goals; Arnold, McDermott, & Szpunar, 2011b) and self-consciousness (i.e., the tendency to think about one's beliefs, aspirations, and values; D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010).

Taken together, these findings suggest that the feeling of navigating a personal future depends on at least two factors: the subjective vividness of mental representations (which itself depends, in part, on the familiarity of imagined contents), and the extent to which imagined events are personally relevant. Auto-noetic experience likely requires the construction of a detailed and coherent event representation—a process that has been referred to as episodic simulation (Schacter & Addis, 2007) or scene construction (Hassabis & Maguire, 2007). This process may be necessary but not sufficient, however, as people can construct detailed representations of fictitious events that are not experienced as being located

in time (Hassabis, Kumaran, Vann, & Maguire, 2007). A full-blown auto-noetic experience might only emerge when imagined events are meaningfully embedded in an autobiographical context, for example by linking imagined events to personal goals and general expectations about one's life. Autobiographical knowledge might indeed provide a personal timeline on which imagined events can be placed (Conway, 2005; Fivush, 2011; Thomsen, 2015), thereby contributing to the subjective sense of mentally visiting one's personal future. On this view, episodic future thinking is more than the mere simulation of specific events; imagined events also have to be meaningfully linked to one's personal life (D'Argembeau, 2015).

If the above view is correct, auto-noetic experience should vary depending on whether or not an imagined event is set into a future personal context. Although this potential role of autobiographical knowledge has not been investigated systematically, one study has compared the subjective characteristics of mental representations of future and atemporal events (de Vito, Gamboz, & Brandimonte, 2012). In a first experiment, participants were instructed to imagine future events occurring in familiar settings (e.g., "Imagine walking in a sunny garden next year"), future events occurring in unfamiliar settings (e.g., "Imagine walking in a tropical jungle next year"), and atemporal events occurring in familiar settings (e.g., "Imagine sitting in your preferred coffee shop"). For each event, participants rated the subjective vividness of their mental representation and their feeling of experiencing the event. In line with previous studies (see above), future events occurring in familiar settings were more vividly represented and were associated with greater feelings of experiencing than future events occurring in unfamiliar settings. However, there was no difference between future and atemporal events occurring in familiar settings. In a second experiment, de Vito et al. (2012) asked participants to imagine themselves in future or atemporal events (as in the first experiment), and to imagine someone else in future events (e.g., "Imagine Silvio Berlusconi walking on the beach next year"). The results showed that the three types of events received similar ratings for subjective vividness, but that the feeling of experiencing

was higher when imagining oneself rather than someone else in future events. As in the first experiment, feelings of experiencing did not differ when imagining oneself in future or atemporal events.

Although intriguing, these findings are open to different interpretations. The absence of difference between mental representations of future and atemporal events could imply that the temporal location of imagined events is irrelevant to auto-noetic experience. Two important issues should be noted, however. First, as suggested above, the temporal dimension of auto-noetic experience might only arise when imagined events are set in an autobiographical context, and it is unclear whether this was the case in the de Vito et al. (2012) study. Indeed, the to-be-imagined future events were constrained by the experimenter (e.g., “Imagine walking in a sunny garden next year”), such that participants might not have necessarily linked these events to their own personal lives. Our view is that an imagined event such as a “walk in a sunny garden next year” will only be perceived as a “real” future event to the extent that it can be meaningfully integrated with general knowledge and expectations about one’s future life (e.g., imagining walking in the gardens of the palace of Versailles that one intends to visit during a holiday in France planned for the next summer). Absent this connection with autobiographical knowledge, an imagined event might not be experienced as a future happening. Second, it should be noted that only one dimension of auto-noetic consciousness—the feeling of experiencing events—was investigated in the de Vito et al. (2012) study. One can certainly have the feeling of experiencing an imagined event without necessarily placing this event in time, but a full-blown auto-noetic experience involves an additional ingredient: the feeling of mental time travel.

Considering these issues, we aimed to replicate and extend the de Vito et al. (2012) study by adding another condition in which imagined future events would be more easily placed in an autobiographical context. In short, participants were asked to imagine three types

of events: future and atemporal events that were cued in a similar way as in the de Vito et al. study, and future events that were cued by personal goals. We did not expect that these three event conditions would necessarily differ in terms of the subjective vividness of mental representations, but we predicted that auto-noetic experience would be enhanced for future events that were cued by personal goals compared to future events constrained by the experimenter, as the former should be more easily placed in an autobiographical context. To further investigate the role of autobiographical knowledge in auto-noetic experience, we also investigated whether the personal relevance of imagined events uniquely contributed to the prediction of auto-noetic feelings after controlling for other event dimensions that have been previously related to auto-noetic experience (e.g., vividness, familiarity, and emotional valence).

2. Method

2.1. Participants

Thirty undergraduates (10 males), all native French speakers, participated in this experiment as volunteers. Their average age was 21.27 ($SD = 2.07$) years. All participants reported to be free of neurological or psychiatric disorders. The sample size was estimated a priori using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) in order to achieve 80% power, considering an alpha error of .05 and a medium within-subject effect size (Cohen's $f = 0.25$).

2.2. Materials and procedure

Participants were asked to imagine a series of events in response to six cue sentences. Four of the cues were adapted and translated into French from previous studies of scene construction (de Vito et al., 2012; Hassabis et al., 2007): *Imagine lying on a sunny, crowded*

beach; Imagine walking in a sunny garden; Imagine sitting in your favourite pub; and Imagine you are standing in the middle of a bustling street market. For two of these cues, participants were instructed to imagine an atemporal situation (i.e., to imagine an event without locating it in time; hereafter referred to as *atemporal events*), while for the two other cues they were instructed to imagine a situation happening in the future (hereafter referred to as *nonpersonal future events*) and an exact time indication was provided (e.g., imagine walking in a sunny garden in a year); the use of cues as atemporal versus future events was counterbalanced across participants.

The remaining two cues were derived from the personal goals of the participants. Between one and seven days before the main experiment, participants had to report five personal goals on an online questionnaire, to rate the importance of each goal, and to estimate when they believed each goal could be achieved. Personal goals were defined as personally important projects that are frequently thought about, for which one makes plans, and that one strives to achieve (Emmons, 1986; Little, 1983). It was specified that these projects could refer to any life domain, such as school, work, family, intimate relationships, material goods, and leisure activities. The two most important goals were selected as cues for the imagination task. These goals did not directly refer to a specific future event (e.g., going to study abroad, living with my girlfriend, creating a music band). Each cue also included a time period which corresponded to the time when participants believed their goal could be achieved (e.g., creating a music band in a year; hereafter referred to as *personal future events*). To match the future personal and future nonpersonal conditions with respect to the temporal distance of imagined events, the two time periods used in the nonpersonal condition were always the same as the time periods specified in the future personal condition.

All six cues (two atemporal, two nonpersonal future, and two personal future) were presented separately on a computer screen. For each cue sentence, participants were instructed

to imagine a specific event (i.e., specific in time and place, and lasting some minutes up to 24 hours) in as much detail as possible, including details about location, actions, people, objects, emotions, and so on. It was further specified that the imagined events should be novel (i.e., not experienced before) and that future events should be plausible (i.e., might reasonably happen). Once participants had an event in mind they were asked to verbally describe it, and descriptions were recorded using a digital audio-recorder for later transcription and scoring. The order of presentation of events was counterbalanced across participants. Before starting the task, two practice trials (*Imagine buying things in a supermarket in a week; Imagine walking in a big city*) were conducted with each participant in order to ensure that all instructions were correctly understood. If necessary the instructions were orally repeated during the experiment.

After each description (for which no time limit was imposed), participants were asked to rate the reported event on a questionnaire evaluating the phenomenological characteristics of mental representations, as well as different event features that have been previously linked to phenomenological experience (D'Argembeau & Van der Linden, 2012; de Vito et al., 2012). All dimensions were rated using a 7-point Likert scale. Some items assessed sensory-perceptual qualities of mental representations: their overall clarity (1 = not at all clear, 7 = extremely clear), clarity of the location (1 = not at all clear, 7 = extremely clear), clarity of people/objects (1 = not at all clear, 7 = extremely clear), amount of visual details (1 = none, 7 = a lot), and amount of other sensory details (auditory, olfactory, gustative and/or tactile; 1 = none, 7 = a lot). Autonoetic consciousness was assessed by rating the feeling of really experiencing the situation "as if I was there" (1 = not at all, 7 = totally), and the impression of going into the future and find oneself at the time when the event would happen (1 = not at all, 7 = totally).

Other items assessed some properties of imagined events, such as event novelty (“I have already experienced the same or a similar event”; 1 = never, 7 = very often), the familiarity of location (1 = not at all familiar, 7 = extremely familiar), the familiarity of persons and objects (1 = not at all familiar, 7 = extremely familiar), the personal importance of the event with respect to personal goals and values (1 = not at all important, 7 = very important), its affective valence (- 3 = very negative, 0 = neutral, 3 = very positive), and the extent to which it had been previously thought about (1 = never, 7 = very often). Event plausibility was also assessed, both in terms of general plausibility (“This event could plausibly happen to everyone”; 1 = not at all plausible, 7 = extremely plausible) and personal plausibility (“This event could plausibly happen to me personally”; 1 = not at all plausible, 7 = extremely plausible) (Scoboria, Mazzoni, Kirsch, & Relyea, 2004). Finally, participants assessed the subjective difficulty to imagine the event (1 = very difficult, 7 = very easy), whether, while imagining the event, other specific (past or future) events which are connected to it came spontaneously to their mind (1 = none, 7 = a lot), and whether they thought about their life in general (e.g., about their goals, expectations, and so on; 1 = not at all, 7 = very much). The total testing time was between 45 and 60 minutes.

2.3. Scoring

Verbal descriptions of each event were transcribed and the numbers of internal and external details were assessed using the standardized scoring procedure developed by Levine, Svoboda, Hay, Winocur, and Moscovitch (2002). The central event was defined in order to segment the transcription into internal details (i.e., details referring to the main event, including happenings, people, time, place, sensory perceptions, thoughts, and emotions) and external details (i.e., details that do not refer to the main event, semantic information, repetitions and metacognitive statements), and the numbers of internal and external details

were tallied. All transcriptions were scored by the first author and a second rater independently scored a random selection (20%) of the descriptions to assess the reliability of scoring. Intraclass correlation coefficients (two-way random effects; Shrout & Fleiss, 1979) indicated high inter-rater agreement for both internal and external details (ICC = .86 and .85, respectively).

3. Results

For each dependent variable, data were averaged across the two events in each condition and were analysed using a one-way (type of events: atemporal, nonpersonal future, personal future) repeated measures analysis of variance (ANOVA). When the assumption of sphericity was not met, the Greenhouse-Geisser correction was used.

3.1. Richness of mental representations

We first examined the amount of details reported in the verbal descriptions of imagined events (Figure 1). The number of reported details did not differ significantly between the three event conditions, neither for internal details, $F(2, 58) = 0.93, p = .40, \eta_p^2 = .03$, nor for external details, $F(1.56, 45.15) = 2.03, p = .14, \eta_p^2 = .07$. Next, we computed an index of the subjective vividness of mental representations (Figure 2) by averaging ratings of overall clarity, clarity of location, clarity of people/objects, amount of visual details, and amount of other sensory details (Cronbach's alpha = 0.74). This index did not differ significantly between the three types of imagined events, $F(2, 58) = 0.73, p = .48, \eta_p^2 = .02$. The same result was obtained when analyzing separately each rating scale composing the subjective richness index.

3.2. Autooetic experience

The mean ratings for the two dimensions of auto-noetic experience are shown in Figure 3. The type of imagined events had a significant influence on both the feeling of experiencing, $F(2, 58) = 3.47, p = .04, \eta_p^2 = .11$, and the feeling of mental time travel, $F(2, 58) = 19.20, p < .001, \eta_p^2 = .40$. Planned comparisons showed that feelings of experiencing were higher for personal future events than both nonpersonal future events, $t(29) = 2.08, p = .047, d = 0.36$, and atemporal events, $t(29) = 2.48, p = .02, d = 0.41$, while nonpersonal future and atemporal events did not differ from each other, $t(29) = 0.40, p = .69, d = 0.07$. The impression of going into the future was also higher for personal future events than both nonpersonal future events, $t(29) = 3.52, p < .001, d = 0.61$, and atemporal events, $t(29) = 5.84, p < .001, d = 1.14$; nonpersonal future events were associated with a higher impression of going into the future than atemporal events, $t(29) = 2.89, p = .01, d = 0.51$.

3.3. Event properties

The mean ratings and results of the ANOVAs for the properties of imagined events are shown in Table 1. As expected, the personal importance of imagined events differed significantly between the three conditions: personal future events were judged as more important than both nonpersonal future events and atemporal events (all $ps < .001$), and nonpersonal future events did not differ from atemporal events ($p = .15$). Similar differences between the three types of events were also noted for affective valence, frequency of previous thoughts, personal plausibility, and thoughts about one's life: for each of these variables, personal future events received higher ratings than both nonpersonal and atemporal future events (all $ps < .05$), whereas nonpersonal and atemporal events did not differ from each other. Finally, the familiarity of persons/objects also varied as a function of the type of imagined events: personal future events were rated as involving more familiar persons/objects than nonpersonal future events ($p < .001$); atemporal events did not differ significantly from either personal future ($p = .11$) or nonpersonal future ($p = .30$) events. The other event

properties (i.e., event novelty, familiarity of location, general plausibility, connection with other events, and subjective difficulty of imagination) did not differ significantly between the three types of events.

3.4. Predicting autooetic experience when imagining events

The preceding analyses showed that autooetic feelings were rated higher when imagining personal future events than both nonpersonal future events and atemporal events. While this finding supports our hypothesis that the personal relevance of events plays an important role in autooetic experience, it should be noted that personal future events differed from nonpersonal and atemporal events on multiple event features other than personal importance (i.e., emotional valence, frequency of previous thoughts, personal plausibility, and thoughts about one's life). Our next goal was then to determine which of these variables are related to autooetic feelings when imagining events, and to investigate whether personal importance provides a unique contribution to the prediction of autooetic experience.

To investigate these questions, we first looked at the bivariate associations between autooetic experience and the various event properties investigated in this study. For these analyses, the two rating scales assessing autooetic feelings (i.e., the feeling of experiencing and the impression of going into the future) were averaged to form a single index of autooetic experience. As in the preceding analyses, we also computed an index of the subjective vividness of mental representations. Due to their hierarchical structure (i.e., the sampled events were nested within participants and thus were not independent), data were analyzed using multilevel modeling (random intercept models; Goldstein, 2011), with events as level 1 units and participants as level 2 units.

As can be seen from Table 2, autooetic experience was significantly related to the subjective vividness and ease of construction of imagined events, as well as multiple event

properties: familiarity of imagined contents (location and persons/objects), personal importance, emotional valence, frequency of previous thoughts, and personal plausibility. In addition, auto-noetic experience was also related to the extent to which participants thought about other events and about their lives during the construction process.

A series of multilevel regression models were constructed to examine the unique contribution of these variables to the prediction of auto-noetic experience. Measures of subjective vividness and ease of construction were introduced first in a regression model because previous studies have shown that auto-noetic experience substantially depends on the subjective sensory-perceptual qualities of mental representations (D'Argembeau & Van der Linden, 2012; Rubin, Schrauf, & Greenberg, 2003). These two variables significantly contributed to auto-noetic experience (likelihood ratio, $LR = 69.21$, $df = 2$, $p < .001$). Adding the familiarity of imagined contents (location and persons/objects) to this model did not result in a significantly better fit ($LR = 2.80$, $df = 2$, $p = .25$), suggesting that the influence of familiarity on auto-noetic experience was mediated by the subjective quality of mental representations.

Next, we investigated to what extent the various event properties that differentiated the three types of imagined events (i.e., personal importance, frequency of previous thoughts, emotional valence, personal plausibility, and thoughts about one's life) uniquely contributed to auto-noetic experience. Adding these variables simultaneously to a regression model that already included subjective vividness and ease of construction as predictors resulted in a significantly better fit ($LR = 55.85$, $df = 5$, $p < .001$).³ However, only personal importance and personal plausibility provided a significant unique contribution to the prediction of auto-noetic experience. Therefore, the best and most parsimonious model was to use subjective richness,

³ Although most of the predictor variables included in this model were intercorrelated (see Supplementary Table 1), simulation experiments have shown that the estimation bias is negligible for fixed-effect parameter estimates and small to moderate for their corresponding standard errors for this magnitude of correlations among level 1 predictors (Shieh & Fouladi, 2003).

ease of construction, personal importance, and personal plausibility to predict auto-noetic experience (Table 3). This model accounted for 60% of the within-participants variance (i.e., variation among events) in auto-noetic feelings.

4. Discussion

While important progress has recently been made in elucidating the formation of episodic future thoughts, the subjective feeling of pre-experiencing imagined events is not yet fully understood. In this study, we investigated whether auto-noetic experience is modulated by the extent to which imagined events can be placed in an autobiographical context. Participants imagined a series of future events that were cued by their personal goals, as well as future and atemporal events that were constrained by experimenter-provided cues. In line with de Vito et al. (2012), we found that the characteristics of atemporal and future event representations were largely indistinguishable (in terms of the richness of mental representations, auto-noetic feelings, and other event properties, such as familiarity, importance, and plausibility) when imagined events were constructed in response to experimenter-provided cues. Importantly, however, our results suggest that at least some imagined events constrained by experimenter-provided cues were not truly autobiographical, in the sense that participants did not necessarily link the imagined situations to their own personal lives. Indeed, compared to future events that were explicitly connected to personal goals, events constructed in response to experimenter-provided cues received lower ratings for personal importance, personal plausibility, and thoughts about one's life during the construction process.⁴

⁴ It should be noted that we do not claim that events constructed in response to experimenter-provided cues are never autobiographical events; they may or may not be, depending on the extent to which the individual is able to integrate the proposed event with general knowledge and expectations about his or her personal life. The

When looking at the characteristics of mental representations, we found that the three types of events (i.e., atemporal, nonpersonal future, and personal future events) were represented with similar levels of detail and vividness, as assessed by the amount of episodic details included in verbal reports and by ratings of subjective vividness. On the other hand, auto-noetic experience significantly varied as a function of the type of imagined events: future events that were cued by personal goals were associated with a higher feeling of experiencing the situation and a greater impression of going into the future compared to atemporal and future events that were constructed in response to experimenter-provided cues. Thus, the personal relevance of the cues did not influence the richness of imagined contents, but instead modulated the degree to which participants were auto-noetically aware of the represented events. Furthermore, in line with previous findings (D'Argembeau & Van der Linden, 2012), we found that the personal importance and plausibility of imagined events were significant predictors of auto-noetic experience, even after controlling for the subjective vividness of mental representations.

Taken together, these findings support the view that the subjective feeling of travelling through time to pre-experience one's personal future in part depends on the extent to which imagined events can be meaningfully placed in an autobiographical context. How knowledge about personal goals modulates this feeling remains to be investigated in detail, but one possible mechanism would be that the goal structure of an individual provides a personal timeline on which imagined events can be placed (Fivush, 2011; Thomsen, 2015). Goals may contribute to link and organize specific episodic representations into a meaningful sequence of events that define a person's future life. Thus, the subjective sense of visiting one's personal future may not lie in any single event taken in isolation but may only arise when an

event is connected to other anticipated events and/or general beliefs and expectations about one's life.

The present study adds to growing evidence showing that personal goal processing is an important component of episodic future thinking. Previous studies have shown that personal goals facilitate the construction of episodic future thoughts (D'Argembeau & Mathy, 2011), shape the content of future simulations to make goal-relevant features more salient (Christian, Miles, Fung, Best, & Macrae, 2013), and help link and organize imagined events in coherent themes and sequences (D'Argembeau & Demblon, 2012; Demblon & D'Argembeau, 2014). Here we further demonstrate that personal goals contribute to the very core of the subjective experience associated with episodic future thought—the sense of mental time travel. Overall, these studies clearly indicate that personal goal processing is an integral part of episodic future thinking, a view that is also supported by neuroimaging data showing that thinking about personal goals and imagining specific future events are associated with common brain activations (for a meta-analysis, see Stawarczyk & D'Argembeau, 2015).

Although, by definition, autothetic experience refers to a subjective state and thus should primarily be assessed using subjective responses (Jack & Roepstorff, 2002; Klein, 2015), the additional collection of objective measures could be useful to further shed light on processes that give rise or modulate this subjective state. Of particular interest, recent fMRI studies have shown that subjective experiences associated with remembering past events can be reliably predicted from distributed patterns of brain activity (Rissman, Chow, Reggente, & Wagner, 2016), and that such patterns can give insights into the types of information that are used for making subjective memory judgments (Johnson, Kuhl, Mitchell, Ankudowich, & Durbin, 2015). These techniques of multivoxel pattern classification of fMRI data could be adapted to further investigate the basis of autothetic experience when imagining future events. A candidate brain region for placing specific event representations in an

autobiographical context is the medial prefrontal cortex (mPFC). Lesion studies have indeed revealed that, while the medial temporal lobe is similarly involved in imagining atemporal and future events (Hassabis et al., 2007), focal lesions to the mPFC are associated with greater difficulties in imagining future compared to atemporal fictitious experiences (Bertossi, Aleo, Braghittoni, & Ciaramelli, 2016), suggesting that the mPFC plays some specific role in episodic future thinking. Neuroimaging data further suggest that the mPFC may function to integrate specific event representations with higher-order autobiographical knowledge (Demblon, Bahri, & D'Argembeau, 2016). Through this integrative process, the mPFC might contextualize specific event representations within one's life story, thereby contributing to the subjective sense of pre-experiencing one's personal future during the imagination process.

Overall, the present and previous findings suggest that episodic future thinking relies on (at least) two distinct component processes: the construction of a detailed event representation, and the integration of this event in an autobiographical context (D'Argembeau, 2015). In his conceptualization of autobiographical memory, Conway (2001, 2005) proposed a similar distinction between specific event memories and conceptual autobiographical knowledge, which provides an organizing context for remembered events. By extending the scope of the autobiographical knowledge base to conceptual representations of one's personal future, this framework may prove useful to account for accumulating evidence showing that episodic future thinking involves more than scene construction. The crux of episodic future thinking may indeed lie in the conjunction of scene construction and contextualizing autobiographical knowledge.

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Table 1. Mean ratings (and standard deviations) of event properties

	Atemporal	Nonpersonal future	Personal future	$F(2, 58)^a$	p	η_p^2
Personal importance	2.78 (1.19)	3.22 (1.31)	6.10 (0.99)	82.99	< .001	.74
Affective valence	0.85 (1.03)	1.25 (1.08)	1.75 (1.10)	7.56	.001	.21
Previous thoughts	2.22 (1.06)	2.13 (0.92)	4.37 (1.71)	44.63	< .001	.61
Novelty	2.47 (1.07)	2.65 (1.03)	2.32 (1.14)	1.12	.33	.04
Familiarity of location	3.47 (1.46)	3.22 (1.16)	3.77 (1.19)	1.28	.29	.04
Familiarity of persons/objects	3.73 (1.15)	3.40 (1.09)	4.32 (1.44)	4.13	.02	.13
General plausibility	5.55 (0.90)	5.55 (0.78)	5.12 (1.32)	2.62	.08	.08
Personal plausibility	5.30 (0.95)	5.35 (0.79)	6.00 (0.81)	10.82	< .001	.27
Connection to other events	3.38 (1.35)	3.18 (1.30)	3.70 (1.71)	1.42	.25	.05
Thoughts about one's life	2.31 (1.21)	2.68 (1.39)	4.70 (1.39)	50.26	< .001	.63
Ease of construction	4.82 (0.87)	4.87 (0.94)	5.22 (0.86)	1.89	.16	.06

Note: ^aThe Greenhouse-Geisser correction was used for previous thoughts ($df = 1.45, 42.04$) and general plausibility ($df = 1.57, 45.54$)

Table 2. Bivariate associations between auto-noetic experience and other variables

Explanatory variable	Standardized coefficient	Z-ratio	<i>p</i>
Subjective vividness	.51	9.83	< .001
Ease of construction	.50	10.14	< .001
Novelty	.11	1.63	.10
Familiarity of location	.22	3.84	< .001
Familiarity of persons/objects	.32	5.79	< .001
Personal importance	.46	9.24	< .001
Valence	.38	6.46	< .001
Previous thoughts	.44	8.22	< .001
General plausibility	-.04	0.63	.53
Personal plausibility	.37	6.03	< .001
Connection to other events	.32	4.94	< .001
Thoughts about one's life	.43	7.36	< .001

Table 3. Standardized regression coefficients from a multilevel regression model predicting auto-noetic experience from subjective richness, ease of construction, personal importance, and personal plausibility

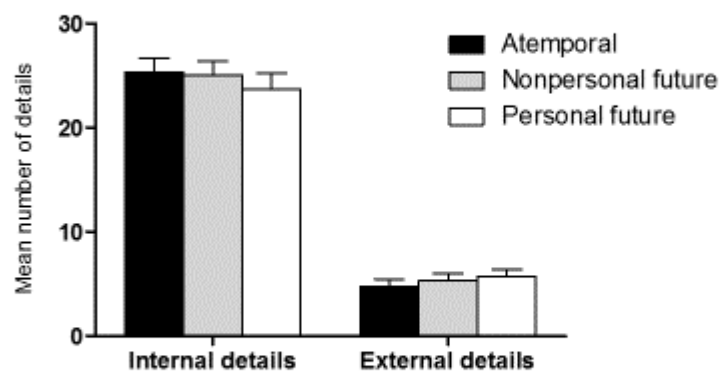
Explanatory variable	Standardized coefficient	Z-ratio	<i>p</i>
Subjective richness	.25	4.43	< .001
Ease of construction	.21	3.76	< .001
Personal importance	.27	6.16	< .001
Personal plausibility	.13	2.76	.006

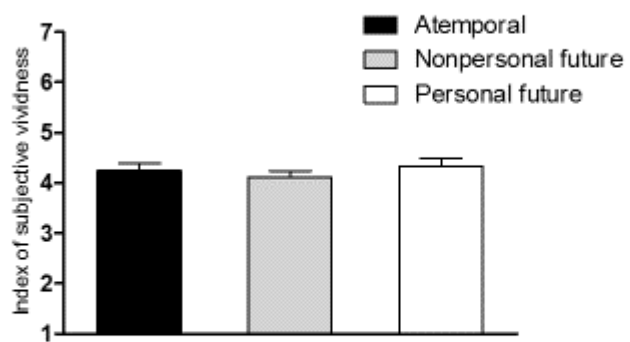
Figure captions

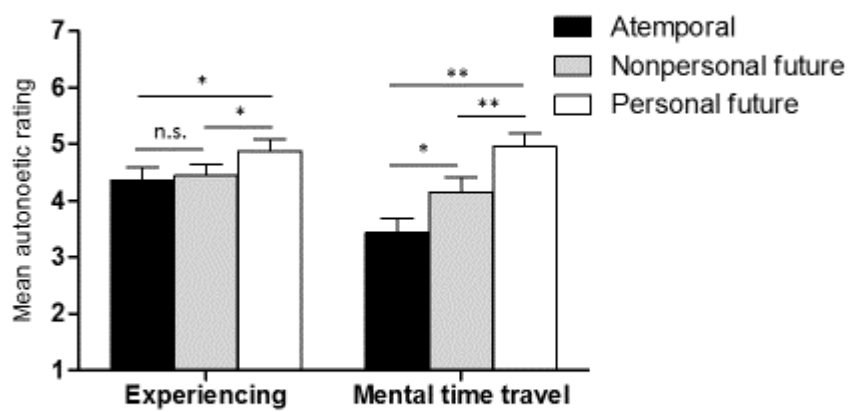
Figure 1. Mean number of internal and external details reported in the verbal descriptions of imagined events. Error bars represent the standard error of the mean.

Figure 2. Mean ratings of subjective vividness as a function of the type of imagined events. Error bars represent the standard error of the mean.

Figure 3. Mean ratings of auto-noetic experience as a function of the type of imagined events. Error bars represent the standard error of the mean. * $p < .05$; ** $p < .001$; n.s. = non-significant.







Supplementary material

The role of personal goals in auto-noetic experience when imagining future events

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Supplementary Table 1. Intercorrelations between predictors at level 1 (within-participants)

	1	2	3	4	5	6
1. Subjective vividness						
2. Ease of construction	.65					
3. Personal importance	.31	.35				
4. Previous thoughts	.36	.40	.68			
5. Emotional valence	.44	.40	.48	.40		
6. Personal plausibility	.25	.31	.37	.40	.20	
7. Thoughts about one's life	.21	.27	.74	.52	.37	.34

Note: Correlations in bold are significant at $p < .001$.