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# Envisioning the times of future events: The role of personal goals

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ABSTRACT

Episodic future thinking refers to the human capacity to imagine or simulate events that might occur in one's personal future. Previous studies have shown that personal goals guide the construction and organization of episodic future thoughts, and here we sought to investigate the role of personal goals in the process of locating imagined events in time. Using a think-aloud protocol, we found that dates were directly accessed more frequently for goal-related than goal-unrelated future events, and the goal-relevance of events was a significant predictor of direct access to temporal information on a trial-by-trial basis. Furthermore, when an event was not directly dated, references to anticipated lifetime periods were more frequently used as a strategy to determine when a goal-related event might occur. Together, these findings shed new light on the mechanisms by which personal goals contribute to the location of imagined events in future times.

## 1. Introduction

People spend a great deal of time envisioning events and scenarios that might happen in their personal future, a capacity referred to as episodic future thinking (Atance & O'Neill, 2001; Suddendorf & Corballis, 2007). While the mechanisms and functions of episodic future thought have been intensively studied in the past few years (Schacter, Benoit, & Szpunar, 2017), little is known about how people estimate the times when imagined future events are expected to happen (Friedman, 2005). A recent study showed that the strategies used to date past and future events are largely the same, suggesting that common processes may be used for locating personal events in past and future times (Ben Malek, Berna, & D'Argembeau, 2017; see also D'Argembeau, Jeunehomme, Majerus, Bastin, & Salmon, 2015). It was found that participants most frequently used general knowledge about their life to infer or reconstruct temporal locations, in line with previous research on memory for the time of past events (for review, see Friedman, 1993, 2004; Thompson, Skowronski, Larsen, & Betz, 1996). Interestingly, however, some events were directly dated and these were judged to be more important for personal goals. This finding suggests that knowledge about personal goals facilitates the estimation of when imagined events are expected to occur, although this conclusion is limited by the correlational nature of the data. In the present study, we aim to examine more directly the role of personal goals in the temporal location process by experimentally manipulating the involvement of goals in imagined events.

A growing body of evidence indicates that episodic future thinking involves the mental simulation of specific events as well as more general autobiographical knowledge that contextualizes imagined scenarios in the individual's life story (D'Argembeau, 2015). Specifically, research has shown that people's aspirations and general expectations about their personal future, including anticipated

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lifetime periods (e.g., “when I’ll be married”) and general events (e.g., “my trip to Brazil next summer”), guide the construction of episodic future thoughts (D’Argembeau & Mathy, 2011) and help organize imagined events in coherent themes and sequences (D’Argembeau & Demblon, 2012). The evidence further suggests that personal goals is an important factor that drives the construction and organization of future-oriented autobiographical knowledge (D’Argembeau, 2016; Thomsen, 2015). Goals are cognitive representations of desired states or outcomes (Austin & Vancouver, 1996), and personal goals may be defined as personally important objectives that individuals pursue in their daily lives (Emmons, 1986; Klinger, 2013; Little, 1983; McAdams, 2013). Goal-related knowledge is represented in a hierarchical structure that organizes higher-order goals (e.g., having a successful academic career) in sequences of sub-goals (e.g., receiving a PhD degree with highest honors, finding postdoc positions in competitive laboratories) that specify how to attain desired states (Austin & Vancouver, 1996; Wadsworth & Ford, 1983). This hierarchical and sequential representation of goals and sub-goals may drive the construction of a personal timeline that facilitates the temporal location of goal-relevant future events. In turn, the ability to locate goal-relevant events at specific future times may play a critical role in planning and goal pursuit. Indeed, goal achievement often requires a sequence of actions that need to be ordered and carried out at specific times (e.g., on a given day or within a particular temporal window). However, whether and how personal goals contribute to temporal location processes remain to be investigated in detail.

Goal-related knowledge might facilitate the temporal location of imagined future events in at least two ways. First, when envisioning ways to attain desired goals people may consider the exact dates when goal-relevant events will likely occur. The temporal location of some goal-relevant future events may thus be encoded in memory (as part of “memories of the future”; Jeunehomme & D’Argembeau, 2017; Szpunar, Addis, McLelland & Schacter, 2013), allowing people to directly access temporal information when thinking again about these events. Second, knowledge about personal goals may facilitate the temporal location of associated future events even when exact dates have not been considered on a previous occasion. As noted above, goals may drive the construction of temporally defined autobiographical periods (i.e., anticipated lifetime periods and extended events) that can be used to estimate when specific events might occur (Thomsen, 2015). For example, the goal of doing a postdoc in the U.S. defines a future period of two or three years on one’s mental timeline, which can be used to locate specific events in future times (e.g., as occurring before, during or after this period). Goal-relevant future events may be more easily linked to this temporal framework, allowing one to determine when they will likely happen.

To investigate the role of personal goals in the temporal location of future events, in the present study we asked participants to imagine a series of future events that were cued by personal goals, familiar places, or scenarios imposed by the experimenter and, for each event, they then described everything that came to their minds while attempting to determine when this event will likely occur. Following our previous findings (Ben Malek et al., 2017), we expected that participants would frequently rely on inferential strategies (using lifetime periods and factual knowledge, in particular) to locate future events in time, regardless of the nature of events (i.e., related to goals, places or scenarios). However, considering the role of personal goals in the organization of episodic future thinking (D’Argembeau, 2016), we hypothesized that goal-related events would be directly located in time more frequently than place- and scenario-related events. Furthermore, because personal goals are strongly linked to autobiographical knowledge structures and may drive the organization of lifetime periods (Conway, 2005; D’Argembeau, 2015; Thomsen, 2015), we hypothesized that when future events are not directly located in time, anticipated lifetime periods would be more frequently used as a temporal location strategy for goal-related than place- or scenario-related events.

## 2. Method

### 2.1. Participants

Fifty young adults who were mostly undergraduate students at the University of Liège volunteered to participate in the study. One participant was excluded because she could not follow the instructions. The final sample consisted of 49 participants (24 females), ranging in age from 18 to 25 years ($M = 22.98$, $SD = 1.96$). This sample size was estimated a priori using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) in order to achieve a statistical power of above 90% to detect a significant difference between two conditions, considering an alpha of .05 and a medium within-subjects effect size ($d = 0.50$). Participants were all native French speakers (one of them was a native bilingual) and reported to be free of neurological, psychiatric, and language disorders. This study was approved by the Ethics Committee of the Faculty of Psychology, Speech and Language Therapy, and Education of the University of Liège.

### 2.2. Materials and procedure

Participants were asked to think aloud while they attempted to locate a series of future events in time. The experimental task was inspired from previous work on past and future event dating (Ben Malek et al., 2017; Brown, 1990; Brown, Schweickart, & Svob, 2016; Nourkova & Brown, 2015) and involved four phases. First, participants were invited to produce six personal goals (‘goal’ condition; e.g., graduating from university, travelling around the world) and six places (‘place’ condition) that could be frequently encountered in their future (e.g., my future apartment, my workplace), which were then used as cues for the imagination of future events. Second, participants were asked to imagine specific events in response to each of these cues; furthermore, six non-personal cues were also presented (‘scenario’ condition), which represented familiar settings (e.g., imagine walking in a shopping street, imagine sitting in a crowded bar) and were inspired from previous work (Hassabis, Kumaran, Vann, & Maguire, 2007; de Vito, Gamboz & Brandimonte, 2012). For each cue (i.e., goal, place, and scenario), participants were instructed to imagine a personal and specific future event (i.e., a unique event occurring in a particular place at a particular time, and lasting no more than 24 h). A brief

description of each generated event was written down by the experimenter. The three types of cues were presented by block and their order of presentation was counterbalanced across participants.

Immediately following the event-generation phase, the descriptions of future events that had been produced were presented one at a time and, for each event, participants were asked to describe everything that came to their minds (i.e., to think aloud; Fox, Ericsson, & Best, 2011) while they attempted to determine as precisely as possible when the imagined event would likely occur. These verbal protocols were audio-recorded. For each trial, participants were also asked to rate their degree of certainty in the reported temporal location on a 7-point Likert scale (from 1 = extremely weak, to 7 = extremely strong).

After having located all events in time, participants were asked to rate each event on several 7-point Likert scales assessing the clarity of event representation (from 1 = not at all clear, to 7 = extremely clear), affective valence (from −3 = very negative, to +3 = very positive, with 0 = neutral), importance for personal goals (from 1 = not important at all, to 7 = very important), sense of mental time travel (from 1 = not at all, to 7 = totally), sense of pre-experience (from 1 = not at all, to 7 = totally), subjective distance (1 = very close, 7 = very distant), previous thought about the event (from 1 = never, to 7 = very often), previous thought about when the event would occur (from 1 = never, to 7 = very often), and the likelihood that the event would happen (from 1 = extremely low, to 7 = extremely strong).

### 2.3. Scoring

All the audio-recorded verbal protocols obtained while participants attempted to locate events in time were transcribed for scoring. When the temporal location of an event was immediately produced (i.e., without using any strategy), this was scored as direct event dating. When the temporal location was not directly produced, we scored the strategies used by the participants during the event-dating phase. To characterize these dating strategies, we used a scoring grid based on strategies identified in previous studies on the temporal location of past (Friedman, 1987; Thompson, Skowronski, & Betz, 1993) and future (Ben Malek et al., 2017) events. Five categories of strategies were considered (see Table 1 for a description of each category and examples of corresponding verbal reports): (1) lifetime periods/extended events, (2) specific events (landmarks), (3) conventional time patterns, (4) factual information, and (5) contextual details. These five categories were not mutually exclusive (i.e., the dating protocol obtained for a particular event could include more than one type of strategy) and each trial was scored for the presence or absence of each category.

All transcriptions were scored by the first author and the reliability of our coding scheme was assessed by asking a second trained rater who was blind to the hypotheses to score a random selection of 15% of the verbal protocols. Percentages of raw agreements showed substantial inter-rater reliability for the five strategies of interest: 90% for lifetime periods/extended events, 96% for specific events, 87% for conventional time patterns, 85% for factual information, and 92% for contextual details. Cohen's kappa was 0.75 for lifetime periods/extended events; the kappa coefficient was not computed for the other four categories because their marginal distributions were not uniform (see von Eye & von Eye, 2008).

## 3. Results

In total, 863 future events were included in the analyses; 19 additional events were excluded because they did not meet the specificity criterion (i.e., a unique event happening at a specific place and time and lasting no longer than a day; Williams et al., 1996), as determined by the first author. For each participant, data were averaged across events in each condition ('goal', 'place' and 'scenario') for statistical analyses. When the assumptions of the general linear model were violated, robust statistical methods were used (using the 20% trimmed means and 2000 bootstrap samples; Field & Wilcox, 2017).

**Table 1**
Definition and examples of categories of temporal location strategies.

| Location strategy | Definition | Examples |
|---|---|---|
| Lifetime periods/extended events | Use of knowledge about lifetime periods or extended events for attempting to locate the event in time | It will happen during my internship; I will organize the party after the summer vacation |
| Specific events (landmarks) | Use of another specific event for which the precise temporal location is known (i.e., temporal landmark) | I will meet John a few days after my 25th birthday; It would be just before my thesis defence which is scheduled on the 1st of November 2018 |
| Contextual details | Use of specific details about the target event (i.e., details about the imagined event itself, such as its location, involved activities and persons, or the weather) to infer its temporal location | I imagine it is snowy, so it will likely happen in December; I will be with François that day, so it has to happen next month |
| Conventional time patterns | Reasoning using calendar time (weeks, months, years) or natural time patterns (e.g., seasons) | It will happen during the 1st or the 2nd week of July, more likely the first days of July; I would say during spring time or summer time, but more likely during summer time |
| Factual information | Use of general knowledge (about self, others, or the world) to infer the temporal location of the event | To avoid mass tourism, I will go there during the 1st week of September; I know that my brother will be abroad until next February, so we will meet at that time |

**Table 2**
Mean ratings (and standard deviations) of characteristics of goal-, place- and scenario-related events.

| | Goal | Place | Scenario | $F(2,96)$ | $p$ | $\eta_p^2$ |
|---|---|---|---|---|---|---|
| Subjective vividness | 3.97 (0.15) | 3.96 (0.18) | 3.68 (0.18) | 2.70 | .07 | 0.05 |
| Affective valence | 1.83[a] (0.11) | 1.53[b] (0.14) | 1.24[b] (0.14) | 9.00 | < .001 | 0.16 |
| Importance for personal goals | 5.50[a] (0.11) | 4.72[b] (0.18) | 3.36[c] (0.18) | 77.90 | < .001 | 0.62 |
| Mental time travel | 4.35[a] (0.14) | 4.18[a] (0.17) | 3.50[b] (0.17) | 26.80 | < .001 | 0.36 |
| Pre-experience | 4.02[a] (0.18) | 3.83[a] (0.20) | 3.51[b] (0.18) | 8.10 | < .001 | 0.14 |
| Event rehearsal | 4.19[a] (0.12) | 3.43[b] (0.16) | 2.82[c] (0.12) | 47.83 | < .001 | 0.50 |
| Time rehearsal | 3.83[a] (0.12) | 3.29[b] (0.17) | 2.62[c] (0.15) | 32.85 | < .001 | 0.40 |
| Subjective temporal distance | 4.44 (0.11) | 4.58 (0.12) | 4.60 (0.14) | 0.61 | 0.54 | 0.01 |
| Temporal location (months) | 55.87[a] (6.26) | 49.98[a] (5.56) | 35.40[b] (3.87) | 7.02 | .002 | 0.13 |
| Likelihood | 5.01[a] (0.09) | 4.92[a] (0.14) | 4.07[b] (0.15) | 29.30 | < .001 | 0.38 |

*Note.* All dimensions were assessed on a Likert scale ranging from 1 to 7, except affective valence, which was assessed on a Likert scale ranging from −3 to 3, and temporal distance from the present (which was assessed in months). The superscript letters a, b and c represent statistical contrasts between the conditions when the ANOVA was significant: the same letter in a row indicates that the conditions did not differ significantly.

### 3.1. Event characteristics

The mean ratings and statistical comparisons of event characteristics for goal-related, place-related, and scenario-related events are shown in Table 2. As expected, goal-related events were rated as more important for personal goals than place- and scenario-related events. Furthermore, place-related events were rated as more important than scenario-related events. Other significant differences between conditions were observed for the following characteristics: affective valence, mental time travel, feeling of pre-experience, rehearsal of event content and temporal information, objective temporal distance, and likelihood; subjective vividness and subjective temporal distance did not significantly differ between conditions (see Table 2 for a detailed description of the statistical differences between the three types of events).

### 3.2. Direct access to temporal location

As expected, participants most frequently used inferential strategies to locate future events in time (see Fig. 1). Importantly, however, a robust repeated-measures ANOVA showed a significant effect of the type of events on the frequency of direct access to temporal location, $Ft = 6.62$, $Fcrit = 3.49$, $p < 0.05$. Post-hoc tests indicated that direct event dating was more frequent in the goal condition than in the scenario condition, $\hat{\psi} = 0.14$ [0.03, 0.25]; differences between the 'place' and 'goal' conditions, $\hat{\psi} = 0.06$ [−0.05, 0.16], and between the 'place' and 'scenario' conditions, $\hat{\psi} = 0.08$ [−0.01, 0.17], were not statistically significant.

The preceding analysis indicated that, on average, a direct access to temporal location was more frequent when events were imagined in response to personal goals. It should be noted, however, that although our experimental manipulation produced the expected difference in terms of the goal-relevance of imagined events (i.e., events were judged more relevant to goals in the 'goal condition' than in the other two conditions; see above), the goal-relevance of events imagined in the 'place' and 'scenario' conditions

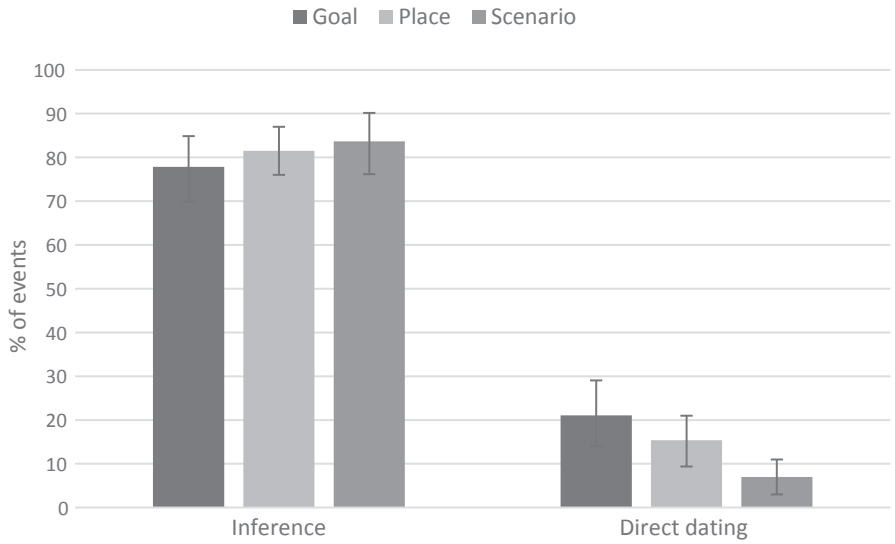


**Fig. 1.** 20% trimmed mean percentages of future events that were located in time using inferential strategies or direct retrieval. Error bars represent the 95% robust confidence interval (Field & Wilcox, 2017).

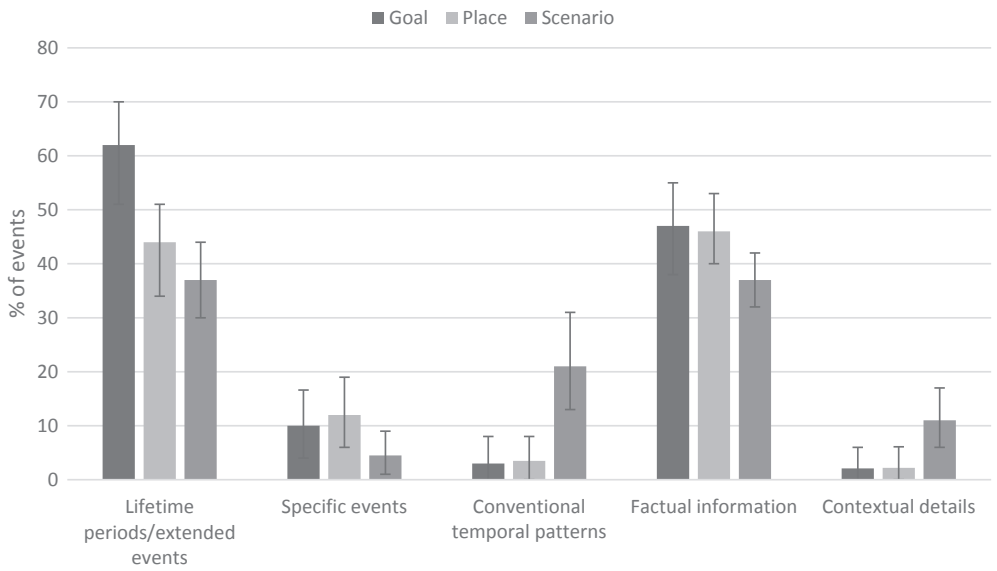


**Fig. 2.** 20% trimmed mean percentages of temporal location strategies for goal-, place- and scenario-related events. Error bars represent the 95% robust confidence interval (Field & Wilcox, 2017).

was not nil and varied across events. Therefore, to further investigate the role of personal goals in the temporal location of future events, we examined to what extent the perceived importance of events for personal goals predicted the mode of temporal location (direct vs. inferential) on a trial-by-trial basis across the entire set of events. In line with our hypotheses, a multilevel (with events as level 1 units, and participants as level 2 units) logistic regression analysis showed that the odds of direct temporal location increased with ratings of the importance of events for personal goals ($b = 0.15$, $SE = 0.05$, $Z = 2.93$, $p = 0.003$). However, when adding ratings of temporal information rehearsal as predictor in the model, we found that direct access was significantly predicted by rehearsal ($b = 0.25$, $SE = 0.06$, $Z = 4.22$, $p < 0.001$) and that the effect of goal-relevance was no longer significant ($b = 0.05$, $SE = 0.06$, $Z = 0.83$, $p = 0.40$), suggesting that the influence of personal goals on direct temporal location was mediated by the rehearsal of event dates.

### 3.3. Frequency of inferential strategies

For events that were not directly located in time, we computed, for each participant and condition, the percentage of events that involved each of the five inferential strategies of interest (see Methods). The 20% trimmed mean percentages of use of each strategy are shown in Fig. 2. A 3 (nature of event) X 5 (type of strategy) robust ANOVA showed a significant main effect of the type of strategy, $Ft = 94.68$, $p < 0.001$. As can be seen from Fig. 2, knowledge of lifetime periods/extended events and factual information were the strategies most frequently used to locate events in time, for the three types of events; these strategies were used significantly more frequently than all other strategies (all $ps < 0.02$). The frequency of use of lifetime periods/extended events and factual information did not differ significantly ($p = 0.53$). Moreover, the use of specific events, conventional temporal patterns, and contextual details did not differ significantly (all $ps > 0.97$).

The ANOVA also showed a main effect of the nature of events, $Ft = 3.07$, $p = 0.047$, as well as a significant interaction between the nature of events and the type of strategies used, $Ft = 9.02$, $p < 0.001$. As can be seen from Fig. 2, this interaction was due to a significantly higher frequency of use of lifetime periods/extended events to locate goal-related events than place-related, $\hat{\psi} = 0.18$ [0.06, 0.30], and scenario-related,$\hat{\psi} = 0.24$ [0.12, 0.36], events; the difference between place-related and scenario-related events did not reach the significance threshold, $\hat{\psi} = 0.06$ [−0.06, 0.19]. Furthermore, conventional time patterns were more frequently used to locate scenario-related events than goal-related, $\hat{\psi} = -0.18$ [−0.29, −0.06], and place-related, $\hat{\psi} = -0.17$ [−0.31, −0.04], events; the difference between goal-related and place-related events was not significant, $\hat{\psi} = -0.01$ [−0.09, 0.07]. There was no significant difference between the three types of events in the frequency of use of the other strategies.

To further examine the role of personal goals in the use of inferential strategies, we investigated whether ratings of the perceived importance of events for personal goals predicted the use of each temporal location strategy on a trial-by-trial basis. A multilevel (with events as level 1 units, and participants as level 2 units) logistic regression analysis showed that the odds of use of lifetime periods/extended events increased with ratings of the importance of events for personal goals ($b = 0.13$, $SE = 0.04$, $Z = 2.81$, $p < 0.005$). The use of other specific (landmark) events also increased with ratings of goal relevance ($b = 0.26$, $SE = 0.07$, $Z = 3.74$, $p < 0.001$). Conversely, the use of conventional time patterns decreased with ratings of the importance of events for personal goals ($b = -0.27$, $SE = 0.06$, $Z = -4.25$, $p < 0.001$). Contrary to what we observed for direct access to temporal information, these effects of goal-relevance remained significant when ratings of rehearsal of temporal information were included in the models. The

perceived importance of events for personal goals did not significantly predict the use of contextual details ($b = -0.11$, $SE = 0.07$, $Z = -1.61$) and factual information ($b = 0.02$, $SE = 0.04$, $Z = 0.52$).

### 3.4. Use of multiple inferential strategies

We also investigated whether the use of multiple strategies to locate an event in time differed between the three conditions. For each participant and event condition, we computed the frequency of events that were located using multiple (two or more) inferential strategies. A one-way robust ANOVA showed a significant main effect of the nature of events, $Ft = 3.26$, $Fcrit = 3.03$, $p < 0.05$. The use of multiple strategies tended to be more frequent in the 'goal' condition (trimmed mean = 29%, 95% CI [20.64–37.58]) than in the 'place' (trimmed mean = 17%, 95% CI [10.97–24.39]) and 'scenario' (trimmed mean = 18%, 95% CI [10.35–26.32]) conditions. However, post-hoc tests showed that these differences were not statistically significant, $\hat{\psi} = 0.12$ [−0.01, 0.24] and $\hat{\psi} = 0.11$ [−0.01, 0.24], respectively; the difference between the 'place' and 'scenario' conditions was not statistically significant, $\hat{\psi} = -0.006$ [−0.13, 0.12].

### 3.5. Certainty of temporal location

Finally, we investigated whether the certainty with which participants located events in time differed as a function of the nature of events. A one-way ANOVA showed a significant effect of the nature of events, $F(2, 96) = 5.63$, $p = 0.005$, $\eta_p^2 = 0.1$. The degree of certainty was judged higher for goal-related events ($M = 4.28$, $SD = 0.13$) and place-related events ($M = 4.25$, $SD = 0.13$) than scenario-related events ($M = 3.25$, $SD = 0.16$; $ps < 0.01$). The degree of certainty of temporal location did not differ significantly between goal-related and place-related events ($p = 0.84$).

## 4. Discussion

While memory for the times of past events has attracted much attention, little is known about how envisioned future events are located in time. Furthermore, the role of personal goals in temporal location processes has not been studied in detail. To address this question, we investigated the strategies that people use when attempting to determine the temporal location of future events that were cued by personal goals, familiar places, and experimenter-provided scenarios. The results replicated our previous findings that people rarely directly determine the temporal location of future events, but instead use inferential strategies (Ben Malek et al., 2017). Interestingly, however, the odds of direct access to event dates were higher for goal-related events. Furthermore, when an event was not directly dated, references to anticipated lifetime periods were more frequently used as a strategy to determine when a goal-related event might occur.

Considerable evidence has indicated that the temporal location of past events is mainly reconstructive and inferential (Friedman, 1993, 2004; Thompson et al., 1993, 1996; Shum, 1998), and recent studies suggest that similar mechanisms are involved in estimating the times of future events (Ben Malek et al., 2017; D'Argembeau et al., 2015). In line with these observations, we found that most future events were not "time stamped." Instead, participants used various inferential strategies to estimate when an imagined event will likely happen. References to anticipated lifetime periods and factual knowledge (about the self, others or the world) were the most frequently used strategies, replicating our previous study (Ben Malek et al., 2017). Specific landmarks, conventional time patterns, and contextual details also contributed to temporal location attribution, but to a lesser extent. Of note, a non-negligible proportion of events were located using multiple (i.e., two or more) inferential strategies, which is also consistent with our previous findings (Ben Malek et al., 2017).

The frequent use of autobiographical periods (i.e., lifetime periods and extended events) for estimating the times of imagined events can be interpreted in terms of hierarchical models of episodic future thinking, according to which autobiographical knowledge structures form partonomies in which specific events are part of general events that are themselves nested in lifetime periods (Conway, Justice, & D'Argembeau, in press; D'Argembeau, 2015). On this view, higher-order autobiographical knowledge contextualizes specific event representations in an individual's personal life and contributes, in particular, to the temporal location of events (Thomsen, 2015). For example, an anticipated lifetime period such as "my postdoc in the U.S." may organize the representation of a series of future events (e.g., giving my first talk at an international conference; visiting my aunt in Boston; going to a concert in New York) and help one to determine that these events will likely occur in about two years from now (i.e., during my postdoc years).

An important finding of the present study is that autobiographical periods were more frequently used to infer the temporal location of goal-related than place- or scenario-related future events. Moreover, the use of autobiographical periods was predicted by the goal-relevance of events on a trial-by-trial basis. These results support the hypothesis that personal goals contribute to the temporal organization of imagined future events because they are closely associated with higher-order autobiographical knowledge (D'Argembeau, 2015, 2016). In fact, the construction of autobiographical periods may in part be determined by personal goals (Thomsen, 2015). For example, the goal of getting married will delineate a period of married life in one's mental time line, which can then be used to determine when associated (i.e., goal-relevant) events will likely happen. Thus, goals may drive the construction of a personal timeline, composed of anticipated autobiographical periods, that serves to temporally organize episodic future thoughts.

Although the majority of future events were located in time using inferential strategies, the dates of some events were directly determined and the odds of direct access to temporal information increased with the perceived importance of events for personal

goals. Interestingly, however, the effect of goal-relevance was no longer significant when rehearsal of time information was taken into account, suggesting that the influence of personal goals on direct temporal location is mediated by the rehearsal of event dates. A possible explanation for these findings is that participants may have already thought about the dates of goal-relevant events on a previous occasion, such that temporal information has been encoded in memory as part of "memories of the future" (Jeunehomme & D'Argembeau, 2017; Szpunar et al., 2013). Previously imagined future events can be directly accessed in response to relevant cues (Cole, Staugaard & Bernsten, 2016; Jeunehomme & D'Argembeau, 2016), and a similar phenomenon might occur for the temporal location of events. In line with this view, the present results showed that participants had more frequently thought about the times and content of goal-related than place- or scenario-related events. This increased accessibility of temporal information may in turn facilitate future planning and contribute to successful goal pursuit.

Another notable difference in dating strategies between the three types of events is that references to conventional time patterns (i.e., the calendar or natural time cycles) were more frequent for scenario-related than goal- and place-related events. Moreover, the odds of use of conventional time patterns decreased with the perceived importance of events for personal goals on a trial-by-trial basis. Participants also reported being less certain about the dates of scenario-related events and estimated that these events were less likely to occur. These findings suggest that conventional time patterns may be used to compensate the lack of knowledge about anticipated lifetime periods when attempting to determine the times of future events that are less clearly embedded in an autobiographical context. The temporal location of these events may be more labile because they are less contextualized within the individual's life story.

Some limitations of this study should be acknowledged. First, as our aim was to investigate the role of personal goals in the temporal location of future events, we experimentally manipulated the contribution of goals in the imagination of events. However, the three kinds of imagined events differed not only in terms of goal-relevance, but also on other dimensions that might influence temporal location processes. Notably, our results suggest that the rehearsal of time information seems a key factor in explaining the direct dating of goal-relevant events. On the other hand, the influence of goals on the use of autobiographical periods did not depend on the rehearsal of time information. Nevertheless, it would be interesting in future studies to investigate temporal location processes for goal-relevant but unrehearsed events (i.e., events that people imagine for the first time). Second, it should be noted that the present study focused on temporal locations. More study is needed to investigate the role of goals in other aspects of temporal representation, such as distances and temporal order (Friedman, 1993, 2004). Finally, temporal location processes were inferred based on verbal reports obtained using a think-aloud procedure (Fox et al., 2011) and it will be important in future studies to obtain converging evidence using other measures (e.g., response times, self-rating of the use of various strategies).

## 5. Conclusion

In conclusion, the present study shows that the temporal location of imagined future events is more frequently directly determined when events are related to personal goals. When people cannot directly locate a future event in time, they use multiple strategies to determine its temporal location and these strategies are also influenced by the goal-relevance of imagined events. Most frequently, people use general knowledge about the anticipated periods of their life to estimate the temporal location of future events, particularly when these are related to personal goals. These findings suggest that personal goals and lifetime periods are central components of a personal timeline that is used to mentally travel to the future.

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## References

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences, 5*(12), 533–539.

Austin, J. T., & Vancouver, J. B. (1996). Goal constructs in psychology: Structure, process, and content. *Psychological Bulletin, 120*(3), 338.

Ben Malek, H., Berna, F., & D'Argembeau, A. (2017). Reconstructing the times of past and future personal events. *Memory, 25*(10), 1402–1411.

Brown, N. R. (1990). Organization of public events in long-term memory. *Journal of Experimental Psychology: General, 119*(3), 297.

Brown, N. R., Schweickart, O., & Svob, C. (2016). The effect of collective transitions on the organization and contents of autobiographical memory: A transition theory perspective. *American Journal of Psychology, 129*(3), 259–282.

Cole, S. N., Staugaard, S. R., & Berntsen, D. (2016). Inducing involuntary and voluntary mental time travel using a laboratory paradigm. *Memory & Cognition, 44*(3), 376–389.

Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language, 53*(4), 594–628.

Conway, M. A., Justice, L., & D'Argembeau, A. (2018). The Self-Memory System revisited: past, present, and future. In J. H. Mace (Ed.). *The organization and structure of autobiographical memory*. New York: Oxford University Press.

D'Argembeau, A., Jeunehomme, O., Majerus, S., Bastin, C., & Salmon, E. (2015). The neural basis of temporal order processing in past and future thought. *Journal of*

*Cognitive Neuroscience, 27*(1), 185–197.
D'Argembeau, A., & Mathy, A. (2011). Tracking the construction of episodic future thoughts. *Journal of Experimental Psychology: General, 140*(2), 258.
D'Argembeau, A. (2015). Knowledge structures involved in episodic future thinking. *Reasoning as Memory,* 128–145.
D'Argembeau, A. (2016). The role of personal goals in future-oriented mental time travel. *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel,* 199–214.
D'Argembeau, A., & Demblon, J. (2012). On the representational systems underlying prospection: Evidence from the event-cueing paradigm. *Cognition, 125*(2), 160–167.
de Vito, S., Gamboz, N., & Brandimonte, M. A. (2012). What differentiates episodic future thinking from complex scene imagery? *Consciousness and Cognition, 21*(2), 813–823.
Emmons, R. A. (1986). Personal strivings: An approach to personality and subjective well-being. *Journal of Personality and Social psychology, 51*(5), 1058.
Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191.
Field, A. P., & Wilcox, R. R. (2017). Robust statistical methods: A primer for clinical psychology and experimental psychopathology researchers. *Behaviour Research and Therapy, 98*, 19–38.
Fox, M. C., Ericsson, K. A., & Best, R. (2011). Do procedures for verbal reporting of thinking have to be reactive? A meta-analysis and recommendations for best reporting methods. *Psychological Bulletin, 137*(2), 316.
Friedman, W. J. (1987). A follow-up to "Scale effects in memory for the time of events": The earthquake study. *Memory & Cognition, 15*(6), 518–520.
Friedman, W. J. (1993). Memory for the time of past events. *Psychological Bulletin, 113*(1), 44.
Friedman, W. J. (2004). Time in autobiographical memory. *Social Cognition, 22*(5), 591.
Friedman, W. J. (2005). Developmental and cognitive perspectives on humans' sense of the times of past and future events. *Learning and Motivation, 36*(2), 145–158.
Hassabis, D., Kumaran, D., Vann, S. D., & Maguire, E. A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences, 104*(5), 1726–1731.
Jeunehomme, O., & D'Argembeau, A. (2016). Prevalence and determinants of direct and generative modes of production of episodic future thoughts in the word cueing paradigm. *The Quarterly Journal of Experimental Psychology, 69*(2), 254–272.
Jeunehomme, O., & D'Argembeau, A. (2017). Accessibility and characteristics of memories of the future. *Memory, 25*(5), 666–676.
Klinger, E. (2013). Goal commitments and the content of thoughts and dreams: Basic principles. *Frontiers in Psychology, 4*, 415.
Little, B. R. (1983). Personal projects: A rationale and method for investigation. *Environment and Behavior, 15*(3), 273–309.
McAdams, D. P. (2013). The psychological self as actor, agent, and author. *Perspectives on Psychological Science, 8*(3), 272–295.
Nourkova, V. V., & Brown, N. R. (2015). Assessing the impact of "The Collapse" on the organization and content of autobiographical memory in the former Soviet Union. *Journal of Social Issues, 71*(2), 324–337.
Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: Mechanisms and functions. *Current Opinion in Behavioral Sciences, 17*, 41–50.
Shum, M. S. (1998). The role of temporal landmarks in autobiographical memory processes. *Psychological Bulletin, 124*(3), 423.
Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: What is mental time travel, and is it unique to humans? *Behavioral and Brain Sciences, 30*(03), 299–313.
Szpunar, K. K., Addis, D. R., McLelland, V. C., & Schacter, D. L. (2013). Memories of the future: New insights into the adaptive value of episodic memory. *Frontiers in Behavioral Neuroscience, 7*, 47.
Thompson, C. P., Skowronski, J. J., & Betz, A. L. (1993). The use of partial temporal information in dating personal events. *Memory & Cognition, 21*(3), 352–360.
Thompson, C. P., Skowronski, J. J., Larsen, S. F., & Betz, A. L. (1996). Autobiographical memory: Remembering what and remembering when: Psychology Press.
Thomsen, D. K. (2015). Autobiographical periods: A review and central components of a theory. *Review of General Psychology, 19*(3), 294.
von Eye, A., & von Eye, M. (2008). On the marginal dependency of Cohen's κ. *European Psychologist, 13*(4), 305–315.
Wadsworth, M., & Ford, D. H. (1983). Assessment of personal goal hierarchies. *Journal of Counseling Psychology, 30*(4), 514.
Williams, J. M. G., Ellis, N. C., Tyers, C., Healy, H., Rose, G., & Macleod, A. K. (1996). The specificity of autobiographical memory and imageability of the future. *Memory & Cognition, 24*(1), 116–125.