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Reconstructing the times of past and future personal events

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ABSTRACT

Humans have the remarkable ability to mentally travel through past and future times. However, while memory for the times of past events has been much investigated, little is known about how imagined future events are temporally located. Using a think-aloud protocol, we found that the temporal location of past and future events is rarely directly accessed, but instead mostly relies on reconstructive and inferential strategies. References to lifetime periods and factual knowledge (about the self, others, and the world) were most frequently used to determine the temporal location of both past and future events. Event details (e.g., places, persons, or weather conditions) were also used, but mainly for past events. Finally, the results showed that events whose temporal location was directly accessed were judged more important for personal goals. Together, these findings shed new light on the mechanisms involved in locating personal events in past and future times.

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KEYWORDS
Time; autobiographical memory; episodic future thinking; goals

Humans have the remarkable ability to mentally travel through past and future subjective times (Suddendorf & Corballis, 1997; Tulving, 2002). This consciousness of time emerges (at least in part) from an internalised view of the past and future as parts of a temporal framework in which we locate life events (Friedman, 2005). When mentally travelling to the past, we often feel that events have occurred at particular points in time, although we may not necessarily know their exact date (Thompson, Skowronski, Larsen, & Betz, 1996). There is substantial evidence that this temporal information often is not an intrinsic property of memories but instead is inferred or reconstructed using various processes (Friedman, 1993, 2004). Little is known about whether similar construction processes are also used to locate imagined events in future times (Friedman, 2005). In the present study, we sought to address this question by investigating strategies that people use to determine the times of past and future personal events.

The times of past events can be determined using three types of information: *locations*, *distances*, and *order* (for review, see Friedman, 1993, 2004). Locations refer to particular points in conventional (e.g., parts of days, months, years), natural (e.g., seasons), or personal (e.g., lifetime periods) time patterns. Examples include recalling that an event happened on a weekend, during winter, or when I was in college. According to time tagging theories (Flexser & Bower, 1974; Hasher & Zacks, 1979), such temporal information is automatically assigned to the event at encoding, while for reconstructive theories (Friedman & Wilkins, 1985; Shum, 1998; Thompson et al., 1996), locations are often not intrinsic properties of memories but are reconstructed using contextual details associated with an event (i.e., persons, places, activities, or any other content) and general knowledge of time patterns and events of one's life (e.g., knowledge of autobiographical periods or specific landmark events). Distances refer to the amount of time that has elapsed between a particular event and the present. Distance-based processes can give the impression that an event happened a long time ago or recently, in part due to some memory properties, such as its vividness (Friedman, 2001). Finally, order refers to before–after relations between events, which can be used to place events relative to each other (Friedman, 2007). These three types of temporal information may each contribute to memory for the times of past events, although people are especially adept at determining temporal locations in the many patterns that structure their lives (Friedman, 1993, 2004).

There is substantial evidence that the temporal location of past events is most frequently determined using reconstructive processes (for review, see Friedman, 1993, 2004; Thompson et al., 1996). For example, based on verbal reports of memory strategies, Friedman (1987) showed that when attempting to date an earthquake that occurred nine months earlier, the majority of participants did not retrieve the date directly, but instead inferred the time of the earthquake from other information (e.g., by relating

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the event to a routine or another event whose time was recalled). In the same vein, studies from Thompson, Skowronski, and Betz (1993) and Skowronski, Betz, Thompson, and Larsen (1995) demonstrated that people frequently use reconstructive strategies to date events from their personal past. In these studies, participants were asked to date a series of personal events that had been recorded in a diary and to report the strategies they used for locating these events in time. It was found that participants most frequently reported having used knowledge of personal life periods (e.g., the final part of a semester, a vacation in Europe) to infer when past events occurred (this strategy was used for 29% of events in Thompson et al. and for 40% of events in Skowronski et al.). Only a few events (18% in Thompson et al. and 10% in Skowronski et al.) were directly located in time. Other studies that used a think-aloud procedure showed that people frequently mentioned both personal (e.g., when I first went to the USA) and public (e.g., during the war) periods when attempting to locate specific past events in time (Brown, 1990; Brown, Schweickart, & Svob, 2016; Zebian & Brown, 2014).

While memory for the times of past events has received much attention, little is known about how people estimate the times of personal events that might happen in the future. By the age of five, children have a differentiated sense of the future, which allows them to judge future distances; by middle childhood, they can use multiple representations of conventional time patterns (e.g. parts of the day, week, month, and year) to locate future events in time (Friedman, 2000, 2002, 2005). Once these temporal structures are fully developed, future times might be determined or inferred using various processes. For instance, people might use culturally shared knowledge about the timing of major life events (e.g., marriage, first job, retirement; Berntsen & Rubin, 2004) and more idiosyncratic autobiographical periods (e.g., when I'll move to France; D'Argembeau & Mathy, 2011; Thomsen, 2015) for locating imagined events in future times, and some planned events might serve as reference points (or temporal landmarks; Shum, 1998) for determining the location of other future events. Interestingly, a recent functional magnetic resonance imaging study has shown that judgments of temporal order recruit a common neural network for past and future events, suggesting that (at least partly) similar processes are used for determining the times of past and future events (D'Argembeau, Jeunehomme, Majerus, Bastin, & Salmon, 2015). However, the precise nature of these processes remains to be investigated in detail.

The aim of the present study was to address this question by examining the strategies that people use to locate personal events in past and future times. Participants were first asked to generate a series of past and future events and, for each event, they then described everything that came to their minds while attempting to determine when this event occurred (past condition) or will likely occur (future condition). Each event was also rated on several scales assessing the phenomenological characteristics of mental representations (e.g., vividness, personal importance, affective valence).

Following previous studies showing that memory for time is largely reconstructive (Brown, 1990; Friedman, 1993, 2004; Thompson et al., 1996), we expected that participants would frequently rely on reconstructive strategies to locate past events in time. Furthermore, we hypothesised that some of the main strategies used to infer the location of past events (i.e., linking events to life periods or landmark events, using general knowledge about patterns that structure one's life; Thompson et al., 1993) would also play an important role in determining the times of imagined future events. However, there might also be differences in the processes used to locate past and future events in time. Theoretical and empirical arguments suggest the existence of asymmetries between remembering the past and imagining the future (for discussion of whether or not these asymmetries imply that episodic remembering and future thinking are different in kind, see Michaelian, 2016; Perrin, 2016). For example, in remembering there is some (albeit imperfect) correspondence between the subject's current representation of a past event and the actual occurrence of this event in the past, whereas future thoughts are about events that have not yet occurred and thus may or may not actually occur. This asymmetry between mental representations of the past and future may affect the use of some temporal location processes. In particular, contextual details of represented episodes (e.g., details about the weather, persons, locations, and so on) might be more frequently used to infer the temporal location of past than future events because of differences in the epistemic status of events (i.e., for past events, event details are shaped by what actually happened and can thus offer clues about temporal location, whereas details of future events are mainly constrained by imagination processes).

In addition to examining the strategies that people use to locate personal events in time, we also sought to determine whether the dates of some future events can be directly accessed, as is the case for some past events (Friedman, 1987; Thompson et al., 1993). Furthermore, we explored whether events that are directly located in time present distinguishing features. In particular, we predicted that events whose dates are directly determined would be judged more important for personal goals than events whose dates need to be inferred using reconstructive processes.

Method

Participants

Thirty-nine young adults volunteered to participate in the study. They were mostly undergraduate students recruited at the University of Liège. Two participants were excluded because of a history of depression (treated with antidepressant drugs) or brain injury. The final sample

consisted of 37 participants (24 females), ranging in age from 18 to 25 years ($M = 22.49$, SD = 1.63). The participants were all native French speakers (four of them were native bilinguals) and reported to be free of neurologic, psychiatric, and language disorders. The sample size was estimated a priori using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) in order to achieve a statistical power of above 80%, considering an alpha of 0.05 and a medium within-subjects effect size ($d = 0.50$). This study was approved by the Ethics Committee of the Faculty of Psychology of the University of Liège.

Materials and procedure

Participants were asked to think aloud while they attempted to locate a series of past and future events in time. The experimental task was inspired by previous work on past event dating (Brown, 1990; Brown et al., 2016; Nourkova & Brown, 2015) and involved three phases. First, participants had to recall 10 past events and to imagine 10 future events in response to cue words (event-generation phase). Twenty cue words referring to common places and objects (e.g., book, apartment, restaurant, dog) were divided into 2 lists of 10 cues that were matched for frequency of use and imageability (Desrochers & Thompson, 2009). The allocation of the two lists to the past and future conditions and the order of presentation of the two conditions were counterbalanced across participants. For each cue word, participants were instructed to remember or imagine a personal and specific event (i.e., a unique event occurring in a particular place at a particular time, and lasting no more than 24 hours). A brief description of each generated event was written down by the experimenter.

Immediately following the event-generation phase, the descriptions of past and 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 event occurred (past condition) or will likely occur (future condition). To avoid influencing temporal location processes, the instructions did not specify which type of temporal information should be reported (e.g., days, months, years). We considered that an event was located in time if the participant could provide at least the year during which the event happened (past condition) or would happen (future condition); note, however, that the majority of past and future events received a more precise temporal location. All verbal protocols collected during the think-aloud task 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: the clarity of event representation (from 1 = not at all clear, to 7 = extremely clear), emotional 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), subjective temporal distance (from 1 = very close, to 7 = very distant), previous thought about the event (from 1 = never, to 7 = very often), and previous thought about when the event occurred or would occur (from 1 = never, to 7 = very often).

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 temporal location was not directly produced, we scored the strategies used by the participants during the event-dating phase. To characterise these dating strategies, we created a scoring grid based on strategies identified in previous studies of memory for the times of past events (Friedman, 1987; Jack, Friedman, Reese, & Zajac, 2016; Thompson et al., 1993), as well as additional strategies (i.e., categories 3 and 4 described below) that were identified when reading the verbal protocols of participants. In the end, 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; events that were not located in time were scored as uncategorised.

As participants could rely on several strategies to date a particular event, each verbal protocol was scored for the presence or absence of each strategy. Thus, the dating protocol obtained for a particular event could include more than one type of strategy; however, a particular piece of information within the protocol was classified in only one category. For example, the following verbal protocol contained two strategies: *If it is going to happen as I wish, it will occur during next summer vacation, so between early July and mid-August … To avoid mass tourism, I would say that it will be during the third week of July*; "Next summer vacation" was coded as a lifetime period/extended event and "to avoid mass tourism" was coded as factual information.

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 20% of the verbal protocols. Percentages of raw agreements showed substantial inter-rater reliability for the five categories of interest: 87% for lifetime periods/extended events, 94% for specific events, 97% for conventional time patterns, 81% for factual

Table 1. Definition and examples of categories of temporal location strategies for past and future events.

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 was during my Master's degree (past event); It will happen during my internship (future event)
Specific events (landmarks)	Use of another specific event for which the precise temporal location is known (i.e., temporal landmark)	I met John a few days after my 25th birthday (past event); It would be just before my thesis defence which is scheduled on 1 November 2016 (future event)
Contextual details	Use of event details (such as locations, activities, persons, or the weather) to infer its temporal location	I was with François that day, so it certainly happened one month ago (past event); It has to be snowy, so it will likely happen in December (future event)
Conventional time patterns	Reasoning using calendar time (weeks, months, years) or natural time patterns (e.g., seasons)	It was a Monday, during this year, on October or November but I would say on October (past event); It will happen during the first or the second week of July, more likely the first days of July (future event)
Factual information	Use of general knowledge (about self, others, or the world) to infer the temporal location of the event	At that time, my brother was still a baby, he is six years younger than me so it was on July 2005 (past event); To avoid mass tourism, I will go there during the first week of September (future event)

information, and 94% 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).

Results

In total, 364 past events and 366 future events were included in the analyses; another 10 events were excluded because they did not meet the specificity criterion. For each participant, data were averaged across events in each condition (past vs. future) for statistical analyses.

Direct retrieval vs. reconstruction of temporal location

As expected, participants mainly used reconstructive strategies to locate past and future events in time (see Figure 1). On average, the temporal location of events was directly produced for only 28% of past events and 25% of future events; very few events were uncategorised (2% in the past condition, and 1% in the future condition). A 2 (mode of location: direct vs. reconstructive) by 2 (temporal orientation: past vs. future) repeated-measures analysis of variance (ANOVA) confirmed that events were more frequently located in time using reconstructive strategies, $F(1, 36) = 102.33$, $p < .001$, $\eta_p^2 = 0.74$; there was no main effect of temporal orientation, $F(1, 36) = 0.73$, $p = .39$, and no interaction, $F(1, 36) = 0.67$, $p = .42$.

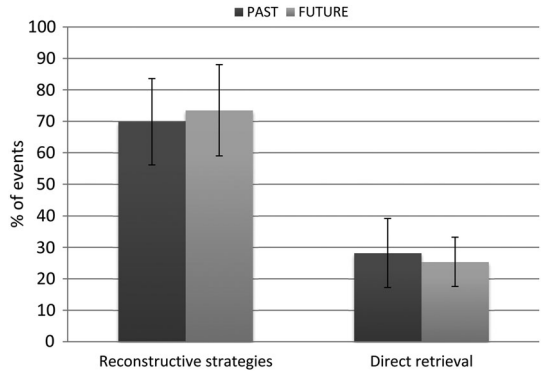

Figure 1. Mean percentage of past and future events that were located in time using reconstructive strategies or direct retrieval. Error bars represent the 95% confidence interval for within-subject designs (O'Brien & Cousineau, 2014).

We also investigated whether the certainty with which participants located events in time differed as a function of their mode of location and temporal orientation (data from five participants were not included in this analysis because they did not report any direct retrieval of temporal location for either past or future events). An ANOVA showed a significant main effect of the mode of location, $F(1, 31) = 18.87$, $p < .001$, $\eta_p^2 = 0.38$, but no main effect of temporal orientation, $F(1, 31) = 1.19$, $p = .28$, and no interaction, $F(1, 31) = 0.45$, $p = .51$. The degree of certainty of temporal location was judged higher for events whose dates were directly retrieved ($M = 5.76$, SD = 0.77) than for events that were dated using reconstructive strategies ($M = 4.72$, SD = 0.81).

Frequency of reconstructive strategies

The mean percentages of the various strategies used for locating past and future events in time are shown in Figure 2. A 2 (temporal orientation) by 5 (type of strategy) ANOVA showed a significant main effect of types of strategies, $F(4, 144) = 61.72$, $p < .001$, $\eta_p^2 = 0.63$. As can be seen from Figure 2, knowledge of autobiographical periods/ extended events was the strategy most frequently used by participants to locate both past and future events in time; this strategy was significantly used more frequently than all other strategies (all $ps < .001$). Factual information was also frequently used by participants to locate past and future events in time and was significantly more frequent than all the other remaining strategies (all $ps < .001$). Differences in the frequency of use of specific events, knowledge of conventional time patterns, and

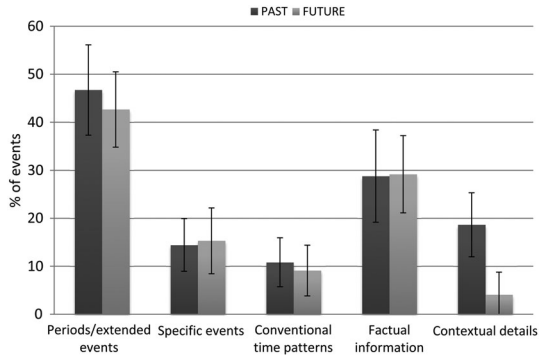

Figure 2. Mean percentage of temporal location strategies for past and future events. Error bars represent the 95% confidence interval for within-subject designs (O'Brien & Cousineau, 2014).

contextual details did not reach statistical significance (all *ps* > .053).

The ANOVA also showed that the main effect of temporal orientation was not significant, $F(1, 36) = 3.44$, $p = .07$, $\eta_p^2 = 0.09$, but there was a significant interaction between temporal orientation and the types of strategies used by participants, $F(3.64, 131.14) = 4.34$, $p = .003$, $\eta_p^2 = 0.11$ (the Huynh–Feldt correction was used here because the assumption of sphericity was violated and ε was greater than 0.75). As can be seen from Figure 2, this interaction was due to a significantly higher frequency of use of contextual details to infer the temporal location of past events than future events ($p < .001$). Apart from contextual details, the frequency of use of temporal location strategies did not differ between past and future events (all *ps* > .32).

We also computed the frequency with which participants used more than one reconstructive strategy for locating past and future events in time. This showed that the use of multiple strategies (two or more) was more frequent for past events ($M = 53\%$ of events, SD = 31) than for future events ($M = 34\%$ of events, SD = 24), $t(36) = 3.68$, $p < .001$, $d = 0.61$.

Finally, we investigated whether the certainty of temporal location varied with the use of some reconstructive strategies. A 2 (use of strategy: yes vs. no) by 2 (temporal orientation: past vs. future) ANOVA on certainty ratings indicated that the certainty of temporal location did not differ between events that were located with or without the use of lifetime periods/extended events, $F(1, 31) = 0.004$, $p = .95$; there was no interaction between the use of this strategy and temporal orientation, $F(1, 31) = 2.52$, $p = .12$ (note that five participants had to be excluded from the analysis because they did not use this strategy). Similarly, the certainty of temporal location did not differ between events that were located with or without the use of factual information, $F(1, 29) = 0.35$, $p = .56$, and there was no interaction between the use of this strategy and temporal orientation, $F(1, 29) = 0.02$, $p = .89$ (seven participants had to be excluded from the analysis because they did not use this strategy). Thus, the certainty with which participants located events in time was not related to the use of lifetime periods/extended events or factual information.[1] The certainty of temporal location could not be examined for the other types of strategies due to missing values for either past or future events in a high number of participants.

Event characteristics that are associated with direct access to temporal location

Our next goal was to investigate whether events that were directly located in time presented distinguishing features. To address this question, the ratings of past and future event features were averaged separately for events that were directly located in time and events that required reconstructive strategies.[2] A series of paired *t*-tests showed that events that were directly located in time were subjectively more vivid, were associated with a stronger feeling of time travel, and were judged more important for personal goals than events that were located in time using reconstructive strategies (see Table 2). The results also showed that events that were directly dated were closer to the present (in terms of both objective and subjective temporal distance). Finally, participants indicated that they had more frequently thought about the temporal location of directly located events than non-directly located events. Event rehearsal and affective valence did not significantly differ between the two kinds of events.

Temporal distribution of events that were directly located in time

Considering the previous finding that, on average, events that were directly located in time were closer to the present, we aimed to further examine the temporal distribution of directly located events for the past and the future. The majority of directly located events were

Table 2. Mean ratings (and standard deviations) of event characteristics in direct retrieval and reconstruction of temporal information.

	Direct retrieval	Reconstruction	*t*(35)	*p*	*d*
Subjective vividness	5.35 (0.82)	4.46 (0.79)	5.26	<.001	0.89
Affective valence	1.33 (0.82)	1.11 (0.68)	1.56	.13	0.26
Personal importance	4.65 (1.13)	4.11 (0.70)	2.94	.006	0.50
Mental time travel	4.95 (0.99)	4.33 (0.82)	4.26	<.001	0.72
Event rehearsal	3.63 (1.15)	3.41 (0.64)	1.26	.22	0.21
Time rehearsal	3.37 (1.09)	2.88 (0.75)	3.06	.004	0.52
Subjective temporal distance	3.09 (0.88)	4.49 (0.51)	−8.90	<.001	1.50
Temporal location (months)	29.39 (30.28)	57.88 (32.69)	−4.90	<.001	0.83

Notes: 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). Data from one participant were not analysed ($n = 36$) because no direct retrieval was used to locate events in time.

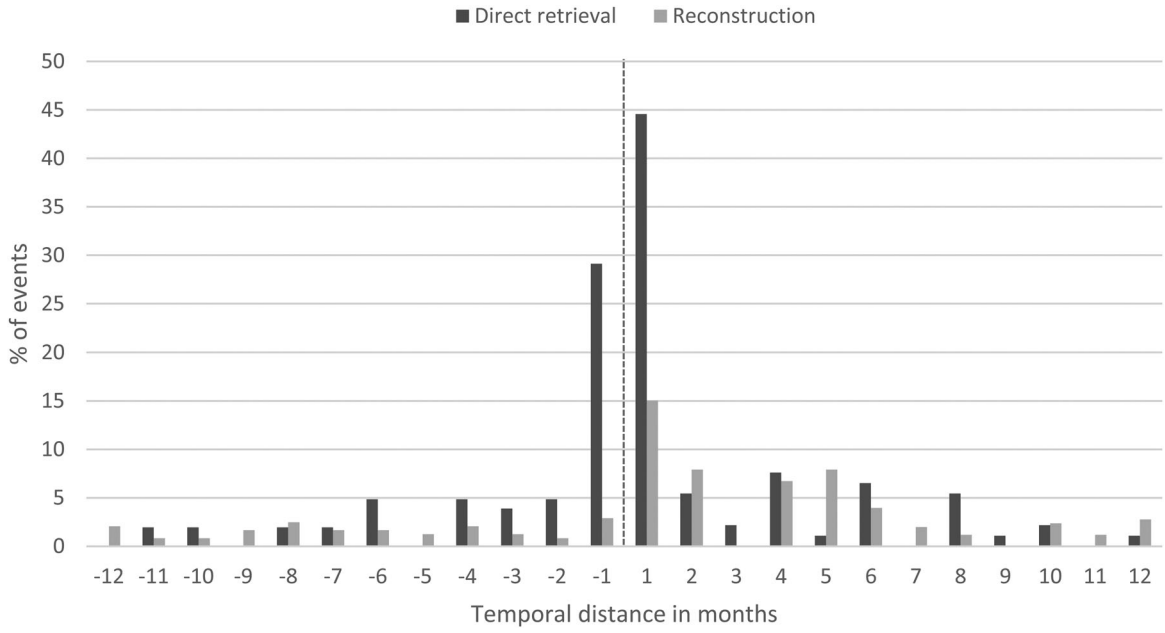

Figure 3. Temporal distribution of past (left panel) and future (right panel) events associated with direct access to temporal information and with temporal reconstruction. Each bar represents the percentage of directly located or reconstructed events in a given one-month time bin (i.e., number of directly located or reconstructed events in this time bin / total number of directly located or reconstructed events).

distributed within a one-year interval from the present, both for the past (55% of directly located events referred to the previous year, with each following year containing less than 10% of directly located events) and the future (77% of directly located events referred to the next year, with each following year containing less than 5% of directly located events). The temporal distribution of directly located events within a two-year interval from the present (i.e., one year in the past and one year in the future) is shown on Figure 3 using one-month time bins. As can be seen, most directly located events referred to the very recent past and future (i.e., the previous or next month), with the percentage of directly located events declining rapidly with increasing temporal distance in both the past and the future. As also shown on Figure 3, such a decline was not observed for the temporal distribution of events whose dates were reconstructed (i.e., the percentages of reconstructed events were more evenly distributed across temporal distances).

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. To address this question, we investigated the strategies that people use when attempting to determine the temporal location of past and future events. The results showed that people rarely have a direct access to the temporal location of past and future events, but instead use reconstructive and inferential strategies. Reference to lifetime periods and factual knowledge were the most frequently used strategies to determine the times of both past and future events, and specific landmarks were also sometimes used for both types of events. Finally, contextual details also contributed to temporal location attribution, but mainly for past events.

In line with previous studies on memory for the times of personal and public events (Brown, 1990; Friedman, 1987; Skowronski et al., 1995; Thompson et al., 1993), we found that only a minority of past events were directly located in time. This finding adds support to the view that temporal information is often not an intrinsic feature of memories, but is instead inferred and reconstructed using various strategies (Friedman, 1993, 2004; Thompson et al., 1996). In the present study, the most frequent strategy for dating past events was the use of autobiographical periods, which is consistent with previous studies (see e.g., Arbuthnott & Brown, 2009; Skowronski et al., 1995; Thompson et al., 1993). Factual knowledge and event details were also frequently used to infer the location of past events, and participants sometimes referred to other specific events that served as temporal landmarks (Shum, 1998). Overall, these findings are consistent with current knowledge about the processes underlying memory for the times of past events (Friedman, 2004).

An important finding of this study is that largely similar strategies were used to locate future events in time. As for past events, knowledge of autobiographical periods was most frequently reported, supporting the view that people have some knowledge of future lifetime periods (e.g., *after my post-doc*) that can be used to determine the temporal location of imagined future events (D'Argembeau, 2015; Thomsen, 2015). Participants also frequently used factual knowledge to infer when imagined events

would likely occur. More specifically, they referred to general information about the self (e.g., I know that I will busy next month), others (e.g., my friend will not be able to join me next summer because she got an internship abroad), and the world (e.g., the concerts generally take place in September) to estimate the temporal location of envisioned future events. Furthermore, some future events whose dates were known served as landmarks for locating other imagined events in time, paralleling the use of temporal landmarks in dating past events (Shum, 1998). In future studies, it would be interesting to further investigate the nature of these landmark events; one possibility is that the dates of future events that are related to important personal goals are highly accessible (see below) and serve as points of reference for locating other future events in time.

A notable difference between the past and future in terms of temporal location strategies was that participants used contextual details (such as locations, activities, persons, or the weather) to a greater extent for past than future events. A possible explanation for this finding is that details of past events are constrained by what happened and thus can be used as clues for determining temporal location, whereas details of future events are more malleable and influenced by imagination processes, thus being less relevant for inferring temporal location. Indeed, details that helped participants to determine the temporal location of future events were mainly details about the weather (70% of reported event details) suggesting that other contextual details (such as locations, activities, persons) may not provide relevant information for inferring temporal location. This difference in the use of contextual details for locating past and future events in time might thus be related to asymmetries between remembering and future thinking in the actuality of represented events (Perrin, 2016).

Another difference between the past and future that might influence temporal location processes is that the dates of past events are fixed and can be verified, whereas the dates of future events are more malleable and may change over time (e.g., the temporal location of imagined future events might be revised depending on current goals, emotional states, or unplanned intervening future events). Thus, when attempting to locate imagined events in time, people might be aware of the fact that the dates of future events might change, which might influence temporal location processes. In addition, differences in the causal structure of event sequences might also affect the way people estimate the times of personal events: past events followed a determined causal order (i.e., some events resulted from other events), which might be used to reconstruct temporal locations, whereas the causal structure of imagined future events is more open (although most future events are represented as parts of higher-order event sequences; D'Argembeau & Demblon, 2012) and thus might be a less reliable indicator of temporal location.

Interestingly, we found that a substantial proportion of past events (53%, on average) were located using a combination of (i.e., two or more) reconstructive strategies, which is consistent with previous findings (Arbuthnott & Brown, 2009). The use of multiple reconstructive strategies was significantly less frequent for future events (occurring in only 34% of events, on average). This suggests that the temporal location of past events often need to be refined or confirmed using multiple sources of information, perhaps as means to check the accuracy of reported dates (e.g., information derived from a past lifetime period can be confirmed by contextual details or factual knowledge). Again, this finding points to some asymmetries in the processes used to locate past and future events in time, which might be related to differences in the epistemic status of remembering and future thinking (Perrin, 2016).

Although temporal location was most frequently inferred using reconstructive strategies, it is interesting to note that some past and future events were directly located in time. For past events, this finding suggests that some episodes might be time-tagged at encoding, such that time information can later be directly retrieved from memory (Friedman, 1993, 2004). Another explanation would be that temporal information was not encoded in memory during the initial episode but instead had been reconstructed during a previous retrieval attempt; this reconstructed date might then be encoded in memory along with the event representation, such that it can directly be accessed during subsequent retrieval occasions. In the same vein, a direct access to the temporal location of future events might occur because people have already thought about these future events as well as their possible dates on a previous occasion, such that this information has been encoded in memory (as part of "memories of the future"; Jeunehomme & D'Argembeau, 2017; Szpunar, Addis, McLelland, & Schacter, 2013). In line with this view, the present results showed that participants had more frequently thought about the times of events that were directly located in time. Recent findings have shown that previously imagined future events can be directly accessed in response to relevant cues (Cole, Staugaard, & Berntsen, 2016; Jeunehomme & D'Argembeau, 2016), and a similar phenomenon might thus occur for the temporal location of imagined events.

Importantly, our findings showed that a number of event features differentiated between events that were directly located in time and events whose dates were reconstructed. Indeed, directly located events were rated as more vivid and associated with a stronger feeling of mental time travel, were more important for personal goals, and were less temporally distant than events located in time using reconstructive strategies. It should be noted that some of these event features (e.g., vividness and personal importance) tend to co-vary with each other and it would be interesting in future studies (by collecting a greater number of directly located events) to further investigate the specific contribution of each of these features to

direct temporal location processes. Be that as it may, the present findings suggest that the times of events that are personally important and close to the present (i.e., within the past and next month) may be particularly accessible. This increased accessibility might facilitate plans for the near future and contribute to successful goal pursuit.

On a more general theoretical level, our results support the view that lifetime periods are central components of autobiographical knowledge that play an important role in locating past and future events in time (Thomsen, 2015). This key role of lifetime periods can be interpreted in terms of hierarchical models of autobiographical memory (Conway, 2005; Conway & Pleydell-Pearce, 2000), according to which autobiographical knowledge form partonomies in which specific events are part of general events which are themselves nested in lifetime periods. On this view, higher-order autobiographical knowledge (general events and lifetime periods) contextualises specific memories in an individual's personal life and contributes, in particular, to determine the temporal location of events. It has been recently proposed that the boundaries of such lifetime periods are defined by transitions that bring about significant changes to one's life circumstances (e.g., relocation; Brown, 2016), and there is indeed evidence that such transitions play a key role in locating specific past events in time (Brown et al., 2016; Zebian & Brown, 2014). Interestingly, our results suggest that mental representations of autobiographical periods can not only be formed following actual changes in material conditions (e.g., changes of job, house, partner), but also in response to expected changes in the future (e.g., when I will have graduated, when I will be living in Paris, when I move in with Claire; note that some of these expected transitional events are likely governed by cultural life scripts; Berntsen & Rubin, 2004). These anticipated life transitions may play a key role in locating imagined events in future times.

Since the upsurge of interest in episodic future thinking about 10 years ago (Atance & O'Neill, 2001; Schacter & Addis, 2007; Suddendorf & Corballis, 2007), most studies have focused on the contribution of episodic and semantic memory (i.e., representations of specific past experiences as well as event schema) in the mental simulation of specific future events (for review, see Schacter et al., 2012). However, there is now substantial evidence that future event representations are structured by higher-order autobiographical knowledge (i.e., representations of personal general events and lifetime periods; D'Argembeau, 2015). In particular, it has been shown that general knowledge about one's personal future plays an important role in the construction and organisation of episodic future thoughts (D'Argembeau & Demblon, 2012; D'Argembeau & Mathy, 2011) and may contribute to the subjective feeling of mental time travel (D'Argembeau & Van der Linden, 2012). The present study adds to this growing body of evidence by demonstrating that autobiographical knowledge also plays an important role in locating imagined events in time. A key difference between episodic future thoughts and mental representations of atemporal events (i.e., events not explicitly located in the past or future; de Vito, Gamboz, & Brandimonte, 2012; Hassabis, Kumaran, Vann, & Maguire, 2007) may be precisely that only the former are placed in an autobiographical context.

Finally, some issues regarding the validity of think-aloud protocols should be acknowledged. One could legitimately argue that thinking aloud might alter temporal location processes (reactivity issue) and that a verbal protocol might not accurately reflect the underlying location processes (nonveridicality issue) because participants might not report some thought or, conversely, might report mental events that did not occur (Russo, Johnson, & Stephens, 1989). Although these validity issues cannot be totally excluded, it should be noted that a recent meta-analysis (Fox et al., 2011) has shown that thinking aloud does not alter task performance, provided that participants are instructed to simply verbalise their thoughts (as was the case in the present study) rather than directing them to provide explanations for their thought processes. Furthermore, previous studies that used a think-aloud procedure to investigate temporal location processes yielded similar conclusions as studies that used other methods (Arbuthnott & Brown, 2009; Friedman, 1987; Skowronski et al., 1995; Thompson et al., 1993), thus providing evidence for the validity of think-aloud protocols for investigating strategies involved in representing the times of personal events.

To conclude, the present study shows that the temporal location of past and future events is only rarely directly accessed and instead mainly relies on reconstructive and inferential processes. Most frequently, people use general knowledge about the periods of their life to estimate the temporal location of both past and future events. This suggests that lifetime periods are central components of the personal timeline that supports mental travels to the past and future.

Notes

1. For past events, we also found that the certainty of dating did not differ between events that were located with or without the use of contextual details, $t(25) = -0.52$, $p = .61$ (but note that 11 participants had to be excluded from this analysis because they did not use this strategy).
2. Data from past and future events were collapsed for these analyses because five participants did not produce direct temporal locations either for the past or the future. However, to examine whether differences between directly located and reconstructed events were similar for the past and future, we also conducted 2 (direct retrieval vs. reconstruction) by 2 (past vs. future) ANOVAs on each event characteristic for participants who reported at least one event per condition (i.e., 32 participants). These additional analyses showed similar differences between directly and reconstructed events as presented in Table 2 and, importantly, we did not find any significant interaction between temporal orientation and mode of temporal location (all Fs$(1, 31) < 2.37$, ps$ > .13$), indicating that the event characteristics that differentiated between direct and reconstructive modes of temporal location were similar for past and future events.

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