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Accessibility and characteristics of memories of the future

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ABSTRACT
Recent research suggests that some imagined future events are encoded in memory, leading to the formation of "memories of the future". However, questions remain regarding the exact components of future event simulations that are encoded and the factors that determine their accessibility. To address these questions, the present study investigated memory for previously imagined future events using both free and cued recall tasks. The results showed that most future event simulations were successfully encoded and remained available in memory after a one week delay, but only some of them were readily accessible, whereas others could only be accessed when relevant cues were provided. Persons and locations were particularly well remembered, suggesting that these components are central to the simulation and memorisation of future events. We also found that memory for future event simulations was related to the clarity and familiarity of represented persons, the subjective feelings of pre-experience and mental time travel, the importance of imagined events to personal goals, and their emotional intensity during the initial simulation phase. Taken together, these findings expand our understanding of the formation, accessibility, and characteristics of memories of the future.

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Human beings spend much of their time simulating scenarios that might happen in their personal future (D'Argembeau, Renaud, & Van Der Linden, 2011). Imagine, for example, a dinner with some friends at your place next week. The simulation of this future event typically involves mental images of particular persons interacting in a specific place and with different objects, and the resulting scene is often associated with a particular emotional connotation. Episodic future thinking is the ability that allows oneself to mentally escape from the present moment to "pre-experience" this kind of event (Atance & O'Neill, 2001).

In the past few years, the capacity to imagine future events has attracted growing interest in various fields of psychology and neuroscience (for review, see Schacter et al., 2012; Szpunar, 2010). A substantial number of studies have provided converging evidence that thinking about future happenings and remembering past events are closely related mental abilities (e.g., Addis, Wong, & Schacter, 2008; D'Argembeau & Van der Linden, 2006; Hassabis, Kumaran, Vann, & Maguire, 2007; Okuda et al., 2003). These findings have led to the view that memory provides an important source of information for imagining possible futures (Schacter & Addis, 2007; Suddendorf & Corballis, 2007). Notably, the constructive episodic simulation hypothesis (Schacter & Addis, 2007; Schacter, Addis, & Buckner, 2008) postulates that people flexibly recombine elements derived from personal past experiences (e.g., location, people, objects, actions, and emotions) for constructing novel future scenarios. Through this process, memory could have an important adaptive value by providing crucial support for future planning and decision-making (Klein, Robertson, & Delton, 2010; Suddendorf & Corballis, 2007).

More than 30 years ago, Ingvar (1985) proposed that some imagined future scenarios are encoded and later accessed in memory – as "memories of the future" – and suggested that one possible function of these memories could be to reduce the cost of repeated future simulations. Such memories of future event simulations could have an important adaptive value in improving the anticipation of future opportunities and risks, thereby promoting goal achievement (Szpunar, Addis, McLelland, & Schacter, 2013; Szpunar & Jing, 2013). So far, however, the formation of memories of the future has received relatively little empirical attention, and the different factors determining whether and how some future event simulations are encoded and maintained in memory are not fully understood.

In a recent study conducted by Szpunar, Addis, and Schacter (2012), participants were asked to imagine new specific future events, in response to random combinations of one familiar person, location, and object extracted from their episodic memories. For each combination, participants were asked to imagine a future event in which they were implicated with all three components and that evoked a particular emotion (i.e., positive, negative, or

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neutral). They were also invited to rate the valence, arousal, and level of detail of the imagined event. Following 10 minutes or one day later, they completed an unexpected cued-recall memory test in which two components from each imagined event were presented (e.g., a location and an object). For each pair of components, participants were asked to recall the corresponding event simulation in order to provide the third missing component (e.g., a person). The results showed that emotional valence played a central role in the formation of memories of future event simulations. More specifically, components associated with positive and neutral future simulations were better recalled than components associated with negative simulations, and this effect increased over time. The analyses of the types of recalled components also revealed that persons were more memorable than objects and locations, suggesting that persons play a central role in the formation of memories of future event simulations.

In another study, McLelland, Devitt, Schacter, and Addis (2015) provided evidence that the level of detail and plausibility of imagined future events, as well as the familiarity of event components, were significant predictors of whether simulations were successfully encoded and later accessible in memory. Participants completed a similar experimental recombination task as in Szpunar et al.'s study. First, event components were collected and rated for familiarity, intensity of emotion, and personal significance before the imagination task. Then, participants were asked to imagine future events involving a combination of three event components (a person, location, and object) and were invited to rate simulations for levels of detail and plausibility. Finally, a cued-recall test similar as the one used in Szpunar et al. (i.e., providing the missing event component in response to the two other components) was administrated 10 minutes after the imagination of future events. The results showed that participants recalled an average of 55% of their future simulations. Moreover, analyses of future event characteristics revealed that more detailed and plausible future event simulations were more memorable than less detailed and plausible simulations. Finally, it was also found that the familiarity of person and location components were both related to memory for future simulations. However, a multiple regression analysis showed that location familiarity did not explain variance above and beyond that explained by detail, plausibility, and person familiarity.

Although these studies provide important new evidence on the factors influencing the formation of memories for future event simulations, some questions remain as regards to what particular aspects of future simulations are maintained in memory. Indeed, these studies relied on an adapted version of the experimental recombination procedure that measured the recall of elements composing a future simulation, but memory for the event simulation itself was not directly assessed. Therefore, it remains possible that, in some cases, participants did not retrieve the imagined future simulation *per se*, but only the associations between the target detail (e.g., a person) and the two other details (e.g., the associated location and object). Memories for future simulations themselves should be directly assessed to clarify this issue. Furthermore, the extent to which components of simulations other than those investigated in these previous studies (e.g., actions or an additional person or object that was not comprised in the three cues but was nevertheless part of an event simulation) were correctly remembered remains unknown.

To address these questions, we examined memory for previously imagined future events using a free recall task that required participants to describe everything they can remember about their future simulations. Participants were first asked to imagine a series of possible future events in as much detail as possible, and were specifically asked to imagine various components for each event, including location(s), person(s), object(s), action(s), and emotion(s). Then, one week later, they were instructed to recall as many previously imagined future events as possible and to describe the content of their mental representation in as much detail as possible. This task allowed us to directly investigate to what extent people remembered their actual event simulation. Drawing on the fundamental distinction between accessibility and availability of information in memory (e.g., Habib & Nyberg, 2008; Tulving & Pearlstone, 1966), we also sought to investigate whether future event simulations that are not readily accessible during a free recall task have nevertheless been encoded in memory and can be accessed when appropriate retrieval cues are provided. To address this question, we used specific cue words to examine whether future events that had not been recalled during the free recall task could be nevertheless retrieved, which would demonstrate that they were available in memory.

Another aim of this study was to examine whether some categories of event components (i.e., locations, persons, objects, actions, and emotions) are better recalled than others, and to determine whether there are differences between free recalled and cued recalled events in this respect. Previous studies suggest that people are central components in both past and future event representations. For example, Dijkstra and Misirlisoy (2006) found that information about people was more often recalled than location and time information when remembering past events. Furthermore, as mentioned above, the studies of McLelland et al. (2015) and Szpunar et al. (2012) both emphasised the importance of persons in memory for future thoughts. Therefore, we expected that the persons involved in future event simulations would be particularly well remembered. In addition, considering that the construction of a coherent spatial scene is also a fundamental process involved in the representation of past and future events (Hassabis & Maguire, 2007, 2009; Robin & Moscovitch, 2014), we predicted that locations would also be well recalled.

Finally, we sought to determine what characteristics of imagined future events predict their successful memorisation. First, considering the general role of depth and elaboration of processing in memory (Craik, 2002), we expected that future simulations that are particularly vivid and detailed would be better encoded and later recalled than less detailed representations. Second, we investigated the role of emotion. Research has shown that emotional arousal typically enhances memory (LaBar & Cabeza, 2006), so we predicted that emotional intensity would facilitate memory for imagined future events. In addition, because positive future simulations have been shown to be more detailed (D'Argembeau & Van der Linden, 2004) and more memorable (Szpunar et al., 2012) than negative simulations, we also expected to observe an effect of emotional valence on memory for future thoughts. Third, we investigated to what extent the importance of imagined events with regard to personal goals contributes to memory for future simulations. Personal goals play an important role in episodic future thought and contribute, in particular, to contextualise imagined events with regard to an individual's personal life (D'Argembeau & Mathy, 2011). Imagined events that are closely related to personal goals should thus be better integrated with pre-existing autobiographical knowledge, which might enhance their encoding and subsequent accessibility in memory.

Methods

Participants

Thirty-five undergraduate students aged between 18 and 30 years took part in this study. One participant was excluded because of a non-compliance to experimental instructions, leaving 34 participants in the analyses (23 females; mean age = 23 years, SD = 2.4 years). This sample size was determined a priori using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) in order to achieve a statistical power of 80%, considering an alpha error of .05 and a medium within-subject effect size (d = 0.5), which corresponds to the effect size reported in some previous studies of memory for future simulations (e.g., Szpunar et al., 2012). All participants provided written informed consent and the study was approved by the University of Liège Ethics Committee.

Materials and procedure

Imagination task

During the first session, participants were asked to imagine a series of plausible and specific future events in response to cue words. Fifteen cue words referring to persons, locations, objects, and broad categories of experiences (e.g., *friend*, *house*, *car*, *work*) were chosen from previous studies on episodic future simulations (D'Argembeau & Van der Linden, 2012; Jeunehomme & D'Argembeau, 2016) and presented in random order. These cue words were selected because they could potentially evoke a variety of future events.

The imagination task was programmed and presented using Open Sesame 2.9.7 software (Mathôt, Schreij, & Theeuwes, 2012). The first slide provided instructions as to the kinds of future events that participants had to imagine. Participants were informed that they should imagine future events that might reasonably happen within the next year, but after the next week. It was also specified that the imagined future events should be specific (i.e., unique events taking place in a specific place at a specific time and lasting a few minutes or hours but not more than a day) and novel (i.e., events that had not already occurred in the past and that participants had not previously thought about).

To ensure that participants understood all instructions, they first had to complete one practice trial, with a different cue word, in order to familiarise them with the entire procedure. This practice trial was followed by a discussion with the experimenter, before starting the experimental trials. Each trial began with the presentation of a fixation cross on the computer screen for a duration of 1 s. After an empty screen of 1.5 s, a cue word was presented in the centre of the screen. Participants were instructed to imagine an adequate future event, as quickly as possible, in response to the cue. As soon as a specific event came to their mind, they were instructed to press the spacebar. No time limit was imposed and the time needed for the imagination of an appropriate future event was recorded. An instruction slide then invited participants to verbally describe the imagined event. More precisely, they were instructed to report as much detail as possible regarding the location where the event would occur, the persons and objects involved, the actions that would take place, and how they would feel. A digital audio recorder was used in order to record event descriptions for later analyses.

Immediately after each event description, participants were instructed to keep the event in mind and to rate the phenomenological characteristics of their mental representation. More precisely, they assessed the vividness of their future event representation (from 1 = not at all, to 7 = extremely vivid), the subjective amount of visual details and other sensory details (from 1 = not at all, to 7 = a lot), the clarity of imagined persons, locations, and objects (from 1 = not at all, to 7 = extremely clear) and their respective familiarity (from 1 = not at all, to 7 = extremely familiar), the easiness of imagination (from 1 = not at all, to 7 = extremely easy), their visual perspective (from 1 = totally through my eyes, to 7 = totally through an external point of view), their feeling of pre-experiencing the event (from 1 = not at all, to 7 = completely) and of mentally travelling in the future (from 1 = not at all, to 7 = completely), the event's emotional valence (from −3 very negative, to 3 very positive) and intensity (from 1 = not at all, to 7 = very intense), its importance with regard to personal goals (from 1 = not at all, to 7 = extremely important), the amount of previous thought about the event (from 1 = never, to 7 = very often), the probability that it will actually occur in the future (from 1 = extremely weak, to 7 = extremely strong),[1] and its subjective temporal distance (from 1 = feels very close, to 7 = feels very far). Finally, participants estimated when the event would reasonably occur (in days, weeks, and months). After all ratings had been made, participants were instructed to press the spacebar, which triggered the next trial.

Recall tasks

One week later, participants returned to the laboratory and were presented with unexpected recall tasks. First, they were asked to recall as many previously imagined future events as possible (free recall task). For each future event they remembered, they were instructed to verbally describe the previously imagined event with as much detail as possible concerning the location where the event would occur, the persons and objects involved, the actions that would take place, and their feelings. As in the imagination task, a digital audio recorder was used to record event descriptions.

Immediately after having described each event, participants were instructed to keep their event representation in mind to rate the phenomenological characteristics of their mental representation. As in the imagination task, they rated the vividness of their future event representation (from 1 = not at all, to 7 = extremely vivid), the subjective amount of visual and other sensory details (from 1 = not at all, to 7 = a lot), the clarity of imagined persons, location, and objects (from 1 = not at all, to 7 = extremely clear), the easiness of imagination (from 1 = not at all, to 7 = extremely easy), their feeling of pre-experiencing the event (from 1 = not at all, to 7 = completely) and of mentally travelling in the future (from 1 = not at all, to 7 = completely), and the event's emotional valence (from −3 very negative, to 3 very positive) and intensity (from 1 = not at all, to 7 = very intense). Furthermore, participants were asked to report whether they had thought about the future event during the previous week (by answering "yes" or "no"; if they responded "yes", they were asked to specify to what extent they had thought about this event, from 1 = rarely, to 7 = very often; in the remainder of the manuscript, these two variables are referred to as "rehearsal" to distinguish them from the rating scale assessing the amount of previous thoughts about the event that occurred before the imagination task). Finally, participants were asked to report whether they had shared this event with other people during the previous week (by answering "yes" or "no"; if they responded "yes", they were asked to specify to what extent they had shared this event, from 1 = rarely, to 7 = very often).

Participants who could not freely recall all previously imagined future events then received an additional cued recall task. For each event that was not produced in the free recall task, participants were asked to try to remember the event in response to a specific cue. Cues were created based on the verbal descriptions of each future event recorded during the imagination task. Each cue word was composed of two or three words chosen in order to represent the general theme of the reported future event (e.g., *first city trip*, *birthday party*), but without providing any specific information about locations, persons, objects, actions, or feelings. Each trial started with the presentation of a cue and participants were told that they had as much time as they wanted to remember the associated future event and to describe it in as much detail as possible. As in the free recall task, each event description was recorded and participants had to answer the same series of questions regarding phenomenological characteristics.

Once the cued recall task had been completed, participants were given a written transcription of each future event description recorded during the imagination task and their respective cue used in the cued recall task. For each event, they were instructed to estimate to what extent the chosen cue corresponded to the event transcription (from 1 = not at all, to 7 = completely).

Finally, participants were debriefed and were asked whether they had expected that their memory for the imagined events would be tested. No participants reported to have expected to be tested for their memory of the events.

Scoring

The first author first checked that the future events reported during the imagination task were specific. Only events happening in a specific place at a specific time and lasting no longer than a day were considered in the analyses. Our purpose was then to assess memory for the content of future simulations as comprehensively as possible. Therefore, we defined scoring categories corresponding to the various event components that have been identified in previous studies of autobiographical memory and future thinking (e.g., Dijkstra & Misirlisoy, 2006; Lancaster & Barsalou, 1997; McLelland et al., 2015). The first author scored the number of distinct event components reported during the imagination task for the following categories: locations, persons, objects, emotions, actions, and temporal information. Then, he assessed whether each component was recalled one week later during free and cued recall tasks. When a component was only loosely described during the imagination task (which happened rarely, as participants were instructed to describe their mental representation as precisely as possible), it was considered as correctly recalled only when it was described using the exact same words during the recall task. For example, a person component that was described as "my usual group of friends" in the imagination task was scored as correctly recalled only if the participant reported "my usual group of friends" at recall (of course, additional information could also be provided, such as the name of these friends). The second author also independently scored both the number of components of each type produced during the imagination phase and the number of components that were later recalled, from a random selection of 20% of events. Intraclass correlation coefficients (ICCs; two-way random effects; Shrout & Fleiss, 1979) showed a strong agreement regarding the number of imagined elements for all categories of components (locations = .73, persons = .90, objects = .81, actions = .81, emotions = .77, and temporal information = .98). Furthermore, ICCs for the proportion of recalled elements in each category revealed a strong agreement for persons (.78), objects (.77), emotion (.91), and temporal information (.98), and a fair agreement for actions (.55) and locations (.61).

Results

In total, the 34 participants reported 510 future events. However, 54 future event descriptions (from 28 participants) did not refer to a specific episode and were excluded from the analyses, thus leaving 456 future events (the mean number of future events reported by participants was = 13, SD = 1.08). Among these, 33 events (7%) involved no person other than the participant himself or herself; therefore, these events had to be excluded when analysing data about person components. Similarly, 14 events (3%) lacking object descriptions, 9 events (2%) lacking action descriptions, and 8 events (2%) lacking emotion descriptions were excluded from analyses involving these components.

Characteristics of future event representations during the imagination phase

The median response time to produce a specific future event was 13.4 s, which corresponds to the typical time needed to imagine novel future events in response to cue words using effortful constructive processes (in a recent set of studies, we found that median response times ranged between 7.5 and 17.1 s when future events were produced using effortful constructive process, and between of 3 and 4.4 s when future events were automatically produced; Jeunehomme & D'Argembeau, 2016). The mean number of words used to describe imagined events was 139 (SD = 67), and the numbers of different components constituting imagined future events are shown in Table 1. On average, future event descriptions included more than one location, two persons, two objects, two actions, and one emotion. Some event descriptions also included temporal information. However, it should be noted that participants were not explicitly asked to report temporal information when describing future events; thus, the number of temporal components is probably underestimated and should be taken with caution.

Descriptive statistics for each phenomenological characteristic of imagined future events are shown in Table 2. Of note, on average, the events were rated as clear, important, and probable, and the participants reported that they had previously thought about the events very infrequently (if at all).

Prevalence and characteristics of memories for future simulations

During the recall tasks, participants were first invited to freely recall events that had been previously simulated during the imagination task and, for participants who could not freely recall all future simulations, additional cue words were provided to help them recall the remaining events. The mean proportion of freely recalled events was .53 (SD = .20; range = .07–1), indicating that, on average, around half of the future events that had been imagined one week earlier were accessible during the free recall task. Among the remaining events, the mean proportion of events recalled in response to cue words was .80 (SD = .20; range = .50–1). Thus, when participants were given specific cues, they were able to retrieve most of the remaining future events. Only 7% of all imagined events were forgotten. Cue words were judged to closely correspond to the imagined events, and were not significantly different in this respect between cued recalled (mean rating = 6.06, SD = 0.89) and forgotten events (mean rating = 5.65, SD = 1.2), $t(33) = 1.56$, $p = .13$, $d = 0.39$.

Next, we investigated the content of memories of future simulations. In particular, we examined the probability of recalling different types of event components during the free recall and cued recall tasks. Mean proportions of recalled components (i.e., the number of recalled components out of the total number of components reported in the imagination task) are presented in Figure 1 for each type of component. A 2 (type of recall) × 5 (type of components) repeated measures analysis of variance (ANOVA) yielded no significant effect of type of recall, $F(1, 31) = 0.46$, $p = .50$, $\eta_p^2 = 0.01$. However, there was a significant main effect of the type of components, $F(4, 124) = 38.75$, $p < .001$, $\eta_p^2 = 0.56$, revealing that some types of components were more often recalled than others. More precisely, planned comparisons revealed that locations and persons did not significantly differ from each other ($p = .40$), but both were significantly better recalled than objects ($ps < .001$), actions ($ps < .001$), and emotions (respectively, $p = .003$ and $p < .001$). Emotions were more often recalled than objects and actions ($ps < .001$), and there was no significant difference between objects and actions ($p = .16$). There was no interaction between the type of components and type of recall, $F(4, 124) = 0.40$, $p = .81$, $\eta_p^2 = 0.01$.

We also examined the phenomenological characteristics of future event memories produced in the free recall and cued recall tasks. To investigate possible differences between free recalled and cued recalled memories, we computed a series of paired *t*-tests on each phenomenological characteristic. Ease of imagination and rehearsal were numerically higher for free recalled than cued recalled memories, but these differences were not

Table 1. Number of elements for the different types of components constituting future events reported during the imagination task.

	M	SD	Range
Locations	1.73	0.90	1–5
Persons	2.21	1.32	1–8
Objects	2.70	1.65	1–10
Actions	2.38	1.66	1–11
Emotions	1.47	0.71	1–5
Time	0.67	0.69	0–4

statistically significant when applying correction for multiple comparisons (see Table 3).

Predictors of the free recall of future event simulations

An important aim of our study was to determine whether some properties of future event representations during the imagination phase predicted the subsequent accessibility of these imagined events in memory. To investigate this issue, we compared the characteristics of future event representations (during the imagination task) for events that were later recalled versus not recalled in the free recall task, using a series of paired *t*-tests. We compared recalled with non-recalled events (i.e., collapsing across cued recalled and forgotten events) because few events were forgotten (i.e., 7%). The analyses revealed that future event simulations that were subsequently recalled involved clearer and more familiar persons, were judged more important, involved more intense emotions, and were associated with greater feelings of pre-experiencing and mental time travel than non-recalled simulations (Table 4).[2] Note that a similar pattern of results was observed when comparing the characteristics of free recalled versus cued recalled future simulations, except that personal importance did not significantly differ between these two kinds of simulations, $t(32) = 1.23$, $p = .228$, $d = 0.22$.

Table 2. Mean characteristics of future events reported during the imagination task.

	M	SD
Vividness	4.31	1.49
Clarity		
Persons	5.05	1.80
Locations	4.32	1.94
Objects	3.84	1.59
Familiarity		
Persons	5.14	1.99
Locations	3.46	2.28
Objects	3.52	1.83
Visual details	4.71	1.30
Other sensory details	3.14	1.66
Ease of imagination	3.18	1.30
Emotional valence	1.31	1.36
Emotional intensity	3.72	1.71
Personal importance	4.19	1.67
Probability	4.96	1.42
Previous thoughts about the event	2.27	1.45
Feeling of pre-experiencing	4.08	1.51
Feeling of mental time travel	3.86	1.46
Visual perspective	2.61	1.85
Subjective distance	4.19	1.60
Distance (days)	105	90

Note: All event characteristics are measured on a scale ranging from 1 to 7, except emotional valence (measured on a scale ranging from −3 to 3) and temporal distance (measured in days).

Phenomenological characteristics of future event representations during the imagination versus the recall phases

Finally, we were interested in investigating whether and how the characteristics of future event representations differed between the initial simulation and subsequent recall of events. Descriptions of future events included significantly fewer words in the recall phase ($M = 97$, $SD = 46$) than in the imagination phase ($M = 139$, $SD = 66$), $t(33) = 5.42$, $p < .001$, $d = 0.82$). To investigate possible differences in the phenomenological characteristics of future event representations, we computed a series of paired *t*-tests on each phenomenological characteristic (see Table 5). These analyses showed that initial representations of imagined future events were clearer (in terms of overall vividness, amount of sensory details, and clarity of persons, locations, and objects) than subsequent memories of these imagined events. Moreover, initial simulations were experienced with more positive and intense emotions, and were accompanied by a greater feeling of pre-experiencing the event and sense of mental travel in the future, compared to recalled simulations. We further investigated whether these differences in phenomenological characteristics were related to the rehearsal of future event simulations during the week separating the imagination and recall tasks. For each phenomenological characteristic, we computed the difference in ratings between the imagination and recall tasks and used this difference as outcome variable in a multilevel regression analysis (with events as level 1 units and participants as level 2 units) with rehearsal as predictor. These analyses showed that rehearsal was significantly related to differences in object clarity (coefficient = −0.34, $Z = -2.24$, $p = .025$) and emotional valence (coefficient = −0.19, $Z = -2.06$, $p = .039$), indicating that rehearsal attenuated differences between imagination and recall for these two variables. The differences for all other characteristics were not significantly related to rehearsal.

Discussion

The aim of this study was to investigate the content and phenomenological characteristics of memories for previously imagined future events, and to shed some light on the factors that facilitate the formation and accessibility of such memories of the future. We found that when asked to freely recall a series of future events they had imagined one week earlier, participants were, on average, able to recall around half of their previous event simulations. This result indicates that only some future event

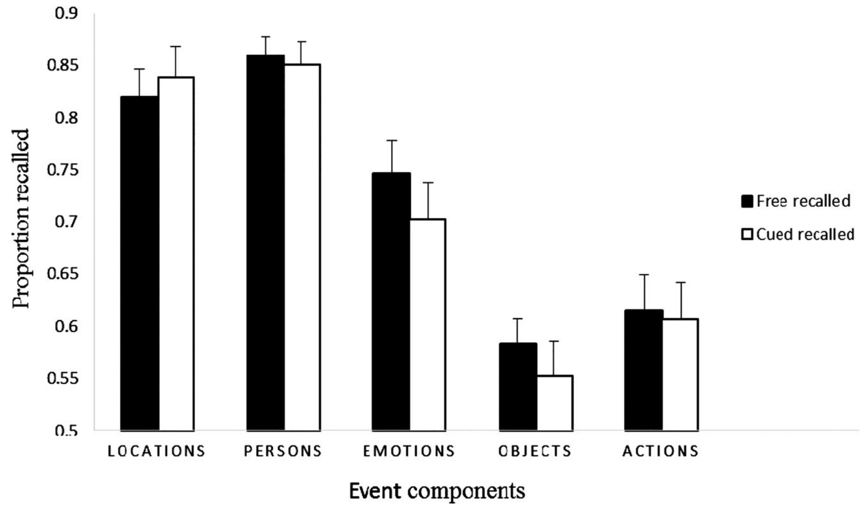

Figure 1. Mean proportions of recalled components for free and cued recalled future events. Error bars represent the standard error of the mean.

simulations are readily accessible in memory, in line with previous observations by McLelland et al. (2015). However, our results also demonstrated that most imagined future events were nevertheless encoded in memory and could be accessed when appropriate retrieval cues were provided. On average, only 7% of previously imagined future events were forgotten. Taken together, these observations suggest that most future event simulations are encoded in memory and remain available for recall for at least one week. Importantly, however, our results also indicate that these memories of the future vary in their accessibility, such that some memories are readily accessible during a free recall task, whereas others can only be accessed when relevant cues are provided.

Table 3. Characteristics of free recalled versus cued recalled memories of future events.

	Free recall *M* (SD)	Cued recall *M* (SD)	*t*(32)	*p*	Cohen's *d*
Vividness	4.02 (0.92)	3.75 (0.90)	2.03	.051	.35
Clarity					
Persons	4.90 (1.23)	4.63 (1.30)	1.48	.148	.26
Locations	3.86 (1.00)	3.84 (1.22)	0.13	.893	.02
Objects	3.41 (0.83)	3.29 (0.96)	0.89	.379	.15
Visual details	4.18 (0.80)	4.04 (1.04)	1.10	.278	.19
Other sensory details	2.61 (1.13)	2.57 (1.31)	0.35	.731	.06
Ease of imagination	3.04 (0.54)	3.28 (0.75)	−2.34	**.026**	.41
Emotional valence	1.24 (0.59)	1.04 (0.50)	1.77	.086	.31
Emotional intensity	3.39 (1.11)	3.19 (1.17)	1.36	.183	.24
Feeling of pre-experiencing	3.46 (0.96)	3.31 (1.1)	1.33	.192	.23
Feeling of mental time travel	3.21 (1.12)	3.05 (1.14)	1.35	.187	.24
Rehearsal	0.43 (0.32)	0.31 (0.32)	2.23	**.033**	.39
Frequency of rehearsal	2.77 (1.13)	2.40 (1.38)	1.26	.225	.22
Having shared the event	0.25 (0.27)	0.18 (0.23)	1.43	.163	.25
Frequency of sharing	2.72 (1.40)	2.65 (1.44)	0.14	.892	.02

Note: All event characteristics are measured on a scale ranging from 1 to 7, except emotional valence (measured on a scale ranging from −3 to 3), rehearsal (proportion of "yes" responses) and having shared the event (proportion of "yes" responses). Statistically significant differences are indicated in bold. However, no *t*-test remained statistically significant after applying correction for multiple comparisons using the Benjamini–Hochberg procedure (with a false discovery rate of .05).

Another important contribution of our study is to show that some components of future event simulations are better remembered than others. Although all categories of event components were fairly well recalled, persons and locations were better recalled than other components (i.e., emotions, objects, and actions), suggesting that persons and locations are central to the simulation and memorisation of future events. This result is consistent with the view that the construction of a spatial context in which other elements can be integrated is a fundamental process of the remembering and imagination of events (Hassabis & Maguire, 2007; Hassabis et al., 2007; Robin & Moscovitch, 2014; Robin, Wynn, & Moscovitch, 2016). Location components might thus be well recalled because they are particularly important for the coherence of the entire event representation. The finding that persons were also among the best recalled components is consistent with previous investigations of memories of the future (McLelland et al., 2015; Szpunar et al., 2012), and with studies showing the central role of information about people in the recall of event memories (Dijkstra & Misirlisoy, 2006; Lancaster & Barsalou, 1997). It has been suggested that persons tend to have more causal connections to other entities (e.g., other persons and objects) and, therefore, are more likely to be central components in event models (Radvansky & Zacks, 2014). By virtue of this network of causal connections, persons may play a role of anchor for linking together other components constituting memories of future simulations.

Emotional responses involved in future event simulations were also well remembered. Previous studies have shown that many future thoughts are imbued with emotional content (Barsics, Van der Linden, & D'Argembeau, 2016;

Table 4. Characteristics of imagined future events that were later recalled versus not recalled during the free recall task.

	Recalled *M* (SD)	Not recalled *M* (SD)	*t*(32)	*p*	Cohen's *d*
Vividness	4.33 (0.77)	4.16 (0.95)	1.29	.205	.23
Clarity					
Persons	5.34 (0.78)	4.75 (1.04)	2.97	**.006***	.52
Locations	4.27 (0.99)	4.20 (1.01)	0.33	.746	.06
Objects	3.82 (0.85)	3.81 (0.95)	0.07	.948	.01
Familiarity					
Persons	5.55 (0.80)	4.87 (0.89)	3.72	**<.001***	.65
Locations	3.42 (1.05)	3.35 (0.97)	0.34	.739	.06
Objects	3.44 (1.05)	3.45 (1.06)	−0.03	.979	.01
Visual details	4.65 (0.67)	4.6 (0.77)	0.38	.707	.07
Other sensory details	3.2 (1.09)	3.10 (1.18)	0.51	.610	.09
Ease of imagination	3.11 (0.72)	3.31 (0.69)	−1.44	.160	.25
Emotional valence	1.32 (0.95)	1.24 (0.48)	0.52	.609	.09
Emotional intensity	3.89 (1.12)	3.52 (1.07)	3.12	**.004***	.54
Personal importance	4.37 (0.79)	4.03 (0.94)	2.41	**.022**	.42
Probability	5.05 (0.79)	4.89 (0.83)	1.23	.227	.21
Previous thoughts about the event	2.38 (1.03)	2.14 (1.06)	1.86	.073	.32
Feeling of pre-experiencing	4.35 (0.92)	3.80 (1.01)	3.56	**.001***	.62
Feeling of mental time travel	4.08 (0.90)	3.62 (0.96)	2.98	**.005***	.52
Visual perspective	2.77 (1.22)	2.72 (1.40)	0.19	.852	.03
Subjective distance	4.15 (0.83)	4.21 (0.80)	−0.38	.707	.07
Distance (days)	118 (59)	97 (49)	1.83	.077	.32

Note: All event characteristics are measured on a scale ranging from 1 to 7, except emotional valence (measured on a scale ranging from −3 to 3) and temporal distance (measured in days). Statistically significant differences are indicated in bold. * indicates differences that remained significant after applying a correction for multiple comparisons using the Benjamini–Hochberg procedure (with a false discovery rate of .05).

Table 5. Phenomenological characteristics of future event representations during the imagination versus recall phases.

	Imagination *M* (SD)	Recall *M* (SD)	*t* (33)	*p*	Cohen's *d*
Vividness	4.41 (0.96)	3.96 (0.90)	2.77	**.009***	.48
Clarity					
Persons	5.06 (0.78)	4.77 (1.1)	3.05	**.005***	.52
Locations	4.33 (0.86)	3.94 (0.96)	3.40	**.002***	.58
Objects	3.84 (0.84)	3.45 (0.86)	3.93	**<.001***	.67
Visual details	4.71 (0.70)	4.18 (0.92)	6.11	**<.001***	1.05
Other sensory details	3.16 (1.06)	2.60 (1.10)	5.80	**<.001***	.99
Ease of imagination	3.17 (0.60)	3.11 (0.60)	0.51	.62	.09
Emotional valence	1.32 (0.48)	1.14 (0.45)	3.47	**.001***	.60
Emotional intensity	3.75 (1.02)	3.30 (1.05)	4.25	**<.001***	.73
Feeling of pre-experiencing	4.10 (1.00)	3.44 (1.02)	5.55	**<.001***	.95
Feeling of mental time travel	3.87 (0.96)	3.22 (1.11)	5.08	**<.001***	.87

Note: All event characteristics are measured on a scale ranging from 1 to 7, except emotional valence (measured on a scale ranging from −3 to 3). Statistically significant differences are indicated in bold. * indicates differences that remained significant after applying a correction for multiple comparisons using the Benjamini–Hochberg procedure (with a false discovery rate of .05).

D'Argembeau et al., 2011), and Szpunar et al. (2012) have suggested that this affective dimension contributes to link components of future event simulations together and to maintain this bound representation in memory (see also Benoit, Szpunar, & Schacter, 2014). Our finding that emotion components were well recalled may thus reflect this role of emotion in the memorisation of event representations (see also below). Another possible interpretation of our findings, however, would be that emotions reported during the recall phase were not always actually recalled, but rather inferred or recreated from other recalled components. Further investigations should be performed to examine these possibilities.

Objects and actions were the least well recalled components. A possible interpretation of this finding is that objects and actions, or at least some of them, are less central in the mental representation of future events than persons, locations, and emotions. Indeed, most objects and actions may not necessarily be important for the global coherence and meaning of imagined events. Therefore, it might be that only central objects and actions (i.e., those that are goal-relevant and that share causal connections with other components) are encoded and retained in memory. For example, take a participant imagining a dinner at home with some friends. She might imagine being around the table in her living room with her two best friends, and might picture the three of them eating soup and talking about their next summer vacation. This participant might visualised a green tablecloth, bowls of soup, and a bottle of red wine on the table, and might feel happy to be there. One week later, this same participant might just report having imagined being happy to talk about their next vacation with her two best friends around the table in her leaving room. These elements might be well retained because they are somehow related to the central goal or theme of the event (i.e., talking about summer vacation). On the other hand, objects and actions that are only incidental to the main theme of the event (such as the tablecloth, bowls of soup, and bottle of wine) might be less well encoded and/or retained in memory. This possibility could be investigated in future studies by asking participants to rate to what extent each event component is central or goal-relevant.

Having clarified the prevalence and content of memories for future event simulations, we were also interested in examining possible differences between memories that were readily accessible during the free recall task and memories that were only accessed when specific retrieval cues were provided. We found that the amount and type of components correctly recalled did not differ between simulations produced during the free recall and cued recall tests. Furthermore, free recalled and cued recalled future event simulations did not differ in their phenomenological characteristics. These observations suggest that although successfully encoded future event simulations vary in their degree of accessibility in memory, the contents and characteristics of retrieved simulations do not depend on their initial level of accessibility.

An important goal of this study was then to shed light on the characteristics of future event simulations that predict their subsequent accessibility in memory. To investigate this issue, we compared the characteristics of initial future simulations that were successfully retrieved during the free recall task with the characteristics of future simulations that were not recalled in this task. First, we found that the clarity and familiarity of persons involved in the initial simulations predicted the subsequent retrieval of imaged events during the free recall task. This result is in line with previous studies (McLelland et al., 2015; Szpunar et al., 2012) and with the idea, proposed above, that persons are central components of future event simulations that serve as anchors for linking other components together. On this view, more familiar and salient persons might facilitate the access to others pieces of information constituting future event representations and, therefore, the overall accessibility of the entire simulations.

We also found that the feeling of pre-experiencing and sense of mental time travel during the initial simulation phase (indexing "autonoetic consciousness"; Tulving, 1985) predicted the subsequent recall of memories for future thoughts. These subjective feelings are, in part, related to the quality of information used to construct future event simulations, and to the relevance of imagined events to personal goals (D'Argembeau & Van der Linden, 2012; Szpunar & McDermott, 2008). Event representations that are more vivid and goal-relevant might induce a higher immersive feeling during the simulation process, making future thoughts more distinctive and thus memorable.

In contrast to our prediction and previous findings (Szpunar et al., 2012), emotional valence was not a significant predictor of memory for future simulations. One possible explanation for these divergent results is that, in our study, participants were not explicitly invited to report events with a particular (positive, negative, or neutral) valence. Taking into account that the large majority of future events that participants reported were positive (in line with previous findings; e.g., D'Argembeau & Van der Linden, 2006), it is possible that we did not collect sufficiently negative events to detect a role of emotional valence. Interestingly, however, our results revealed that emotional intensity was an important factor contributing to memories of the future. Numerous studies have demonstrated that emotional arousal typically enhances memory for external events and stimuli (LaBar & Cabeza, 2006) but, to our knowledge, this is the first study showing that emotional intensity also enhances memory for imagined future events.

As expected, the importance of imagined events with regard to personal goals was also a significant predictor of memory for future simulations. Previous studies suggest that personal goals play an important role in the construction and organisation of episodic future thoughts and may, in particular, contribute to contextualise imagined events with respect to an individual's personal life (Cole & Berntsen, 2016; D'Argembeau & Demblon, 2012; D'Argembeau & Mathy, 2011). Following this view, we suggested that highly goal-relevant future event simulations might be better encoded in memory because they would presumably be better integrated with autobiographical knowledge structures (i.e., with higher order goals and general expectations that people have about their personal lives) than less goal-relevant simulations. This integration with pre-existing autobiographical knowledge might indeed facilitate the encoding, consolidation, and later access to imagined future events in memory (see Conway, 2001, for a similar argument with respect to memory for external events, that is, the view that only events that are goal-relevant and integrated with higher order autobiographical knowledge are maintained in memory for more than a few days). The present results provide preliminary support for this view, although the precise role of pre-existing autobiographical knowledge in the memorisation of future event simulations remains to be investigated in detail.

Our findings concerning personal importance may at first sight seem inconsistent with a recent study of McLelland et al. (2015) in which it was found that personal importance did not significantly predict future simulation recall. However, it is worth noting that this previous study assessed the personal importance of individual event components (i.e., persons, locations, and objects), and not the significance of the entire future simulation itself, as was the case in the present study. These two measures of personal importance are not equivalent – for example, one might imagine a mundane event involving someone considered to be very important (e.g., to do some shopping with one's best friend) – and it is likely that the integration process proposed above depends on the overall significance of the simulation (rather than the significance of its individual components). It should also be noted that, in the present study, the personal importance of initial simulations did not differ between events that were later accessed during the free recall task and events that were accessed in the cued recall task. This suggests that personal importance might be more important for the initial formation of memories of the future rather than their later accessibility. Whatever it may be, the role of goal-relevance in the encoding, consolidation, and retrieval of future event simulations would merit further investigation.

A final question that was considered in the present study was whether the characteristics of future event representations differed between the initial simulation phase and the subsequent recall of events. We found that participants judged their representations as less clear (including the clarity of locations, persons, and objects), as containing fewer visual and other sensory details, and as less positive and emotionally intense during the recall phase compared to the initial event simulation phase. Furthermore, the feelings of pre-experiencing the event and of mental time travel were also less pronounced when future events were recalled than when they were imagined for the first time. These results show that when people attempt to recall previous future simulations after a week, they re-experience an impoverished version of their initial representations. This finding is consistent with previous studies demonstrating that the richness of memories for imagined events declines quite rapidly over time (and more rapidly than the richness of memories for experienced events; Suengas & Johnson, 1988). An important point to keep in mind when interpreting our data, however, is that the task of participants was to recall their previous event simulations as precisely as possible. The richness of event representations might not have been reduced had we simply asked participants to re-imagine the events (which does not necessarily require to imagine exactly the same contents). Indeed, it has been shown that repeated simulations of future events can even increase the level of detail, emotional intensity, and perceived plausibility of imagined events (Szpunar & Schacter, 2013).

In summary, the present research provides evidence that most future event simulations are encoded and remain available in memory after a one-week delay. However, only some of these simulations are readily accessible in memory, whereas others can only be accessed when relevant cues are provided. Our results also demonstrate that although most components of future event simulations are fairly well recalled, persons and locations are particularly well remembered, suggesting that these components are central to the simulation and memorisation of future events. The fact that free and cued recalled memories are comparable in their components and characteristics suggests that, although successfully encoded future events vary in their degree of accessibility in memory, the richness of retrieved simulations does not depend on their initial level of accessibility. The overall accessibility of future event simulations is related to the clarity and familiarity of represented persons, the subjective feelings of pre-experience and mental time travel, and the emotional intensity of imagined events. Our data further suggest that the importance of imagined events for personal goals might contribute to the initial encoding of memories of the future. Finally, our results show a global decline in the richness of future event representations when future events are recalled after one week compared to when they are imagined for the first time. Taken together, these findings expand our understanding of the formation, accessibility, content, and phenomenological characteristics of memories of the future.

Notes

1. Different types of plausibility can be distinguished, such as personal versus general plausibility (i.e., the likelihood that an event could occur given one's personal circumstances versus the likelihood that an event could occur to people in general; Scoboria, Mazzoni, Kirsch, & Relyea, 2004). In their study of memory for future simulations, McLelland et al. (2015) specifically assessed the role of personal plausibility. In the present study, we did not distinguish between different types of plausibility, but we believe that our subjective probability scale is more likely to reflect personal rather than general plausibility.
2. We also conducted a series of multilevel logistic regression analyses (with events as level 1 units and participants as level 2 units), using event recall as outcome variable and each event characteristic as predictor. These analyses led to similar results as the paired *t*-tests: person clarity (coefficient = 0.20, $z = 3.46$, $p < .001$) and familiarity (coefficient = 0.16, $z = 3.20$, $p = .001$), emotional intensity (coefficient = 0.14, $z = 2.31$, $p = .021$), feeling of pre-experiencing (coefficient = 0.24, $z = 3.33$, $p < .001$), and mental time travel (coefficient = 0.20, $z = 2.73$), $p < .001$) were significantly predictors of event recall; personal importance was only marginally significant (coefficient = 0.11, $z = 1.82$, $p = .069$). These latter analyses should be taken with caution, however, because the relatively small sample size used in this study can produce biased estimates in logistic regression models (Moineddin, Matheson & Glazier, 2007).

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