On the role of autobiographical knowledge in shaping belief in the future occurrence of imagined events

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Abstract

Recent studies suggest that different forms of episodic simulation—mental representations of past, future, or atemporal events—recruit many of the same underlying cognitive and neural processes. This leads to the question whether there are distinctive hallmark characteristics of episodic future thinking: the subjective sense that imagined events belong to and will occur in the personal future. In this study, we aimed at shedding light on the cognitive ingredients that contribute to this sense of future occurrence by asking participants to imagine personal and experimenter-provided future events associated with high or low degrees of belief in future occurrence and then to reflect on the bases for their beliefs. Results showed that contextualizing autobiographical knowledge (i.e., articulating links between items of information associated with imagined future events, goals, and personal characteristics) is a critical aspect of belief in future occurrence, and autobiographical knowledge can be flexibly used to either support or suppress belief in future occurrence. These findings indicate that episodic future thought depends not only on simulation processes (i.e., the construction of detailed mental representations for future events), but also requires that imagined events are meaningfully integrated within an autobiographical context.

Keywords: future thinking; mental simulation; belief in future occurrence; autobiographical knowledge; metacognition

Introduction

Over the past decade, mounting evidence has indicated that episodic future thinking—the ability to mentally simulate events that may take place in one's personal future—relies on the flexible selection and combination of information stored in memory to create novel event representations (Schacter, Benoit, & Szpunar, 2017; Suddendorf & Corballis, 2007). The evidence further suggests that such constructive processes are engaged in different forms of episodic simulations, irrespective of whether imagined events refer to the personal future (e.g., imagining giving a talk at an international conference the next summer; D'Argembeau & Mathy, 2011), or are more purely imaginary and atemporal in nature (e.g., imagining one is lying on a beach in a tropical bay, without placing this event in the past or future; Hassabis & Maguire, 2007, 2009). For instance, it has been found that representations of future and atemporal events are characterized by similar phenomenological properties (e.g., sensory details, clarity of location; de Vito, Gamboz, & Brandimonte, 2012) and rely on largely overlapping brain networks (Hassabis, Kumaran, & Maguire, 2007; Schacter et al., 2012).

While these findings have contributed to elucidate how episodic simulations are constructed, there has been little consideration of the distinctive hallmarks of episodic future thinking. In particular, a central question concerns the temporal dimension of mental representations (Schacter et al., 2012) and the cognitive processes involved in "tagging" events as belonging (or not) to one's personal future (D'Argembeau, 2016; Klein, 2016). This question is not only important for better understanding which, if any, cognitive components are unique to the experience of episodic future thought, but also for theorizing on the potential functional benefits of prospection (Baumeister, Vohs, & Oettingen, 2016; Schacter et al., 2017). Indeed, teasing apart imagined events that

realistically belong to the personal future from events that are primarily imaginary or highly implausible is critical for using future projections as valid bases to guide decisions and actions. Therefore, it is important to examine what cognitive ingredients are necessary to make imagined events feel "real" and part of one's personal future. This sense of futureness can be conceptualized as a type of "cognitive feeling": a subjective experience that indicates the status of one's knowledge, understanding, or expectations, thereby serving as information for judgments, decision-making, and other cognitive activities (Clore & Parrott, 1994; Schwarz, 2012).

According to Klein (2016), the sense of futureness is not grounded in event simulation *per se* but arises from the mode of consciousness associated with the imagination of events, which constitutes the necessary condition for enabling temporal self-projection into the future. In the same vein, Dalla Barba and colleagues (Dalla Barba & Boissé, 2010; Dalla Barba & La Corte, 2013) have proposed that the ability to represent events as part of one's personal future depends on a particular type of consciousness—referred to as temporal consciousness (see also Wheeler, Stuss, & Tulving, 1997). Recent empirical studies on the subjective experience of imagining future events offer promising perspectives to elucidate the nature and determinants of this sense of futureness (D'Argembeau & Van der Linden, 2012; Ernst & D'Argembeau, 2017; Lehner & D'Argembeau, 2016). Capitalizing on research on metacognitive appraisals in autobiographical remembering (Scoboria et al., 2014; Scoboria, Nash, & Mazzoni, 2017; Scoboria, Talarico, & Pascal, 2015), Ernst and D'Argembeau (2017) proposed that the sense that an imagined event belongs to one's personal future depends on a number of cognitive feelings, and most notably the belief that an event will actually occur. In this view, the tagging of a mental representation as a

personal future event is not an intrinsic property of the event, but instead results from metacognitive attributional processes (see also Redshaw, 2014) that occur at the time that future events are mentally constructed (imagined).[1] These attributional processes are grounded in different underlying cognitive components and sources of information, which serve to shape the cognitive feelings that come to be associated with episodic future thoughts.

At least three distinct types of cognitive feelings, namely *belief in occurrence*, *autonoetic experience* and *belief in accuracy*, are assumed to act in concert to ultimately give the sense of self-projection into a veridical personal future. Looking at the determinants of these cognitive feelings, Ernst and D'Argembeau (2017) found that belief in occurrence (i.e., the feeling that an event will genuinely occur in the future) largely depended on the integration of imagined events within an individual's autobiographical context (e.g., including links between imagined events, personal goals, and the personal plausibility of events in the context of one's life) rather than the quality of mental representations per se (e.g., amount or strength of sensory-perceptual details). Conversely, autonoetic experience (i.e., the subjective sense of pre-experiencing events) and belief in accuracy (i.e., the conviction that the specific content of the imagined event corresponds to what will in fact happen in the future) were strongly related to the quality of imagined events, whereas the autobiographical context of events played a

[1] The attribution of mental experiences to the personal future on the basis on their characteristics is not necessarily conscious and deliberate but may most of the time rely on automatic (heuristic) processes (Johnson, 2006), the product of which is experienced as a prereflective feeling of futureness (Klein, 2016).

more marginal role in these cognitive feelings (but see Lehner & D'Argembeau, 2016, for evidence that autonoetic experience is enhanced when imagined events are related to current personal goals). These findings thus suggest that constructing vivid and detailed mental representations may be sufficient to induce some feeling of "pre-experiencing" but does not necessarily give rise to the subjective sense that imagined events will genuinely occur in the personal future, which requires in addition placing imagined events into a context of autobiographical knowledge. As such, the synergy of imagined event representations within an individual's autobiographical context represents a pivotal feature of episodic future thinking that shapes feelings that imagined contents genuinely belong to the personal future (see also, Scoboria, Mazzoni, Ernst & D'Argembeau, in press).

One limitation of Ernst and D'Argembeau (2017) was that the determinants of belief in occurrence for imagined future events were investigated using a correlational approach (i.e., by examining to what extent natural variations in belief in occurrence and other cognitive feelings were related to various event features). In the present study, we sought to more directly investigate the bases of belief in occurrence during episodic future thinking by cueing participants to think about imagined events that varied in degree of belief in future occurrence and examining how this affected the resulting mental representations and associated metacognitive appraisals. Participants were asked to imagine personal future events associated with high or low degrees of belief in future occurrence (i.e., events for which they felt certain or uncertain about their future occurrence), and then rated cognitive feelings (belief in occurrence, autonoetic experience, belief in accuracy) and other characteristics (e.g., sensory details, personal importance) for both kinds of events. Considering previous studies showing that the

levels of detail and vividness of mental representations do not differentiate between future and atemporal events (de Vito et al., 2012; Lehner & D'Argembeau, 2016), we did not expect that imagined events associated with high versus low belief in future occurrence would necessarily differ in terms of episodic details. Importantly, however, we predicted that the level of integration of imagined events with autobiographical knowledge (as indicated by strength of links with other events in memory, personal plausibility and personal importance) would be positively associated with the strength of belief in future occurrence.

Another goal of this study was to shed additional light on the bases of feelings that imagined events will or will not occur in one's personal future. To examine this, participants were asked to verbally describe what contributed to their belief that imagined events would or would not happen in the future, and we examined the content of these justifications provided to support belief (or non-belief) in occurrence. We expected that justifications indicating that imagined events are integrated in an autobiographical context (as indicated by links with other events, personal characteristics, and goals) would be frequently mentioned and would predict variation in belief in occurrence for imagined future events.

Finally, we also aimed to examine belief in occurrence for experimenter-provided future events (Neroni, Gamboz, de Vito, & Brandimonte, 2016). Some previous studies have prompted episodic future thinking using experimenter-provided cues, such as "Imagine walking in a sunny garden next year'' (e.g., de Vito et al., 2012). Our view is that such imagined events may or may not be subjectively perceived as "real" future events depending on the extent to which they can be meaningfully integrated with general knowledge and expectations about one's future life (see also

Lehner & D'Argembeau, 2016). Therefore, we predicted that participants would also frequently use autobiographical information (links with other events, goals, and personal characteristics) to justify their belief (or non-belief) in the occurrence of future events that are imagined in response to experimenter-provided cues.

Method

Participants

Thirty-five participants (21 women), ages 18 to 30 (mean = 23.26, *SD* = 2.26), mainly students at the University of Liège or members of the community (mean education years = 15.91, *SD* = 1.82), took part in the study. They were recruited through online advertising via a university website. The sample size was estimated a priori using G∗Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) in order to achieve a statistical power of 80%, considering an alpha of 0.05 and a medium within-subject effect size (*d* = 0.50). Four additional participants were tested but subsequently excluded due to difficulties in following the instructions. All participants were fluent in French and the testing was conducted in French. The study was approved by the University of Liège Ethics Committee and the University of Windsor Research Ethics Board, and all participants gave written informed consent.

Materials and procedure

Participants were first asked to produce a list of ten personal future events that could happen in the next year, including five *certain* and five *uncertain* events (see Appendix A for verbatim instructions). *Certain events* were defined as events for which participants felt confident that the event would actually occur in the future. Conversely, *uncertain events* were defined as events that were plausible, but for which participants felt uncertain about their future occurrence. Thus, certain and uncertain events were

expected to be associated with stronger and weaker belief in occurrence, respectively. The certain and uncertain events were in part included to address the issue that when cued to describe imagined future events research participants tend to retrieve and report about events that are high in belief in future occurrence (Scoboria, Mazzoni, Ernst & D'Argembeau, in press), an issue that also arises when cueing participants to recall past events (Scoboria & Talarico, 2013). Cueing for uncertain events leads to less extreme distributions in belief in occurrence ratings, thus providing more representative sampling of the range of believed mental representations available for study.

All events had to be specific (i.e., unique events occurring at a particular time and place and lasting no longer than a day) and the following examples were provided to aid participants to understand the notion of specificity: "*An event generally lasts a few minutes or hours, but less than a day. For instance, if you think about your week of holiday in Rome, this is not specific enough. But if you think about a visit of the Coliseum during this holiday in Rome, this is a specific event. You also have to select future events that do not refer to habits or routines. For instance, going to the swimming pool every Wednesday is a routine. However, passing the exam to get your swimming certificate is a specific event.*"

Participants provided a brief title for each event and were then asked to select the two most representative events for each category (i.e., the two most certain and two most uncertain events). These four events were used to complete a subsequent imagination task. Furthermore, two additional events (referred to hereafter as experimenter-provided events) selected from previous studies on scene construction ("imagine walking in a sunny garden" and "imagine being on a tropical beach"; de Vito et al. 2012; Lehner & D'Argembeau, 2016) were included. Including the experimenter-

provided events allowed us to explore the characteristics of mental representations originating entirely from self-generation (the two certain and two uncertain imagined events) versus those originating from self-generation in response to external cues (the two experimenter-provided events; Neroni et al., 2016). Similarly to self-generated events, participants were asked to imagine experimenter-provided events as occurring within the next year.

During the imagination task, participants were asked to imagine and describe aloud each event in as much detail as possible, including details about location, actions, people, objects, emotions, and so on (see Appendix A for verbatim instructions). Event descriptions and justifications were audio-recorded and later transcribed for scoring. No time limit was imposed for these descriptions. Immediately after each description, participants were asked to provide justifications for their belief (or non-belief) in the future occurrence of the event (Ernst & D'Argembeau, 2017). More specifically, they were asked to describe what made them feel that this event belonged (or did not belong) to their future, that is, what made them think that the event would happen (or would not happen). It was specified that there were no right or wrong answers and that we were interested in learning about what gave them the sense that the event would or would not happen, and participants were encouraged to describe everything that came to mind when considering belief in future occurrence.

After providing descriptions and justifications for all six events, participants rated each event using a series of 7-point Likert scales. Cognitive feelings when imagining each event were assessed using the following scales (adapted from Ernst & D'Argembeau, 2017; Scoboria, Mazzoni, Kirsch, & Relyea, 2004; Scoboria et al., 2014; 2017): four items for belief in occurrence (Scoboria, Mazzoni, Ernst & D'Argembeau,

in press; averaged, current α = 0.89 for certain events, α = 0.90 for uncertain events, and α = 0.97 for experimenter provided events), two items for autonoetic experience (mental time travel, feelings of pre-experiencing; averaged, Spearman-Brown coefficients = 0.66 for certain events, 0.71 for uncertain events, and 0.76 for experimenter-provided events) and one item for belief in accuracy (i.e., the degree to which the content of the imagined event corresponds to what will happen in the future). Another set of rating scales (adapted from Ernst & D'Argembeau, 2017; Lehner & D'Argembeau, 2016; Sutin & Robins, 2007) assessed additional phenomenological characteristics of imagined events. These included sensory-perceptual characteristics (i.e., amount of sensory detail, clarity of location), and integration of events within an autobiographical context (i.e., personal importance, links with other personal past or future events and personal plausibility, that is the judgment that an event could occur to the self; Scoboria, et al., 2004). Two additional items measured the frequency with which participants had previously thought and talked about the event (i.e., rehearsal; averaged, Spearman-Brown coefficients = 0.88 for certain events, 0.76 for uncertain events, and 0.88 for experimenter-provided events) and one item measured the sense of personal control regarding the actual occurrence of the event. Finally, participants provided an estimated date of occurrence for each event.

The certain, uncertain and experimenter-provided events were presented in a counterbalanced order. In addition, the order of presentation of the rating scales was also counterbalanced across participants.

Scoring of event narratives

Amount and type of details. Verbal descriptions of imagined events were transcribed verbatim and scored using the standardized Autobiographical Interview

procedure (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; for a thoughtful discussion of the strengths and weaknesses of the various measures and scoring methods used to assess episodic future thinking, see Miloyan & McFarlane, 2018). The central event was first determined and then each distinct detail or chunk of information was categorized as either internal (i.e., details referring to the main event, including happenings, people, time, place, sensory perceptions, thoughts, and emotions) or external. Based on studies showing the role of semantic memory and, especially of autobiographical semantic knowledge, in the construction of future events (D'Argembeau, 2015; Irish & Piguet, 2013; Renoult, Davidson, Palombo, Moscovitch, & Levine, 2012), we distinguished two subtypes of external details depending on whether a detail referred to autobiographical or non-autobiographical information (for a similar method applied to past events see Strikwerda-Brown, Mothakunnel, Hodges, Piguet, & Irish, 2018). As such, external autobiographical details entailed information about specific personal events (different from the central event), generic or extended personal events, and personal semantics. Conversely, external non-autobiographical details corresponded to general semantic knowledge about the world, repetitions and metacognitive statements (e.g., "*There are a lot of tourists in Punta Cana*"). The numbers of internal, external autobiographical, and external non-autobiographical details were tallied. Interrater reliability was verified for each category of details on a random selection of 15% of the transcripts. Intraclass correlation coefficients showed high inter-rater agreement for internal (ICC = 0.88), external autobiographical (ICC = 0.84), and external non autobiographical details (ICC = 0.73).

Justifications for belief in occurrence. To investigate the content of justifications provided for belief in occurrence, we used an adapted version of the

scoring procedure from Ernst and D'Argembeau (2017). This system included 11 categories of justification (see Table 1). The first three categories involved the use of personal knowledge (i.e., references to other personal events, characteristics, or goals) for linking and integrating events with personal characteristics and life story. The next two categories involved the use of general knowledge (about others or the world) to support belief in occurrence. The sixth category, commitment, involved externally-motivated behaviors or events that were already planned (or in which the person was already engaged). The seventh and eight categories involved the use of specific details about the event or its temporal location to support belief in occurrence. The ninth and tenth categories involved the use of external information (including material evidence and sharing the event with others). The last category involved metacognitive judgments about properties of events or mental representations.

More than one category of justification could be used for a given event. Thus, for each event, we coded the absence (0) or the presence (1) of each type of justification. If present, we also coded whether the reported justification served to support belief in occurrence (referred to as positive justification), or whether the justification served to suppress belief in the occurrence for the event (referred to as negative justification). Examples of positive and negative justifications are provided in Table 1. Note that positive and negative justifications were not mutually exclusive and that both forms of justification could be identified within the same event. Inter-rater reliability of the scoring procedure was verified on a random selection of 25% of the transcripts. Percentages of agreement were high for all the categories of justifications, which ranged from 90% to 98%. Cohen's kappa was high for links with other events (0.78 and 0.80 for positive and negative justifications, respectively), personal

characteristics (0.88 and 0.80), knowledge about others (0.79 and 0.93), sharing (0.64 for positive justifications), commitment (0.76 for positive justifications), material evidence (0.82 for positive justifications), goals (0.78 for positive justifications), and knowledge about the world (0.94 for negative justifications). Kappa coefficients were not computed for the other categories because their marginal distributions were not uniform (Von Eye & Von Eye, 2008).

Table 1 about here

Statistical analyses

Since classic parametric assumptions were not met for a substantial number of dependent variables, all analyses were conducted using robust statistical methods (Field & Wilcox, 2017; Wilcox, 2012). More specifically, we conducted a series of robust repeated-measures ANOVAs using 20% trimmed means and 2000 bootstrap samples (per Field & Wilcox, 2017). We also conducted robust regression analyses to investigate predictors of belief in occurrence. For these latter analyses, we fitted robust multilevel models (random intercept models with events as level 1 units and participants as level 2 units) in order to take the hierarchical structure of the data into account (Goldstein, 2011). An alpha level of 0.05 was used for all analyses. All descriptive statistics refer to the 20% trimmed means and their 95 % confidence intervals calculated using the percentile bootstrap method (Wilcox, 2012).

Table 1. Categories of justification provided for belief (or non-belief) in occurrence for future events

Category of justification	Description	Examples
Link with other personal events	The event is linked to another specific event, a routine/generic event, or a life period.	Positive justification: *"I will go to Kenya and we will certainly find a moment to go to the beach"* Negative justification: "*I plan to go on holiday and I also have to retake an exam so I have a lot of other things to do before preparing my engagement*".
Personal characteristics	The event is linked to personal characteristics such as self-images, personality traits, values, autobiographical facts or any other enduring self-characteristics.	Positive justification: "*I am really interested in French politics*". Negative justification: "*I prefer countries like Finland rather than tropical ones because I don't like hot weather*".
Goals	Reference to personal goals, wishes, or internal motivations. This category differs from the Commitment category (see below) in that it refers to self-driven goals, which are not	Positive justification: "*It is something I really want to do*" Negative justification: "*Rather than going on holiday, I prefer to buy a car*"

	primarily initiated by external (e.g., material, social) sources.	
Knowledge about others	Description of personal characteristics of other persons, including their self-images, personality traits, values, or autobiographical facts.	Positive justification: "*"My friend will leave on Tuesday and she would like to see us before her departure"*." Negative justification: "*My father doesn't want to move*".
Knowledge about the world	Reference to semantic information and general knowledge about the world.	Positive justification: "*In summer, it starts to be sunny so it is highly likely that this could happen*". Negative justification: "*There are few places in this kind of schools. To be accepted, it is necessary to have an excellent school record*".
Event detail	Episodic details about the event, including people, perceptual information, emotion, location, and so on.	Positive justification: "[…] *A long garden, with a conservatory at the back, people who are eating, a table and a barbecue*". Negative justification: "*The fact that there are horses walking in the garden and dogs running everywhere is not very likely*".
Temporal location	Any information that contributes to the temporal location of the event (from vague	Positive justification: "*I start the 3rd of July, in one week, at 9:30 am*".

	information about temporal distance to the exact date of the event)	Negative justification: "*This could happen, but not within this year*".
Commitment	Obligations and already planned events, things involving an external constraint or a commitment.	Positive justification: "*It is a formal notice from the police. I have the obligation to go*". Negative justification: "*I may have to work on that day so I may not be able to participate in this event*".
Material evidence	Any verifiable, external, concrete element that confirms the occurrence of the event.	Positive justification: "*I have already booked my flight, so we have to go*". Negative justification: "*I think that I lack money to do that*".
Sharing	The event has been shared, rehearsed, or evoked with (an)other person(s)	Positive justification: "*We already talked about this event several times*". Negative justification: "*I have already told to my dad that I will not come to see him this year*"
Metacognitive judgments	Metacognitive judgements about properties of events or their mental representation, which are used to justify event occurrence.	Positive justification: "*I visualize it like that. I can easily imagine that this will happen and that is the reason why I imagine it like that and not in another way"*.

Negative justification: "*The park that I have imagined is not a real one that I know but an imaginary one. It is uncertain because I should visualize a park like this or like that*".

Results

A total of 210 events were included in the following analyses (70 events in each condition). We first examined the amount of detail reported in the verbal descriptions of imagined events. Then, we analyzed the justifications provided by participants to support belief (or non-belief) in occurrence and investigated to what extent indications of the integration of events with autobiographical knowledge predicted belief in occurrence. Finally, we examined other metacognitive appraisals (autonoetic experience, belief in accuracy) and phenomenological characteristics of imagined events.

Amount of imagined details

The amount of internal and external (autobiographical and non-autobiographical) details reported for the three types of imagined events is shown in Figure 1. A robust repeated measures ANOVA showed that the amount of internal detail was significantly different across the three types of events, $F_t = 6.98$, $F_{Crit} = 3.43$, $p < .05$. Post hoc tests showed that certain events contained more internal details than uncertain events, $\hat{\psi} = 4.17$ [1.55, 6.79], whereas no significant difference was found between certain and experimenter-provided events, $\hat{\psi} = 2.45$ [-0.76, 5.66], or between uncertain and experimenter-provided events, $\hat{\psi} = -1.71$ [-4.45, 1.02]. The number of external autobiographical details was also significantly different across the three types of events, $F_t = 6.12$, $F_{Crit} = 3.47$, $p < .05$. While no significant difference was found between certain and uncertain events, $\hat{\psi} = -0.02$ [-1.58, 1.53], both contained more external autobiographical details than experimenter-provided events (certain versus experimenter-provided events: $\hat{\psi} = 1.50$ [0.64, 2.36]; uncertain versus experimenter-

provided events: $\widehat{\psi}$ = 1.52 [0.22, 2.83]). Finally, the number of external non-autobiographical details also differed significantly between the three event conditions, F_t = 3.56, F_{Crit} = 2.83, $p < .05$. Post hoc tests showed that more external non-autobiographical details were produced for uncertain events than for experimenter-provided events, $\widehat{\psi}$ = 1.05 [0.27, 1.82]; the other comparisons between conditions were not statistically significant.

Figure 1 about here

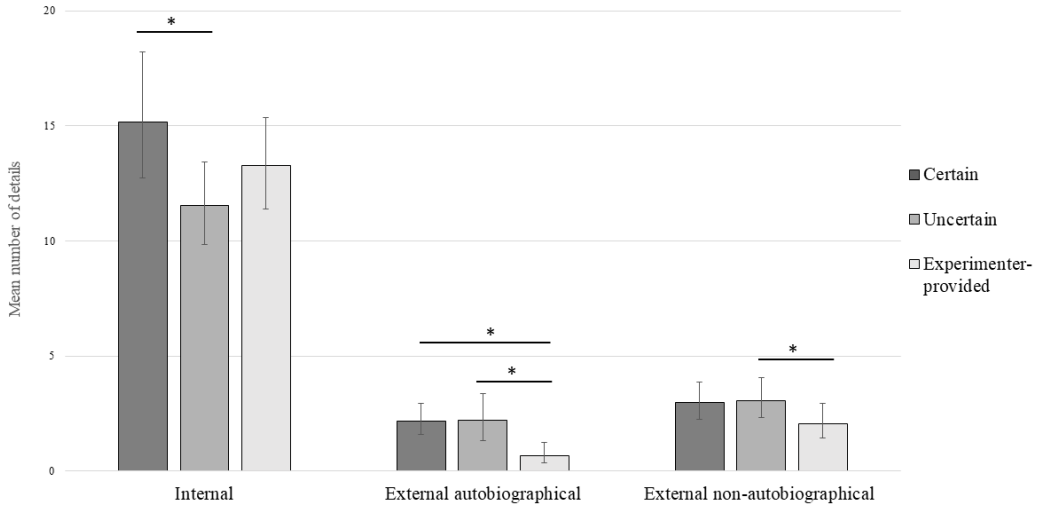

Figure 1. Trimmed means for the number of internal, external autobiographical, and external non-autobiographical details produced for certain, uncertain and experimenter-provided events. Error bars show 95% robust confidence intervals. * Indicates differences that were statistically significant as shown by robust post hoc tests.

Justifications for belief in occurrence

An important goal of this study was to shed additional light on the bases of the feeling that imagined events will or will not occur in the future. Figure 2 shows the

percentages of the different types of information that were reported by participants to justify their belief or non-belief in the future occurrence of imagined events. Figure 2 displays the percentages of positive justifications for certain events and the percentages of negative justifications for uncertain events; we examined positive justifications for certain events and negative justifications for uncertain events as these two types of events were associated with high and low levels of belief in occurrence, respectively.[2] For experimenter-provided events, positive and negative justifications are both displayed considering the fact that these events could potentially be either believed or not believed (as confirmed by the finding that they were associated, on average, with moderate levels of belief in occurrence; see below).

As can be seen from Figure 2, links to other personal events were most frequently used to justify belief or non-belief in occurrence for all types of events. For certain events, commitments were also frequently mentioned to justify belief in occurrence; temporal locations, personal characteristics, and goals were used to some extent. For uncertain events, besides links to other events, personal characteristics and knowledge about others were frequently mentioned as reasons for low belief in future occurrence. For experimenter-provided events, links to other events and personal characteristics were the justifications most frequently used to support or suppress belief in occurrence.

[2] Unsurprinsingly, negative justifications were rare for certain events (i.e., occuring for only 7% of events; e.g., '*Unless I forget my appointment or there is a hitch, it is certain that I will go to visit the veterinarian with my cat'*) and thus were not considered further. Positive justifications were mentioned for 22% of uncertain events and mostly involved links with other personal events (mentioned for 11% of uncertain events; e.g., '*[...] but when I buy some bread or make other purchases here, I could speak in Spanish. If I meet people, I could speak in Spanish'*).

It is interesting to note that the same categories of justifications were associated with either supporting or suppressing belief in occurrence. In particular, links with other events and personal characteristics were frequently reported as both positive and negative justifications. However, some justifications showed a more restricted use: commitments were almost exclusively associated (spontaneously provided in narratives) with support for belief in occurrence for certain events.

Figure 2 about here

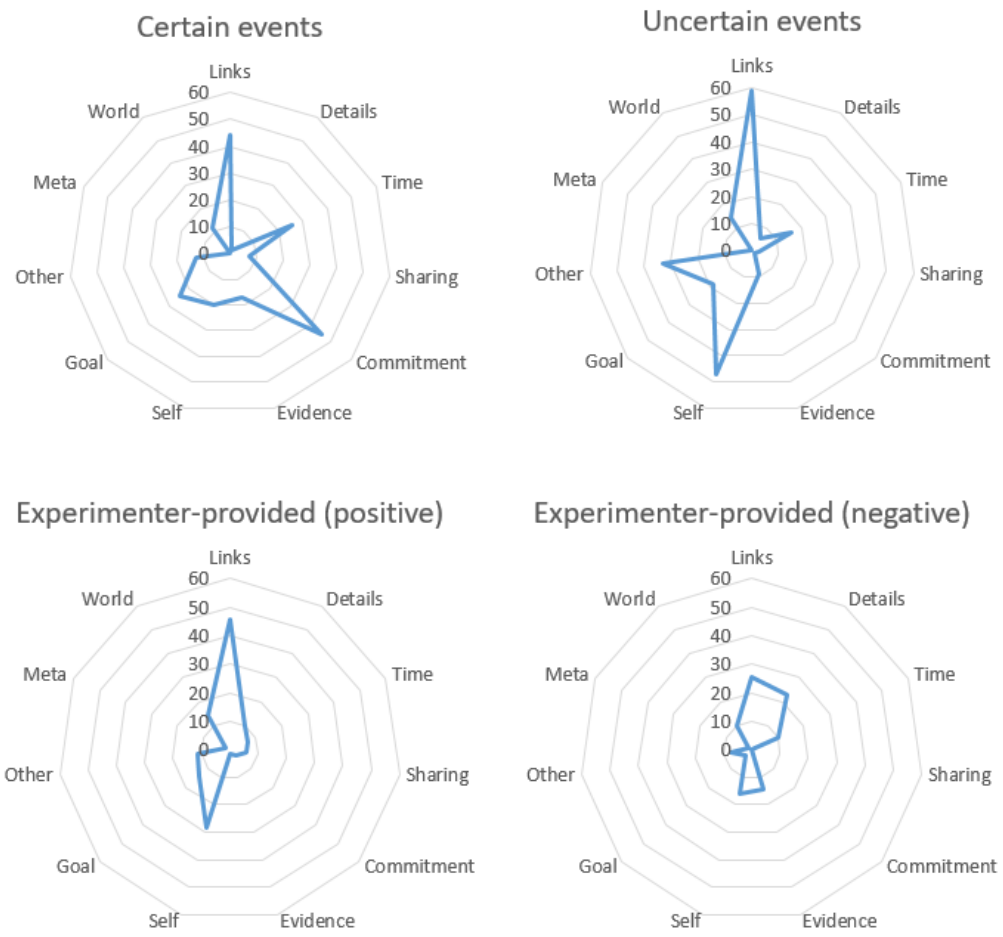

Figure 2. Percentages of justifications used to support or suppress belief in occurrence. For certain and uncertain events, the radar charts display the percentages of positive and negative justifications (i.e.,

justifications used to support or suppress belief in occurrence), respectively (see Methods). For experimenter-provided events, positive and negative justifications are presented separately. Links: links to other events; Time: temporal location; Evidence: material evidence; Self: personal characteristics; Other: kowledge about others; Meta: metacognitive judgements; World: knowledge about the world.

Belief in occurrence ratings

The distributions of belief in occurrence for the three types of events is shown in Figure 3, where it is evident that ratings were highly skewed to the left for events in the certain condition (consistent with prior research on belief in occurrence; Scoboria et al., 2014; see Scoboria, Mazzoni, Ernst & D'Argembeau, in press, for discussion of skew in the distribution of belief in occurrence ratings and robust analytic methods for handling item skew). The distribution was approximately normal for uncertain events and was somewhat bimodal for experimenter-provided events, suggesting that these events tended to be either believed or not believed. To examine differences in belief between the three types of events, ratings for the two events of each type were averaged and submitted to a robust repeated-measures ANOVA. This analysis showed that belief in future occurrence significantly differed between the three types of events, $F_t = 88.20$, $F_{Crit} = 3.73$, $p < .05$. As can be seen from Table 2, post hoc tests indicated that events in the certain condition were associated with higher degrees of belief in occurrence than events in the uncertain and experimenter-provided conditions.

Figure 3 about here

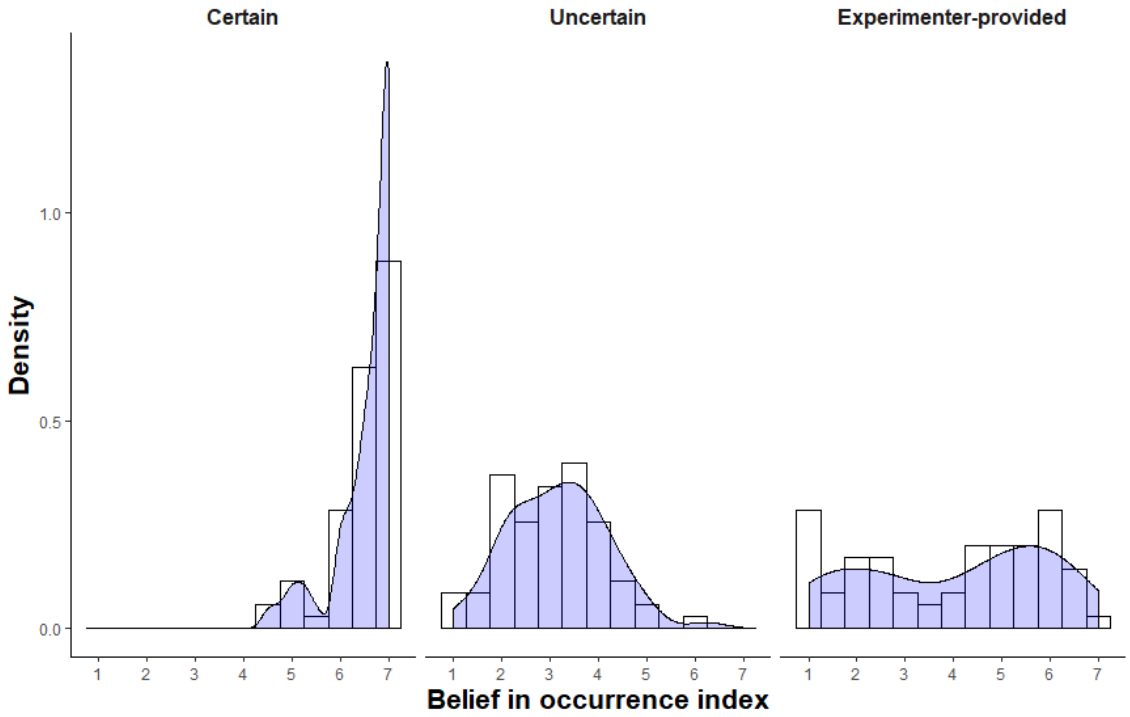

Figure 3. Distributions of belief in future occurrence ratings for certain, uncertain, and experimenter-provided events

To test the hypothesis that belief in future occurrence is determined, at least in part, by the integration of imagined events in an autobiographical context (Ernst & D'Argembeau, 2017), we examined to what extent justifications indicating that imagined events were integrated with autobiographical knowledge predicted degrees of belief in occurrence. To examine this question, we conducted a robust multilevel regression analysis (with events as level 1 units and participants as level 2 units) with ratings of belief in future occurrence as the outcome variable. Variables coding for the presence or absence of the following positive justifications were entrered as predictors: links with other personal events, characteristics, and goals (i.e., the three types of justifications reflecting the integration of events in an autobiographical context). The type of imagined event was also included as a predictor (with the certain event condition

as the reference category), along with justifications involving commitments as these were frequently used to support belief in occurrence. The resulting regression weights are shown in Table 3. Supporting our hypotheses, the use of links with other personal events, characteristics, and goals were all statistically significant, and positively associated with belief in occurrence for imagined future events.

Tables 2 and 3 about here

Table 2. Trimmed means and post hoc tests assessing differences in cognitive feelings and event features between certain, uncertain and experimenter-provided events

	Trimmed means [95% CI]			Robust post hoc tests ($\widehat{\psi}, 95\%\ CI$)		
	Certain	Uncertain	Experimenter-provided	Certain vs uncertain	Certain vs experimenter-provided	Uncertain vs experimenter-provided
Cognitive feelings						
Belief in future occurrence	6.72 [6.55, 6.83]	3.22 [2.89, 3.50]	4.02 [3.48, 4.61]	3.50 [3.05, 3.94]	2.70 [1.94, 3.46]	-0.80 [-1.66, 0.06]
Autonoetic experience	5.14 [4.79, 5.49]	3.88 [3.51, 4.23]	4.04 [3.61, 4.45]	1.26 [0.82, 1.70]	1.11 [0.47, 1.75]	-0.15 [-0.80, 0.49]
Belief in accuracy	4.93 [4.55, 5.19]	3.40 [2.98, 3.83]	3.38 [2.98, 3.90]	1.52 [0.88, 2.17]	1.55 [0.79, 2.30]	0.02 [-0.69, 0.73]
Sensory perceptual characteristics						

Sensory details	4.93 [4.50, 5.38]	3.93 [3.36, 4.45]	4.60 [4.21, 5.00]	1.00 [0.45, 1.55]	0.33 [-0.25, 0.92]	-0.67 [-1.28, -0.05]
Clarity of location	5.36 [4.86, 5.86]	4.33 [3.81, 4.83]	4.83 [4.50, 5.19]	1.02 [0.05, 2.00]	0.52 [-0.50, 1.54]	-0.50 [-1.24, 0.24]
Autobiographical context						
Personal plausibility	7.00 [6.88, 7.00]	3.90 [3.45, 4.36]	4.57 [4.05, 5.02]	3.10 [2.49, 3.70]	2.43 [1.84, 3.02]	-0.67 [-1.48, 0.14]
Personal importance	5.62 [5.17, 6.10]	4.98 [4.52, 5.36]	3.19 [2.69, 2.74]	0.64 [-0.21, 1.50]	2.43 [1.60, 3.26]	1.79 [0.92, 2.66]
Link with other events	4.71 [4.07, 5.33]	3.62 [3.19, 4.00]	4.36 [3.81, 4.90]	1.10 [0.23, 1.96]	0.36 [-0.59, 1.31]	-0.74 [-1.57, 0.10]
Sense of control	5.05 [4.48, 5.52]	4.50 [4.10, 4.93]	4.52 [4.05, 5.02]	0.55 [-0.38, 1.48]	0.52 [-0.32, 1.37]	-0.02 [-0.73, 0.68]

Rehearsal	4.50 [3.81, 5.14]	3.62 [3.23, 4.01]	2.43 [1.88, 3.07]	0.88 [0.05, 1.71]	2.07 [1.08, 3.06]	1.19 [0.40, 1.98]
Objective temporal distance (in days)	66.40 [48.64, 89.67]	156.26 [121.17, 202.26]	114.19 [86.79, 144.50]	-89.86 [-140.47, -39.25]	-47.79 [-96.97, 1.40]	42.07 [-21.82, 105.97]

Table 3. Multilevel regression analysis predicting belief in future occurrence

Predictor	*b*	*SE*	*Z*	*p*
Event type (uncertain)	-2.61	0.27	-9.83	< 0.001
Event type (experimenter-provided)	-2.22	0.24	-9.23	< 0.001
Links with other events	0.90	0.19	4.69	< 0.001
Personal characteristics	0.77	0.23	3.29	0.001
Goals	0.47	0.23	1.97	0.048
Commitments	0.79	0.29	2.73	0.006

Other cognitive feelings and event features

The mean ratings for other cognitive feelings and event features for the three types of events are shown in Table 2. There was a significant difference between the three types of events for autonoetic experience, $F_t = 17.05$, $F_{Crit} = 3.02$, $p < .05$, and belief in accuracy, $F_t = 20.54$, $F_{Crit} = 3.16$, $p < .05$. Post hoc tests indicated that certain future events were characterized by higher autonoetic experience and belief in accuracy than uncertain and experimenter-provided events, whereas no significant differences were observed between uncertain and experimenter-provided events (see Table 2).

Regarding the other phenomenological properties of imagined events, a series of robust repeated-measures ANOVA showed main effects of event type for nearly all measures: sensory detail, $F_t = 9.55$, $F_{Crit} = 3.06$, $p < .05$, location clarity, $F_t = 4.42$, $F_{Crit} = 3.45$, $p < .05$, personal plausibility, $F_t = 74.75$, $F_{Crit} = 3.25$, $p < .05$, personal importance, $F_t = 30.05$, $F_{Crit} = 3.22$, $p < .05$, links with other events, $F_t = 5.06$, $F_{Crit} = 3.11$, $p < .05$, rehearsal, $F_t = 17.94$, $F_{Crit} = 3.12$, $p < .05$, and objective temporal

distance, $F_t = 8.14$, $F_{Crit} = 3.43$, $p < .05$. The only measure that showed no significant difference between the three types of imagined events was sense of control, $F_t = 1.89$, $F_{Crit} = 3.40$. Post hoc tests revealed three main sets of results (see Table 2). First, compared to uncertain and experimenter-provided events, certain events were judged as more personally plausible and more frequently rehearsed. Second, personal (certain and uncertain) events were judged more important than experimenter-provided events. Third, certain events were associated with higher levels of sensory details, location clarity and links with other events, and greater objective temporal distance than uncertain events, but did not differ from experimenter-provided events on these variables.

Discussion

Recent theory and research has emphasized that different forms of episodic simulation—mental representations of past, future, or atemporal events—recruit many of the same underlying cognitive and neural processes (de Vito et al., 2012; Hassabis & Maguire, 2009; Schacter et al., 2012). Notwithstanding these similarities, it has been argued that episodic future thinking does not only depend on simulation processes (i.e., the construction of detailed mental representations), but also requires that imagined events are framed as having the potential to genuinely occur in one's personal future (D'Argembeau, 2016). In the present study, we aimed at shedding some light on this distinctive hallmark of episodic future thinking and, more specifically, on the cognitive ingredients of the sense of futureness associated with imagined events. To examine these questions, we asked participants to imagine a series of personal events for which they felt certain or uncertain about their future occurrence (i.e., events theoretically associated with high or low degrees of belief in future occurrence), as well as non-

personal experimenter-provided events. This manipulation was effective in producing imagined events that differed in strength of belief in future occurrence and an important goal of this study was then to delve deeper into the cognitive bases of feelings of future occurrence or non-occurrence.

To investigate the sources of information underlying belief in future occurrence, we asked participants to verbally describe what led them to believe that imagined events would or would not happen in the future. In line with our hypothesis that belief in future occurrence depends on a synergy of imagined contents with personal autobiographical knowledge, we found that justifications referring to personal goals, personal characteristics, and links with other personal events were frequently used to support belief in occurrence for imagined events (thus replicating Ernst & D'Argembeau, 2017). Interestingly, the present results further showed that autobiographical knowledge (in particular, links with other events and personal characteristics) was also frequently mentioned when imagined events felt uncertain (for example, an imagined scenario may not feel "real" because it conflicts with other personal events that have already been planned, because it does not fit with one's personal traits and values, because it is personally implausible, or because it does not fit with one's autobiographical history). These findings thus suggest that autobiographical knowledge can be flexibly used to either support or suppress belief in occurrence for imagined future events.

Besides the use of autobiographical knowledge, future events for which occurrence felt certain were frequently justified by references to commitments or temporal locations, suggesting that obligations and schedules also offer basis for belief in future occurrence. Importantly, however, autobiographical knowledge and commitments were independent predictors of variation in belief in occurrence across

imagined events. Furthermore, different types of autobiographical information (links with other events, goals, personal characteristics) provided unique contributions to the prediction of belief in occurrence. This suggests that different properties of imagined events may have additive effects on belief in future occurrence, such that stronger belief may result from the conjunction of multiple features (e.g., links with other events and commitments).

Participants' ratings of the characteristics of imagined events also support the view that belief in future occurrence depends on the integration of imagined contents with autobiographical knowledge. Specifically, we found that more certain future events were rated as more personally plausible and more linked with other personal events than more uncertain future events (note, however, that there was no difference between certain and uncertain events in terms of personal importance). Interestingly, experimenter-provided events were on average associated with moderate levels of belief in future occurrence (falling in between certain and uncertain events) but the distribution of ratings was somewhat bimodal, suggesting that the events were either believed or not believed. This might be due to the fact that some experimenter-provided events may be meaningfully integrated with the individual's autobiographical knowledge (thus leading to the subjective feeling that these events are "real") whereas others may not. For example, events that resembled the experimenter-provided events may have already been previously experienced or planned by some participants, meaning that a believed mental representation already existed for these events for such individuals. Whatever it may be, our results have potentially important implications regarding the choice of methods used to elicit episodic future thoughts in laboratory studies: one should be aware that asking participants to generate episodic future

thoughts in response to experimenter-provided cues does not necessarily lead to the imagination of strongly believed future events and in fact produces a mixture of believed and non-believed events. This issue echoes recent recommendations on the measurement of episodic future thought (Miloyan & McFarlane, 2018), which notably aim to draw attention to possible differences between observer-rated scoring of imagined events and participants' subjective experience and metacognitive judgments.

While certain and experimenter-provided events differed in degrees of belief in future occurrence, these two kinds of events were associated with similar amounts and strength of episodic details (as shown by the numbers of internal details verbally reported and by ratings of sensory-perceptual characteristics). This finding is consistent with a previous study that compared the imagination of goal-related and experimenter-provided events (Lehner & D'Argembeau, 2016). Other studies indicate that the episodic richness of mental simulations depend in part on the familiarity of imagined elements (in particular, the event's location) rather than their future dimension (de Vito et al., 2012; Robin & Moscovitch, 2017) or temporal distance (Arnold, McDermott, & Szpunar, 2011). Taken together, these studies support the view that the construction of detailed mental scenarios or scenes is a common ingredient for various forms of episodic simulations (Cheng, Werning, & Suddendorf, 2016; Hassabis & Maguire, 2007, 2009; Schacter et al., 2017).[3] Importantly, however, the present findings

[3] It should be noted, however, that in the present study imagined events were associated with fewer episodic details in the uncertain than certain condition. While the reason of this difference remains to be investigated in detail, we suggest that the feeling of

demonstrate that scene construction alone is not sufficient for creating the sense that imagined events belong to the personal future; additional integration with autobiographical knowledge is required (D'Argembeau, 2016; Ernst & D'Argembeau, 2017; Lehner & D'Argembeau, 2016).In the same vein, Redshaw (2014) argued that the representation of events *as future events* requires metarepresentational insight, which allows one to embed events within a specific future context and to conceive the relationship between these events and current reality.

Beyond belief in occurrence, the three types of imagined events also differed on other cognitive feelings. More specifically, more certain future events were associated with a stronger sense of pre-experiencing (i.e., autonoetic experience) and belief in the accuracy of imagined contents than more uncertain and experimenter-provided events. While belief in occurrence, autonoetic experience, and belief in accuracy represent distinct metacognitive attributions, which are conceptually and empirically distinguishable (Ernst & D'Argembeau, 2017; Scoboria et al., 2015, 2017; Scoboria, Mazzoni, Ernst & D'Argembeau, in press), they frequently co-occur and may act in concert to create the subjective experience of mentally visiting one's personal future (see Scoboria et al., 2014, 2015 for similar results regarding memories for past events).

In addition to shedding light on the cognitive processes underlying belief in future occurrence, the present results may have potentially important implications for the pragmatic dimension of future-oriented thinking. One of the main theorized functions of prospection is to guide action in order to formulate and bring about desired

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uncertainty about event occurrence might restrain the elaboration of a detailed mental scenario.

outcomes and to avoid aversive ones (Baumeister et al., 2016; Suddendorf & Corballis, 2007). By definition, the future is unknown and remains fundamentally uncertain, so one needs to envision and weigh the utility of multiple alternative possibilities (for events, actions, and outcomes) to effectively prepare for action (Baumeister, Maranges, & Sjastad, 2018). Humans have developed an increasingly sophisticated capacity to exert flexibility in envisioning a myriad of possibilities, and this capacity to 'see the future' provides tremendous adaptive advantage (Suddendorf, Bulley, & Miloyan, 2018). However, for this matrix of envisioned possibilities to be useful in guiding decisions and actions, one should be able to identify and prioritize mental scenarios that are most relevant and adaptive to one's current goals and life situation. Belief in occurrence is a strong candidate for this role of mental indicator: when envisioning a set of alternative possibilities, the feeling that an event will become genuine (will in fact occur, in a manner similar to how vivid memories for past events tend to be tagged with strong feelings of prior occurrence) may act as a cognitive feeling that marks scenarios that are relevant for decisions and implementation, given one's goals and personal context. Studies that further examine the development and contribution of belief in occurrence to future-oriented behavior thus represent a fruitful line of research to broaden our understanding of the benefits of episodic future thinking in decision-making and goal pursuit (Bulley & Irish, 2018; Bulley et al., 2016).

In this perspective, it would also be important to investigate the relations between belief in future occurrence and the affective qualities of imagined events. Previous studies have shown that many future-oriented thoughts experienced in daily life refer to emotionally significant events (Barsics, Van der Linden, & D'Argembeau, 2016), and the amount and strength of episodic details when imagining events vary with

their emotional value (e.g., D'Argembeau & Van der Linden, 2004; de Vito, Neroni, Gamboz, Della Salla, & Brandimonte, 2015). Belief in future occurrence may also be affected by the emotional valence and/or intensity of imagined events. For example, a study by Szpunar and Schacter (2013) suggests that repeated simulations of emotional events increase their subjective plausibility. Gaining further insight into the relations between emotion and belief in future occurrence may have important implications for understanding the functions and dysfunctions of prospection in healthy individuals and clinical populations (Bulley & Irish, 2018; Hallford, Austin, Takano, & Raes, 2018).

In conclusion, the present findings add to an accumulating body of evidence suggesting that episodic future thinking lies at the conjunction of episodic simulation and contextualizing autobiographical knowledge (e.g., D'Argembeau & Mathy, 2011; Ernst, Philippe, & D'Argembeau, 2018; Lehner & D'Argembeau, 2016; for review, see D'Argembeau, 2016). As such, the subjective sense of realness associated with imagined contents—the belief that a mental scenario will genuinely materialize in the future—arises from the meaningful integration of episodic representations with higher-order knowledge about one's environment, personal future, and most notably one's goals and general expectations. In turn, variation in belief in occurrence when envisioning possible future scenarios may contribute to the pursuit of scenarios that are most relevant and effective in guiding future decisions and actions.

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Appendix A. Instructions for event selection and description tasks and for justifications of belief (or non-belief) in future occurrence

Instructions were given in French (the English translation is indicated in square brackets).

Event selection

Dans cette étude, nous vous demanderons de penser à une série d'événements qui pourraient vous arriver dans le futur. Un « événement » désigne une situation qui se produit à un moment particulier et dans un lieu spécifique. Un événement dure généralement quelques minutes ou quelques heures mais moins d'une journée. Par exemple, si vous pensez à votre semaine de vacances à Rome, ceci n'est pas un événement suffisamment spécifique. Par contre, si vous pensez au moment où vous visiterez le Colisée durant ces vacances à Rome, il s'agit ici d'un moment spécifique. Il faudra aussi que les événements futurs que vous sélectionnerez ne soient pas routiniers. Par exemple, dire que vous allez à la piscine les mercredis est routinier. Par contre, le passage de votre brevet de natation est un moment spécifique. Les événements que vous évoquerez peuvent être importants ou banals et peuvent concerner n'importe quel domaine de votre vie (comme les études ou le travail, votre famille, vos amis, vos loisirs, etc.). Après avoir sélectionné une série d'événements, vous devrez y penser de façon plus détaillée et répondre à une série de questions les concernant.

Plus spécifiquement, nous vous demanderons d'évoquer deux types d'événements futurs qui pourraient vous arriver au cours de l'année à venir :

- Des événements spécifiques dont vous êtes sûr(e) qu'ils se produiront réellement dans votre futur.
- Des événements spécifiques pour lesquels vous n'êtes pas certain(e)s qu'ils vont réellement avoir lieu dans votre futur. Il doit s'agir dans ce cas d'événements plausibles (des événements qui pourraient vous arriver ou qui sont prévus) mais pour lesquels vous avez des doutes et n'êtes pas sûr(e) qu'ils se produiront réellement dans votre futur.

Pour chaque catégorie, je vais vous demander de lister cinq événements futurs, en me donnant une brève description de chaque événement. Pour commencer, je vais vous demander de me donner 5 événements dont vous croyez qu'ils vont réellement se produire dans l'année à venir. Donnez-moi les 5 premiers événements qui vous viennent à l'esprit.

Maintenant, je vais vous demander de me donner 5 événements qui pourraient vous arriver dans l'année à venir mais dont vous n'êtes pas sûr(e) qu'ils vont réellement se produire. Donnez-moi les 5 premiers événements qui vous viennent à l'esprit.

Maintenant que nous avons une série d'événements futurs pour chacune des catégories, je vais vous demander de sélectionner les deux événements futurs qui sont les plus représentatifs de chacune des catégories, c'est-à-dire les deux événements pour lesquels vous êtes le plus sûr et les deux pour lesquels vous êtes le moins sûr qu'ils vont réellement se produire.

[In this study, you will be asked to think about a series of events that might happen in your future. An ‘event’ corresponds to a situation that occurs at a particular time and place. An event generally lasts a few minutes or hours, but less than a day. For instance, if you think about your week of holiday in Rome, this is not specific enough. But if you think about a visit of the Coliseum during this holiday in Rome, this is a specific event. You will also have to select future events that do not refer to habits or routines. For instance, going to the swimming pool every Wednesday is a routine. However, passing the exam to get your swimming certificate is a specific event. You can select important or more mundane events that could be related to any domain of your life (e.g., education, work, family, friend, leisure activities, and so on). After having selected the series of events, you will have to describe them in more detail and to complete a series of additional questions regarding these events.

More specifically, I will ask you to evoke two types of future events that might happen within the next year:

- Specific events for which you feel certain about their occurrence in your future
- Specific events for which you feel uncertain about their occurrence in your future. These must remain plausible events (events that could happen to you or which are planned) but for which you have some doubts and feel unsure that they will actually occur in your future.

For each type of event, I will first ask you to list five future events and give me a brief description of each event. To begin with, I will ask you to provide five events for which

you feel certain that they will occur in the next year. Give me the first five events that come to your mind.

Now, I will ask you to provide five events that might happen to you in the next year but for which you feel uncertain about their actual occurrence. Give me the first five events that come to your mind.

Now that we have a series of future events for each category, I will ask you to select the two most representative events of each type, that is the two events for which you feel the most certain and the two events for which you feel the most uncertain about their future occurrence.]

Event description

Nous allons maintenant reprendre un par un les événements futurs que vous avez sélectionnés afin de les développer et de répondre à des questions complémentaires. A ces événements futurs vont également s'ajouter des événements supplémentaires, qui ne font pas parties des événements futurs que vous avez listés initialement, mais pour lesquels je vous donnerai une courte description et vous demanderai également d'imaginer que ces événements se produisent dans votre futur.

Je vais vous demander d'imaginer chaque événement de manière détaillée et de me décrire tout ce qui vous vient à l'esprit en imaginant cet événement. Pour commencer, imaginez que vous (titre de l'événement) au cours de l'année à venir. Imaginez cet événement de façon détaillée et dites-moi tout ce qui vous vient à l'esprit.

[Now, we are going to consider the future events that you have selected one by one and you will be asked to develop each event and to answer additional questions. In addition to these future events, short descriptions of other events that are not part of the future events that you have selected will also be provided and you will be asked to imagine that these events will happen in your future.

I will ask you to imagine each event in detail and to tell me everything that comes to your mind while imagining this event. To start, imagine that you (title of the event) within the next year. Imagine this event in detail and describe everything that comes to your mind.]

Justifications for (non-)belief in occurrence

Pourriez-vous m'expliquer ce qui vous donne le sentiment que cet événement va réellement avoir lieu dans votre futur ou au contraire ce qui fait que vous n'avez pas l'impression qu'il va réellement se produire dans le futur ? Il n'y a pas de bonne ou de mauvaise réponse, ce qui nous intéresse c'est de comprendre ce qui vous donne l'impression que cet événement va se produire ou non dans votre futur. N'hésitez pas à me dire tout ce qui vous vient à l'esprit et qui contribue, d'après vous, à vous donner ce sentiment.

[Could you please tell me what gives you the feeling that this event will actually occur in your future, or on the contrary, what makes you feel that it will not happen in your future? There is no right or wrong answer, we are interested in what gives you the feeling that this event will happen or will not happen in your future. Do not hesitate to tell me everything that comes to your mind and that, according to you, contributes to give you this feeling.]

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