CHAPTER 5

# *Memory and Future Imagining*

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## INTRODUCTION AND BACKGROUND ISSUES

People devote considerable time and energy to imagining or simulating specific events that may take place in the future. Whether anticipating the outcome of impending discussions with significant others or colleagues, mentally preparing for an upcoming presentation, or imagining what a future night out, vacation, or job opportunity will be like, simulation of specific future events is a common feature of mental life. This process has been referred to by various terms, including *episodic simulation* (Schacter, Addis, & Buckner, 2007, 2008), *episodic future thinking* (Atance & O'Neill, 2001; Szpunar, 2010), and *future event simulation* (Griffiths et al., 2012).

Simulating upcoming events is one of several ways in which people can think about the future. We have recently described a preliminary taxonomy of future thinking that distinguishes among four basic modes of prospection (simulation, prediction, intention, and planning) and propose that each one can take episodic or semantic forms (for detailed discussion, see Szpunar, Spreng, & Schacter, 2014). Within the context of our taxonomy, *episodic* refers to simulations, predictions, intentions, or plans in relation to specific autobiographical events that might occur in the future, whereas *semantic* refers to simulations, predictions, intentions, or plans that relate to more general or abstract states of the world that may arise in the future. The present chapter focuses exclusively on one cell in our proposed taxonomy—simulation of specific future episodes or events—which we will refer to here interchangeably as *episodic simulation* or *future event simulation*.

Although social and clinical psychologists have long been interested in the functions and shortcomings of future thinking (Gilbert & Wilson, 2007; MacLeod & Byrne, 1996; MacLeod, Tata, Kentish, & Jacobsen, 1997; Miloyan, Pachana, & Suddendorf, 2014; Wilson & Gilbert, 2003), interest in the cognitive and neural mechanisms that give rise to future event simulation has only been galvanized within the past decade (for detailed reviews, see Buckner & Carroll, 2007; Klein, 2013; McLelland, Schacter, & Addis, 2015; Schacter, Addis, & Buckner, 2007, 2008; Schacter et al., 2012; Suddendorf & Corballis, 2007; Suddendorf & Renshaw, 2013; Szpunar, 2010). We do not attempt to duplicate the extensive coverage of episodic simulation in the aforementioned recent reviews. Instead, we present a selective overview of important findings from cognitive psychology and neuroscience while also highlighting key methodological advances

*Stevens' Handbook of Experimental Psychology and Cognitive Neuroscience, Fourth Edition,* edited by John T. Wixted.

DOI: 10.1002/9781119170174.epcn105

from this emerging literature. In particular, we detail specific cuing methods employed along with their strengths and weaknesses, approaches to assessing details associated with simulated events along with their underlying structure, and issues specific to studying the manner in which the brain represents the personal future. We conclude by further discussing the relation of episodic simulation to other forms of future thinking.

Finally, we focus specifically on the study of future event simulation as it applies to cognitive and neuroimaging studies of *adult* populations. Although studies of nonhuman populations and young children are certainly relevant to the theme of this chapter, research in those domains must often infer the presence of mental representations of specific future events rather than highlight the quality of such representations. For the interested reader, the literature contains numerous discussions of issues that arise in the context of studies aimed at demonstrating instances of thinking about specific future events in nonhuman animals and young children (Atance, 2008; Clayton, 2015; Clayton, Bussey, & Dickinson, 2003; Martin-Ordas, Atance, & Caza, 2014; Osvath & Martin-Ordas, 2014; Suddendorf & Corballis, 1997, 2007; Tulving, 2005).

## RECENT AND EMERGING TRENDS

### Eliciting Future Event Simulations

Discussions about the manner in which simulations of future events are elicited in experimental settings must take into account that the study of episodic simulation initially developed in the context of questions about the extent to which future thinking was related to episodic memory or memory for specific personal experiences (Tulving, 1983, 2002). The roots of such comparisons are grounded in the seminal observations of Tulving (1985), who documented the case of patient KC, an amnesic patient who lacked the ability to remember episodic details about past experiences as well as the ability to imagine future personal experiences (see also Hassabis, Kumaran, Vann, & Maguire, 2007; Klein, Loftus, & Kihlstrom, 2002). When asked to think about what he might be doing tomorrow, KC drew a blank, much as he could not recollect any specific details about what he did yesterday (Tulving, 1985). Since then, most relevant cognitive and neural studies have compared and contrasted episodic simulation with episodic memory.

#### *Open-Ended Cuing Approaches*

Although the precise cues that are used to elicit future event simulations can differ from study to study, the most popular approach to date has been to provide participants with relatively open-ended cues that allow them considerable freedom in determining the precise contents of their simulations. The cuing procedures have often been based on similar methods previously used in autobiographical memory research. For instance, many researchers make use of a variant of the Galton-Crovitz word-cuing technique (Crovitz & Schiffman, 1974; Galton, 1879) in which participants are presented with a series of cue words (e.g., *apple, car,* etc.) and asked to remember or simulate events following the general instruction, which we have abstracted based on the existing literature (see also Appendix A at the end of this chapter):

> In response to each cue, we would like you to generate a personal memory or future event that is specific in time and place; that lasted or will last no more than a few hours; and that happened or could plausibly happen within the last or next [time frame that the researcher is interested in]. You should remember or imagine each event as it happened or as it would happen through the perspective of your

own eyes. Please note that the memories or future events you generate need not be directly tied to the specific cue words. The cue words are intended only to serve as a starting point for bringing specific events to mind. Once a specific event comes to mind, stick with that event for the entire duration of the trial.

In the first behavioral study to directly compare episodic memory and simulation, Williams et al. (1996) modified the word-cuing technique by embedding neutral, negative, and positive cue words in brief sentences that directed participants to either remember specific events (e.g., "Try to remember an occasion from the past on which you felt *proud*.") or imagine specific future experiences (e.g., "Try to picture a situation in the future in which you will feel *proud*."). Based on this procedure, Williams et al. (1996) reported the important observation that the depressed individuals showed less-specific autobiographical memories as well as less-specific future imaginings than did controls and also that the specificity levels for past and future events were correlated in both groups.

Other, more recent researchers have chosen to use brief scenarios (e.g., Hassabis et al., 2007) or pictures (Gaesser, Sacchetti, Addis, & Schacter, 2011) instead of words or words embedded within sentences as cues to elicit memories and future events. As we discuss further on in this chapter, these decisions are often associated with the specific aims of the research being conducted. Further, the time given to participants to remember or imagine events can vary from tens of seconds to several minutes, a factor that is often related to the level of detail that researchers are interested in extracting from participants based on their memories or simulations. For instance, studies using shorter trial durations will almost exclusively collect phenomenological ratings associated with remembered or simulated events (e.g., "How detailed was your mental image of the event?"), whereas studies using longer trial durations often require participants to provide detailed descriptions (and often phenomenological ratings as well). We will return to this point further on when we turn to differences in the level of detail that participants provide about their memories or future events. Importantly, the specific instructions provided to participants may also vary from study to study depending on the interests of the researcher. For instance, those interested in natural variations in perspective associated with future thinking may not require participants to focus on future events limited to a first-person perspective (McDermott, Wooldridge, Rice, Berg, & Szpunar, 2016; Rice & Rubin, 2011).

As an example of the standard Galton-Crovitz word-cuing technique in action, Spreng and Levine (2006) used this approach to elicit memories and simulations in the laboratory with the purpose of characterizing the temporal distribution of past and future events in the absence of specific instructions regarding temporal distance from the present (which was also the main goal of the original Crovitz & Schiffman, 1974, paper, though the latter focused only on memories). The authors reported that participants were more likely to report temporally near as opposed to temporally distant past and future events under such circumstances (see also Spreng & Levine, 2013). Hence, at the level of behavioral analysis, the Galton-Crovitz word-cuing technique has provided insight into the interrelated nature of memory and future thinking.

Some researchers have used even more open-ended cuing approaches in which specific event cues are not provided. For example, D'Argembeau and Van der Linden (2004, 2006) asked participants to generate past and future events in response to cues that only specified that the past and future events should involve a particular emotional valence (i.e., positive or negative) and occur within a particular time frame (e.g., last or next week). With this approach, D'Argembeau and Van der Linden (2004) demonstrated that whereas memories were typically represented in greater phenomenological detail than future events, memories and future events contained decreasing levels of phenomenological detail with increasing distance from the present. Later, D'Argembeau and Van der Linden (2006) used a similar open-ended approach to show that individual difference variables such as the propensity to engage in mental imagery in daily life can affect the phenomenological quality associated with memories and future events. Specifically, the authors found that participants who thought about the world using imagery tended to remember and imagine events in greater detail. These early findings provided additional evidence that episodic memory and future event simulation are closely related to one another.

Turning briefly to the role of open-ended cuing approaches in the context of brain imaging, the Galton-Crovitz word-cuing technique has also provided a method for eliciting specific events in the scanner and enabled researchers to more precisely relate neural activity associated with episodic memory and future event simulation. In order to more fully appreciate the importance of this contribution, we must first consider the results of Okuda et al. (2003), who used positron emission topography (PET) scanning to assess neural activity associated with remembering the past and imagining the future. In that study, participants were asked to talk about their past and future for 60 seconds per block of scanning, with past and future trials administered in separate blocks. Although the data revealed a striking overlap between memory and future thinking in various regions of the brain, the use of a blocked design did not enable the researchers to be certain that participants were thinking about specific events. In order to overcome this issue, Addis, Wong, and Schacter (2007) and Szpunar, Watson, and McDermott (2007) made use of event-related fMRI designs in conjunction with the Galton-Crovitz word-cuing technique to evoke and measure estimates of neural activity that could be associated with individual events. Importantly, these two studies corroborated the data reported by Okuda et al. (2003) in that a similar "core network" (Schacter et al., 2007) of regions composed of medial and lateral aspects of frontal, parietal, and temporal cortices supports memory for the past and imagination of the future (for a recent meta-analysis of the neuroimaging literature and the core network, see Benoit & Schacter, 2015; see also Figure 5.1).

An important feature of the methods employed by Addis et al. (2007) warrants further discussion. In that study, the authors assessed the neural activity associated with two phases of episodic memory and future event simulation, namely, construction and elaboration. Specifically, participants were instructed to press a button once they had constructed a specific event and then to continue elaborating on details associated with the event for the duration of the experimental trial (in this case, 20 seconds total). The authors found that neural differences between memory and future thinking were most apparent in the construction phase of remembering or simulation. Remarkably, a region of right hippocampus—a region typically associated with memory-related processing (Eichenbaum & Cohen, 2001)—was more strongly engaged during the construction of future events than during the construction of memories. This observation has stimulated a line of research devoted to understanding the various ways in which the hippocampus is involved in recombining details from

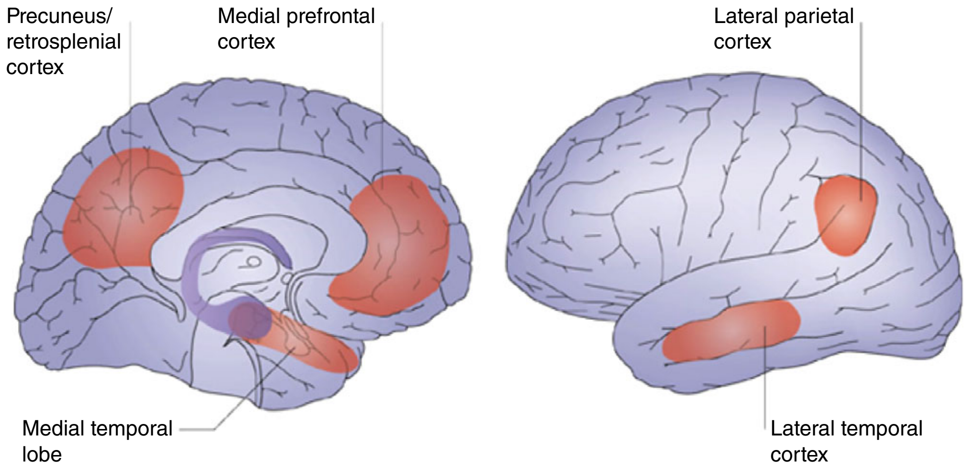


**Figure 5.1** A core brain network that supports episodic memory and episodic simulation.
Schematic illustration from Schacter, Addis, et al. (2007) of the core network of regions that become active when people remember past experiences (episodic memory) and imagine future experiences or engage in related kinds of mental simulations (episodic simulation). Prominent components of this network include medial prefrontal regions, posterior regions in the medial and lateral parietal cortex extending into retrosplenial cortex and precuenus, the lateral temporal cortex, and the medial temporal lobe. A more recent meta-analysis of a large sample of studies by Benoit and Schacter (2015) has confirmed the joint involvement of core network regions in episodic memory and episodic simulation.

memory into a coherent mental simulation of the future, encoding those simulations, and subsequently retrieving those simulations from memory (Addis, Pan, Vu, Laiser, & Schacter, 2009; Gaesser, Spreng, McLelland, Addis, & Schacter, 2013; Martin, Schacter, Corballis, & Addis, 2011; for detailed reviews, see Addis & Schacter, 2012; Schacter, Addis, & Szpunar, 2017). Further on, we will consider other approaches that researchers have taken when considering the time course over which simulations of the future are constructed and elaborated.

In general, the initial data to emerge on the relation of episodic memory and simulation were largely based on the use of open-ended cuing techniques and resulted in an extremely cohesive set of data suggesting that the two were similarly influenced by experimental manipulations and individual difference variables, shared neural correlates, and that impairment to one was commonly accompanied by impairment to the other. For instance, following the seminal observations of Williams et al. (1996) noted previously, coexisting deficits in episodic memory and simulation have been demonstrated in healthy adults (Addis, Wong, & Schacter, 2008), older adults with mild Alzheimer's disease (Addis, Sacchetti, Ally, Budson, & Schacter, 2009), individuals with mild cognitive impairment (Gamboz et al., 2010), post-traumatic stress disorder (Brown et al., 2014), schizophrenia (D'Argembeau, Raffard, & Van der Linden, 2008), and autism (Lind & Bowler, 2010; Lind, Williams, Bowler, & Peel, 2014) (for more complete discussion, see Schacter et al., 2008, 2012; Szpunar, 2010). This collection of observations led to the hypothesis that one adaptive function of human memory may be to provide the building blocks necessary to generate detailed and coherent mental representations of future events (Schacter & Addis, 2007; see also Buckner & Carroll, 2007; Suddendorf & Corballis, 2007; Tulving, 2002, 2005). Indeed, this constructive episodic simulation hypothesis (Schacter & Addis, 2007) has served as a guide for subsequent work on future thinking.

We conclude our discussion of open-ended cuing techniques by highlighting an important limitation of the general approach. In generating simulations that are based on concrete nouns, approximate dates, or hypothetical scenarios depicted in generic phrases or pictures, there is no way of knowing whether participants imagine a truly novel event or whether a relevant memory is brought to mind and recast as a possible future occurrence. Moreover, there is no way of knowing how often participants may have thought about those events in the past. Next, we discuss the emergence of the experimental recombination procedure, a cuing technique that ensures that participants simulate novel events they have likely never thought about before.

### *Experimental Recombination Procedure*

The experimental recombination procedure was initially developed by Addis, Pan, et al. (2009) in order to ensure that participants were generating novel future events that were based on details extracted from episodic memory. To achieve these goals, Addis, Pan et al. (2009) required participants to initially generate a list of personal memories that were each characterized by a specific person, place, and object. Importantly, particular people, places, and objects can be listed only once. Hence, depending on the number of memories that are collected, the researcher is left with an equivalent number of people, places, and objects drawn from specific personal memories. After stimulus generation, the authors randomly reorganized the lists of people, places, and objects to form a random set of person-location-object cues that were used to evoke simulations of the future. In this case, the participant receives the basic experimental instructions associated with simulating specific future events (see previous discussion) and also the instruction to imagine interacting with the specific person indicated in the cue, in the specific location indicated in the cue, and in a manner that involves the specific object indicated in the cue. The random nature of this approach ensures that participants are simulating future events and not recasting past experiences (for further details, see Appendix B).

Another purpose served by the experimental recombination procedure is that it holds constant the frequency of prior thinking about a future event. This feature of the procedure plays an important role for researchers interested in memory for simulations of future events (Martin et al., 2011; Szpunar, Addis, McLelland, & Schacter, 2013; Szpunar, Addis, & Schacter, 2012) or in the effects of repeated simulation on evaluations of future events (Szpunar & Schacter, 2013; Wu, Szpunar, Godovich, Schacter, & Hofmann, 2015). For instance, Szpunar et al. (2012) used the experimental recombination procedure to evoke novel simulations of positive, negative, and neutral future events. After a variable delay (10 minutes or 24 hours), the authors re-presented the simulation cues to participants with one aspect of the cue missing and asked participants to fill in the missing detail. The person, place, or object was removed from previously presented cues equally often. The authors found that although emotional simulations were better remembered than neutral simulations after a short delay, positive simulations were better remembered than neutral and negative events after a longer delay, a finding that parallels work on the fading affect bias in the autobiographical memory literature

(Walker & Skowronski, 2009). Importantly, the experimental recombination procedure enabled the researchers to not only rule out the possibility that the frequency of prior thought about specific events could account for these results but also provided an objective way in which to assess memory for specific details of simulated events (see also Martin et al., 2011). As a final note, Szpunar et al. (2012) varied the manner in which person, place, and object details were collected from participants. In one experiment, as with Addis, Pan, et al. (2009), the authors asked participants to generate specific memories associated with unique people, places, and objects. In a second study, participants were allowed to provide lists of familiar people, places, and objects. The advantage of the latter approach is that participants are able to rely on their cellular phones, social media accounts, and online maps to more quickly complete the stimulus generation phase of the experiment. The authors found the same behavioral results regardless of the stimulus collection approach.

More recently, van Mulukom, Schacter, Corballis, and Addis (2016) have expanded the utility of the experimental recombination procedure by asking participants to list people, places, and objects from distinct social circles. In that study, participants were required to imagine events that were based on details that came from either the same social circle or separate social circles. The authors found that the disparateness of event details influenced the detail with which events were imagined and their perceived plausibility. Specifically, more closely related details evoked more detailed and plausible simulations. This social sphere manipulation holds promise for producing insights into factors that play a role in the evaluation of simulated events, such as perceived plausibility.

Finally, recent research by Devitt, Monk-Fromont, Schacter, and Addis (2016) has used the experimental recombination procedure to investigate whether and how imagining novel events based on recombined elements can result in autobiographical memory conjunction errors, in which people come to believe that an imaginary recombined event actually happened. Devitt et al. (2016) reported two experiments documenting that indeed imagining recombined elements of actual memories produced autobiographical memory conjunction errors compared with control conditions (e.g., judging the pleasantness of recombined details without constructing an imagined event). These conjunction errors were more likely to occur when details were partially rather than fully recombined (i.e., two details from one memory recombined with a single detail from another memory versus details from three separate memories), which the authors attributed to increased plausibility and ease of simulating partially recombined versus fully recombined events. Thus, the experimental recombination procedure provides a potentially useful methodological tool for further exploring confusions between imagined and remembered events, a topic of longstanding theoretical interest (see Johnson, Foley, Suengas, Raye, 1988; Loftus, 2003; Schacter, 2012).

Clearly, the experimental recombination procedure has served a useful role in the study of future event simulation and has opened the door for researchers to ask new questions. Nonetheless, the approach is not without its own limitations. Perhaps most important, although the experimental recombination procedure evokes novel simulations of the future, these simulations tend to be somewhat random and unrelated to concerns or goals that individuals may have about the future (Klinger, 1975; Klinger & Cox, 1987). In order to address goals and concerns associated with the future, researchers commonly resort to more-specific cuing techniques that may ask participants to think about goal-oriented scenarios (Gerlach, Spreng, Gilmore, & Schacter, 2011), steps they would take to achieve autobiographical goals (Spreng, Stevens, Chamberlain, Gilmore, & Schacter, 2010), or simply to imagine events associated with their current concerns of the future (Cole & Berntsen, 2016). Indeed, the most appropriate approach for cuing simulations of the future will depend on the goals of the researcher. Next, we turn to methods of data collection as they pertain to the amount or type of details that researchers are interested in extracting from participant-simulated events and the manner in which those events are structured.

## Details of Simulation

The analysis of the contents of simulated events typically entails phenomenological ratings provided by participants following simulation of events or more-detailed descriptions that participants generate in the course of event simulation. The use of phenomenological ratings (e.g., "How detailed is your mental image of the event?") is especially useful in cases in which little time is afforded to ascertain a detailed description of specific events, such as for behavioral studies that require many trials leaving little time for event description and also for event-related fMRI studies that require short trial durations to isolate estimates of neural activity associated with episodic memory and future event simulation. In all cases, the phenomenological details are assumed to provide some insight into the quality of the mental representation experienced by the participant. Most studies of future event simulation have employed phenomenological ratings in some capacity, and some have relied on them as a primary measure (e.g., D'Argembeau & Van der Linden, 2004, 2006).

One limitation associated with phenomenological ratings is that the researcher must often ask participants many interrelated questions in order to assess how, for instance, memories and future events differ from one another in terms of simulated detail. This issue is highlighted by the adaptation of the Memory Characteristics Questionnaire (Johnson et al., 1988; Suengas & Johnson, 1988), which requires participants to rate not only how detailed their mental image was but also how coherent the mental image was in terms of the arrangement or people, objects, and so on (for further detail, see Appendix C). Although this questionnaire, and variations of it, has provided many interesting insights into the characteristics of simulated events, it is also possible that repeated attempts to rate simulated events on the basis of various characteristics could alter some of those characteristics. For instance, various studies have shown that repeated thinking about events increases their level of perceived detail (e.g., Anderson, 1983; Carroll, 1978; Szpunar & Schacter, 2013). Moreover, although providing a rating indicating that a mental image of an event is or is not coherent in terms of the spatial arrangement of people or objects is informative, phenomenological ratings do not provide any insights into exactly how these features of simulated events may be represented by the participant.

One approach that has been used to overcome such limitations is the *autobiographical interview* (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). First employed in the study of autobiographical memory, participants provide descriptions of past and future events over the course of several minutes. The details of those descriptions, which are typically audio recorded, can then be transcribed and scored for detail. First, a central event is identified. Then, the autobiographical interview scoring procedure distinguishes between internal or event-specific details, such as details about specific people, locations, and objects involved in the central event, and external details, such as repetitions, semantic background information, and meta-cognitive commentary (for further details, see Appendix D). As an example of the utility of this approach in the context of future event simulation, Addis et al. (2008) showed that previously documented reductions in internal details in older adults' autobiographical recollections (Levine et al., 2002) extend to simulations of future events. Similarly, the authors also documented that previously observed age-related increases in external details during autobiographical remembering (Levine et al., 2002) extend to simulated future events. Addis et al. (2008) interpreted these findings in the context of the constructive episodic simulation hypothesis, arguing that the parallel age-related changes observed during past and future events (i.e., reduced internal details and increased external details) reflect the impact of episodic memory declines in older versus younger adults. However, an alternative account for such findings is that older, relative to younger, adults possess a more general conversational or narrative style so that they are more likely to construct narratives that contain relatively more external than internal details. To address this possible confound, Gaesser et al. (2011) asked young and old adults to describe memories, future events, or scenes from pictures. Importantly, older adults generated fewer internal and more external details about pictures, as well as memories and future events, than did older adults, highlighting that general factors such as narrative or conversational style can affect performance on the autobiographical interview. However, regression analyses indicated that deficits in generating internal details for memories and future events persisted when performance on the picture description task was taken into account, implicating some role for age-related changes in episodic memory above and beyond the effects associated with narrative style. Nonetheless, given the narrative nature of the autobiographical interview, it is important that narrative processes are controlled in any instances in which differences across groups are considered. Indeed, studies of future event simulation in brain-damaged individuals that make use of the autobiographical interview have begun to incorporate this picture description control task (e.g., Race, Keane, & Verfaellie, 2013).

The foregoing considerations highlight that a critical methodological challenge for studies of future event simulation that rely on the autobiographical interview is to distinguish specific episodic influences from the effects of more general factors such as narrative or conversational style. To address this problem, Madore, Gaesser, and Schacter (2014) developed an *episodic specificity induction*: brief training in recollecting specific details of recent experiences. Their experiments demonstrate that the ability to remember past events and simulate future events rich in internal detail can be boosted by an episodic specificity induction that has no effect on how people describe a picture. For instance, in one study younger and older adults watched videos depicting everyday actions. After one video, participants were required to recall as many specific details as they could about the video (e.g., details about the location, what individuals in the video were wearing, etc.; this specificity induction is based on the well-established *cognitive interview* initially developed by Fisher & Geiselman, 1992). Following a second video, participants were required instead to provide their impressions of the video (e.g., what equipment might have been used to create the video, when the video might have been made, etc.). The order of the specificity and impression inductions was counterbalanced. After each induction, and before viewing the next video, participants were presented with a series of picture cues and asked to remember events from their past in response to some pictures, imagine events in their future in response to other pictures, and describe the content present in yet other pictures. The authors found that the specificity induction served to selectively boost the amount of internal but not external details associated with remembered and imagined events. Importantly, there was no effect of the specificity induction on the production of internal details during picture description, because this task does not require participants to access specific details from episodic memory. A similar pattern of results was observed in a follow-up study in which episodic memory and simulation were compared with a semantic task that required generating definitions of words in a sentence: The specificity induction boosted subsequent internal but not external details during the memory and simulation tasks, but it had no effect on detail generation during the definition task (Madore & Schacter, 2016; for related results, see Madore, Addis, & Schacter, 2015; Madore & Schacter, 2014; for a review and theoretical elaboration, see Schacter & Madore, 2016).

Based on the foregoing results, it seems clear that specificity inductions can provide useful tools for separating episodic and non-episodic influences during tasks such as the autobiographical interview that are commonly used to assess future event simulation. Also, given that many documented cases of deficits in future event simulation are characterized by reductions in internal details, as discussed previously (e.g., Addis, Sacchetti, et al., 2009; Brown et al., 2014; Williams et al., 1996), such inductions hold promise for possibly ameliorating such deficits.

Finally, we briefly highlight other potential uses of the autobiographical interview and related detail-oriented scoring techniques. For instance, Hassabis and Maguire and their colleagues (Hassabis et al., 2007; Hassabis & Maguire, 2007; Mullaly & Maguire, 2013) have put forth the idea that scene construction represents a key feature of event cognition. In one study, Hassabis et al. (2007) asked hippocampal amnesic patients and healthy control participants to simulate events in response to phrases such as “Imagine you are lying on a white sandy beach in a beautiful tropical bay.” Using a 12-item spatial coherence index scale as their dependent variable (among various other dependent variables), the authors found that the descriptions provided by hippocampal-amnesic patients, as compared to healthy control participants, were rated as being more fragmented and lacking in spatial coherence. Notably, spatial relations represent one aspect of internal details that are coded for in the autobiographical interview. Hence, it may be interesting for future work to assess whether cognitive inductions directed toward specific features of simulated events, such as their spatial relations, can be used to selectively enhance the production of those features of interest.

Although the autobiographical interview has provided many insights into episodic memory and simulation, some researchers may be more generally interested in overall levels of specificity associated with simulated events and may wish to employ the use of less intensive scoring approaches. One such alternative approach (Baddeley & Wilson, 1986) involves scoring descriptions of autobiographical (past or future) events on a three-point scale whereby a score of 3 indicates an episodic memory that is specific in time and place, a score of 2 indicates a personal but nonspecific event or a specific event for which time and place are not mentioned, a score of 1 indicates a vague personal memory, and a score of 0 indicates no response or a response based on semantic memory (see also Barsalou, 1988; for an example of this approach in the context of episodic simulation, see Williams et al., 1996).

## Structure of Simulation

Beyond devising techniques to elicit and measure detail associated with episodic simulations, researchers have been interested in further delineating the structure of simulated events. For instance, D'Argembeau and colleagues (D'Argembeau & Demblon, 2012; D'Argembeau & Mathy, 2011; Demblon & D'Argembeau, 2014) have demonstrated that abstract or general autobiographical memory structures that are known to support the retrieval of episodic memories (i.e., personal semantic knowledge and knowledge about general events; Conway, 2005; Conway & Pleydell-Pearce, 2000) also serve to support the construction of future events. In one study, D'Argembeau and Mathy (2011) asked participants to describe specific memories and future events in response to word cues (e.g., *friend*) and scored participant protocols on the basis of whether details about personal semantic information, general events, or specific events were included (Haque & Conway, 2001). The authors found that participants tended to construct memories and future events by initially accessing personal semantic information (e.g., "That makes me think of my friend Philippe who plays bass guitar in our band . . . ") and working their way toward incorporating event specific knowledge (e.g., "If the record sells well, I can imagine us giving a big concert . . . ").

D'Argembeau and Demblon (2012) further demonstrated that episodic memories and simulations of future events are organized as event clusters that refer to general time periods or personal goals. Using an event-cuing paradigm (Brown & Schopflocher, 1998), D'Argembeau and Demblon (2012) asked participants to generate episodic memories and future events in response to cue words (e.g., *vacation*). Later, the authors asked participants to use those memories and future events to respectively generate additional memories and future events. For example, in response to the cue word *vacation,* a participant might imagine a future event wherein they attend an improvisational comedy performance during a trip to Chicago. Later on, when asked to imagine another future event (cued event) in response to the previously generated event (cuing event), the participant might imagine another activity that they could partake in during their scheduled trip (e.g., eating deep dish pizza). The authors found that episodic memories and future events often served to cue past and future events that were thematically related to the cuing events, suggesting that general information about time periods or goals help to organize cognitions about the past and future (for evidence of event clustering under less constrained conditions, see Demblon & D'Argembeau, 2014). In general, such findings fit well with an emerging line of work suggesting that semantic or general memory structures serves to scaffold our ability to think about the future (Irish, Addis, Hodges, & Piguet, 2012; Irish & Piguet, 2013; for related discussion, see Anderson & Dewhurst, 2009; Klein, 2013).

Whereas many researchers have focused on similarities and differences in the *construction* of episodic memories and future events, Anderson, Peters, and Dewhurst (2015) used the standard Galton-Crovitz cuing technique coupled with an adapted production listing procedure (Anderson & Conway, 1993) to compare and contrast *elaboration* of episodic memories and simulations. The production listing procedure (Anderson & Conway, 1993) requires participants to elaborate on details of events in various orders (e.g., chronological versus reverse chronological) to highlight mechanisms that guide event elaboration (e.g., temporal factors). Anderson et al. (2015) give the example of a participant recalling "reading a funny story about a squirrel in the newspaper" in response to the cue word *magazine* and subsequently providing elaborated details along the lines of: “At the top of my street,” “waiting for Steph,” “she texts me,” “I go into the shop,” “buy newspaper,” and so on. Notably, the authors found that participants were especially proficient in listing memory and future event details in chronological as compared to reverse chronological order, suggesting that temporal and schema-based factors play an important role in the elaboration of event details in episodic memory and future thinking. Interestingly, event likelihood modulated performance for future but not past events, further revealing that thematic factors related to goal processing may play an important role in event elaboration.

Although we focus here on the nature of factors that serve to structure and organize episodic simulations, it will also be important for future work to consider the role of component processes involved in future thinking and the manner in which those processes are involved in structuring simulated events (D’Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010). For instance, some initial work has highlighted an important role for executive resources in the construction but not elaboration of episodic simulations of future events (Hill & Emery, 2013). The extent to which such processes are involved in maintaining abstract or general reference frames as participants access information associated with specific event details remains to be examined in the literature.

## Functional Brain Imaging

Much of the emerging research on the relation of episodic memory and simulation has come about in the context of using functional brain imaging to identify their respective neural correlates. In this context, the Galton-Crovitz word-cuing technique and experimental recombination procedure have respectively ensured that participants are simulating specific and novel events in the scanner. However, the neuroimaging literature is often plagued by another limitation. Specifically, estimates of neural activity associated with specific past and future events are often compared against low-level baseline tasks that are meant to incorporate basic processes associated with episodic memory and future event simulation but that lack the episodic detail associated with thinking about the past and future (Schacter et al., 2012). For instance, Addis et al. (2007) used a semantic retrieval task that required participants to generate two words related to a presented cue word and then to organize all three words into a sentence. This task was meant to control for the generation and integration of information present in the context of future event simulation. Taking a different approach, Szpunar et al. (2007) asked participants to simulate events involving a familiar individual (Bill Clinton) with whom they had shared no personal experiences. Although such control tasks can differ considerably, it is important to note that the general findings associated with the core network involved in remembering the personal past and imagining the personal future are highly replicable, regardless of the particular control task that is employed (Benoit & Schacter, 2015; Figure 5.1). Nonetheless, efforts to pinpoint the neural substrates of specific processes associated with simulating the future will require the ability to isolate activity in various regions of the core network. Such insights will be possible only with the development of more precise control conditions.

As an initial attempt to circumvent such issues, we and others (Barron, Dolan, & Behrens, 2013; Gaesser et al., 2013; Szpunar, St Jacques, Robbins, Wig, & Schacter, 2014; van Mulukom, Schacter, Corballis, & Addis, 2013) have begun to make use of functional magnetic resonance (fMR)-repetition suppression in the study of future event simulation. fMR-repetition suppression is a technique that evokes repetition-related reductions in neural activity to demonstrate that specific regions of the brain are sensitive to processing specific classes of stimuli (Grill-Spector, Henson, & Martin, 2006; Schacter, Wig, & Stevens, 2007). For instance, fMR-repetition suppression has been used to demonstrate that distinct regions of the medial temporal lobe are sensitive to the initial, relative to repeated, processing of objects and scenes (Litman, Awipi, & Davachi, 2009) or items and their context (Diana, Yonelinas, & Ranganath, 2012). Although most of this work has been conducted within the domain of perceptual processing, the technique has been extended to identify processes involved in making self-other judgments (Jenkins, Macrae, & Mitchell, 2008) and more recently to distinguish between novel and repeated future event simulations (van Mulukom et al., 2013).

Building on the work reported by van Mulukom et al. (2013), Szpunar, St Jacques, et al. (2014) set out to assess whether repetition suppression could be used to isolate the contributions of specific core network regions to future event simulation. Simulations of future events often involve details about people, places, and scenarios that tie those details together. The premise of the study by Szpunar, St Jacques, et al. (2014) was to manipulate the frequency with which specific elements of a complex event were simulated in order to assess which aspects of the core network would show repetition suppression in response to those particular elements. Among other findings, the results of this study neatly demonstrated that regions of the core network commonly associated with representing information about people, such as medial prefrontal cortex (e.g., Raposo, Vicens, Clithero, Dobbins, & Huettel, 2011), showed repetition suppression when people were repeated but not when locations or scenarios tying people and locations together were repeated. Moreover, regions commonly associated with representing information about places, such as retrosplenial, parahippocampal, and lateral parietal cortices (e.g., Epstein, 2008), showed repetition suppression when places were repeated but not when people or scenarios tying people and locations together were repeated. Last, regions commonly associated with representing information about social scenarios, such as medial prefrontal, posterior cingulate, temporoparietal, and lateral temporal cortices (e.g., Van Overwalle, 2009), showed repetition suppression when particular scenarios were repeated but not when people or locations in isolation were repeated. In sum, repetition suppression holds promise for pinpointing specific cognitive processes subserved by regions of the core network in the context of future event simulation.

Recent work has used episodic specificity induction, which we discussed previously, as another analytical tool for teasing apart the contributions of specific brain regions to particular aspects of future imagining, in this case focused on identifying the contribution of episodic retrieval. Consistent with the idea that the specificity induction enhances the contribution of episodic retrieval to future imagining (e.g., Madore et al., 2014; Schacter & Madore, 2016), an fMRI study by Madore, Szpunar, Addis, and Schacter (2016) revealed that when participants performed a future-imagining task (based on Addis et al., 2007) following an episodic specificity induction, there was increased activation in several core network regions associated with the retrieval of episodic details, including the hippocampus, compared with when participants performed the same future-imagining task following a control induction.

Another analysis approach that may further serve an important role in decomposing the nuanced contributions of various core network structures to future event simulation is multi-voxel pattern analysis (MVPA), wherein machine-learning algorithms are used to decode information (e.g., mental representations) captured by neural activity distributed across cortex (for a detailed review, see Norman, Polyn, Detre, & Haxby, 2006). Using this approach, Kirwan, Ashby, and Nash (2014) demonstrated that whereas traditional univariate analyses did not reveal differences in activity in hippocampus during the elaboration of episodic memories and future events (see also Addis et al., 2007), MVPA nonetheless revealed differences in the spatial distribution of activity in this region. Although these findings are promising, additional work will be needed to demonstrate the utility of MVPA in the context of deconstructing neural contributions to future event simulation (for additional discussion, see Hassabis et al., 2014).

## CONCLUSION AND FUTURE DIRECTIONS

In this chapter we have provided an overview of emerging research on future event simulation based on discussion of methods used for evoking simulated events, collecting details about those events, understanding their structure, and delineating their neural correlates. Although we anticipate that the techniques used to pinpoint the cognitive and neural mechanisms of future event simulation will only be further refined over time, we wish to highlight that studies of episodic simulation may ultimately be about event simulation more generally and not necessarily about the future. Along with possessing the ability to simulate future events, people often also simulate the past as turning out differently than it actually did (i.e., counterfactual simulation; De Brigard & Giovanello, 2012; Roese, 1997) and events that have no temporal basis (i.e., atemporal simulation). Notably, although future event simulation has been shown to differ from counterfactual and atemporal simulation at a cognitive level (De Brigard, Szpunar, & Schacter, 2013; de Vito et al., 2012), the results of fMRI studies generally suggest that the core network supports all of these forms of simulation (Schacter, Benoit, De Brigard, & Szpunar, 2015; Schacter et al., 2012). More work is needed to determine the extent to which temporal factors should be considered in the context of various forms of episodic simulation, because the episodic system appears to subserve the ability to simulate events that are projected into the future, past, or no time in particular.

Finally, as noted at the outset of the chapter, we have recently suggested that episodic simulation may represent one form of cognition that may adaptively prepare the individual for the future (Szpunar, Spreng, et al., 2014). In addition to episodic simulation, it is also the case that people may simulate future autobiographical states that are not related to specific episodes (e.g., what it will be like to graduate from college) and abstract states of the world that are not necessarily tied to the personal future (e.g., the effects of global warming on ecosystems). Although full consideration of these various forms of simulation is beyond the scope of this chapter, we suspect that the various cuing techniques and methods of assessing details and structure associated with episodic simulations will turn out to be useful in the study of simulation more broadly construed. In addition, survey techniques may also turn out to provide insights into how and how often people naturally engage in various forms of simulation in their daily lives (and also the extent to which such thoughts may come to mind spontaneously; Berntsen & Jacobsen, 2008). For instance, D'Argembeau, Renaud, and Van der Linden (2011) found that only half of the thoughts that people have about their future are about specific events. Given the recent advances in the study of simulation of specific future events (for fuller discussion of recent developments, see Schacter, Benoit, & Szpunar, 2017), the future appears ripe for new discoveries about the manner in which we simulate more general aspects of our lives and the world around us.

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## APPENDIX A: SAMPLE GALTON-CROVITZ STIMULUS LIST

When constructing word cues for a future event simulation study that includes more than one condition, researchers typically attempt to create groups of word lists that are matched on characteristics such as frequency, imageability, and concreteness in order to increases the chances that participants are able to generate detailed simulations or memories of events (Addis et al., 2007).

Here we present a sample stimulus set made using the MRC Psycholinguistic Database (www.psych.rl.ac.uk), which is composed of three lists matched in terms of letters, syllables, letters, frequency (minimum 100), imageability (minimum 300), and concreteness (minimum 300) (compiled by David Maillet). For this sample study, counterbalancing might be used to determine which list would be used to elicit episodic memories, future events, or used as a set of lures for a recognition memory test presented after the study. As further discussed in Appendix B, whether memory for simulations is tested post-study depends on the specific interests of the researcher.

### Sample Lists

**List 1**: Porch, Shower, Book, Soup, Lake, Bird, Couch, Ice, Tie, Truck, Cake, University, Telephone, Grave, Policeman, Bridge, Fish, Spoon, Piano, Ceremony, Mail, Bank, Road, Suit, Map, Pen, Ocean, Fire, Magazine, Cane, Movie, Bag, Costume, Bath, Bill, Radio, Mirror, Desk, Tea, Ball, Flower, Fan, Pencil, Pillow, Carpet

**List 2**: Key, Fork, Lamp, Newspaper, Park, Coffee, Market, Lightening, Candle, Boat, Hat, Train, Dog, Gun, Toy, Orchestra, Cigarette, Highway, Moon, Shoe, Tomato, Stairs, Breakfast, Butter, Circus, Ring, Church, Pool, Cherry, Steak, Doll, Cat, Chocolate, Knife, Grass, Dress, Refrigerator, Kettle, Jar, Jam, Cream, Party, Oven, Envelope, Journal

**List 3**: Bee, Bed, Hospital, Photograph, Table, Boot, Juice, Glove, Appointment, Diamond, Camera, Pie, Crowd, Honey, Candy, Kiss, Closet, Library, Milk, Orange, Gift, Bell, Chair, Soap, Cabinet, Rat, Hotel, Watch, Beer, Forest, Blanket, Tree, Apple, Basket, Purse, Rose, Belt, Fireplace, Clock, Plane, Flag, Snow, Car, Cocktail, Brush

## APPENDIX B: SAMPLE EXPERIMENTAL RECOMBINATION PROCEDURE PROTOCOL

When constructing participant-specific cues using the experimental recombination procedure, researchers will commonly provide a general set of instructions that are intended to guide the manner in which participants generate specific memories containing names of specific people, places, and objects (memory method) or lists of familiar people, places, and objects (list method). Here we present an example of the list method of stimulus generation.

### Instructions

**People:** Please list (*number of items experimenter requires*) names of people that you know personally and that you are most likely to interact with in the future. For each person, please provide his or her first name and first initial of his or her last name in order to avoid any confusion in cases when you list a particular name more than once. In order to complete this list you may use the contact list in your cellular phone, e-mail account, Facebook account, or any other social media that would help to jog your memory. *NB. The exact instructions will depend on what the researcher wants to study. For instance, some researchers may be interested in amassing lists of names from multiple social circles (e.g., van Mulukom et al., 2016).*

**Places:** Please list (*number of items experimenter requires*) names of places that you have been to before and that you are most likely to visit again in the future. For each instance, please ensure that the location you list is specific (e.g., Harvard Yard instead of Harvard University) so that you can easily imagine precisely where an event would take place. If there is more than one of the locations you mention (e.g., Starbucks) please make sure to specify which one you are referring to. (e.g., Starbucks–Harvard Square). Finally, please only use each location once (e.g., do not list different rooms within your apartment as examples, only list your apartment). Please feel free to use Google Maps or any other Internet tools to help jog your memory. *NB. The exact instructions used will depend on exactly what the researcher wants to study. For instance, in some cases the researcher may want to ensure that the locations are highly specific (e.g., Johnston Gate–Harvard Yard instead of Harvard Yard; my apartment-kitchen instead of my apartment; e.g., Szpunar et al., 2014).*

**Objects:** Please list (*number of items experimenter requires*) names of objects that you commonly interact with and that are portable and can be used in a variety of locations. For instance, a cell phone would be a good example because it is easily portable and can be used in a variety of settings, whereas a couch or toilet paper would be bad examples because they are either not portable (couch) or not typically used in a variety of settings (toilet paper). Please feel free to use the Internet to help jog your memory.

### Experimental Recombination and Cue Generation

Once participants have generated their stimulus lists the items from those lists will be randomly reorganized to generate a unique set of person-location-object cues that will serve to evoke simulations of future events (see text for specific instructions). As outlined in the text, participants will generally be instructed to imagine events that involve interacting with the specified person, in the specified location, and in a manner that involves the specified object. *NB. Depending on the interests of the researcher, the simulation cues may further be paired with other cues for simulation (e.g., emotion tags; Szpunar et al., 2012).*

### Memory Test (Optional)

One distinct advantage of the experimental recombination procedure is that it enables the researcher to objectively assess memory for simulated events. Importantly, given the random nature of the cues, participants have likely never thought about the events in question before and so memory of the simulated event is often based on the singular simulation that participants had generated earlier in the experimental session. To assess memory for simulations the researcher will typically remove one aspect of the simulation cue (e.g., person, location, or object) and ask the participant to fill in the missing detail. The three aspects of the simulation cue should be removed equally often (e.g., Martin et al., 2011; Szpunar et al., 2012).

## APPENDIX C: SAMPLE ADAPTED MEMORY CHARACTERISTICS QUESTIONNAIRE

When assessing phenomenological characteristics associated with simulated events most researchers will tailor the questions they ask depending on their specific interests (e.g., ratings of detail, plausibility, spatial coherence, and so on). Nonetheless, the field has benefited considerably from the adaptation of the memory characteristics questionnaire (Johnson et al., 1988) in that the survey includes a variety of features of events that have turned out to differ between episodic memory and simulated events. Using this approach, memories and future events are typically rated on seven-point scales for visual details (1 = none, 7 = a lot), sounds (1 = none, 7 = a lot), smell-taste (1 = none, 7 = a lot), clarity of location (1 = not at all clear, 7 = very clear), clarity of spatial arrangement of objects (1 = vague, 7 = clear and distinct), clarity of the spatial arrangement of people (1 = vague, 7 = clear and distinct), clarity of time of day (1 = not at all clear, 7 = very clear), valence of the emotions involved in the event (1 = negative, 7 = positive), intensity of the emotions involved in the event (1 = not intense, 7 = very intense), feelings of reexperiencing (or preexperiencing) the event when remembering (or imagining) it (1 = not at all, 7 = a lot), importance of the event for the self-image (1 = not at all important, 7 = very important). Participants may also be asked to indicate the visual perspective associated with their remembered or imagined event and the temporal distance from the present in which the event took or will take place. *NB. The various ratings included in the memory characteristics questionnaire will often be grouped according to their interrelationships for the purposes of analysis. For instance, ratings for visual details, sounds, and smell-taste are often aggregated into a general sensorial details measure, and ratings for clarity of location, spatial arrangement of objects, and spatial arrangement of people are commonly grouped into a clarity of location index. As a point of comparison, Hassabis et al. ( 2007) included items such as "I could see the whole scene in my mind's eye" and "It was a collection of separate images" in order to assess spatial coherence in their work. The extent to which various measures of spatial clarity and coherence assess similar phenomenological features of simulated events has not been formally investigated.*

## APPENDIX D: USING THE AUTOBIOGRAPHICAL INTERVIEW TO STUDY FUTURE EVENT SIMULATION

In many instances researchers audio record verbal descriptions of future events in order to extract details that are difficult to otherwise tap with phenomenological ratings or that can help to add greater depth to information that can be ostensibly collected via the use of rating scales. The manner in which such protocols are scored can vary widely. Whereas some researchers simply choose to code verbal protocols to gain insights into the reasons why future events are simulated (e.g., relationship issues, work issues, etc.; D'Argembeau & Van der Linden, 2004) other approaches set out to assess in greater detail the extent to which simulated events are composed of episodic or specific and semantic or general details (see text for discussion of temporal factors; D'Argembeau & Mathy, 2011).

Perhaps the most commonly used approach is the autobiographical interview (Levine et al., 2002), which involves scoring verbal protocols for the presence of various internal details (e.g., people, places, objects, spatial relations, emotions) and external details (e.g., extraneous information, repetition of details). Notably, internal and external details are generally respectively equated as indicating the presence of episodic and semantic information. As a brief example, consider the word cue *baby* and the associated verbal protocol of a future event:

> Well, my friend Fadi and his wife Diana just had a baby. Therese and I are due for a visit home next weekend, so I imagine that we would make a stop on Saturday afternoon to Fadi and Diana's place to see the new baby. I can imagine arriving at their home and ringing the bell. It would probably take a while for someone to answer the door because this is

> their third child, so things are probably a little hectic. After a few seconds, Diana answers the door to greet us. We are all happy to see one another. We come inside, remove out shoes, and make our way upstairs where Fadi is sitting with the newborn infant . . .

The paragraph includes internal or episodic details about specific people (Fadi, Diana, Therese), places (Fadi's home), and objects (shoes), along with external or semantic details that do not depict anything about the contents of the specific episode per se but rather provide relevant background information (e.g., Fadi and his wife just had a baby). As noted in the text, such scoring techniques can be used to focus on not only distinctions between episodic and semantic details but also various instances of episodic details (e.g., spatial versus temporal information). *NB. Scoring of verbal protocols using the autobiographical interview requires considerable training for multiple scorers (at least two) who are blind to the goals of the research.*