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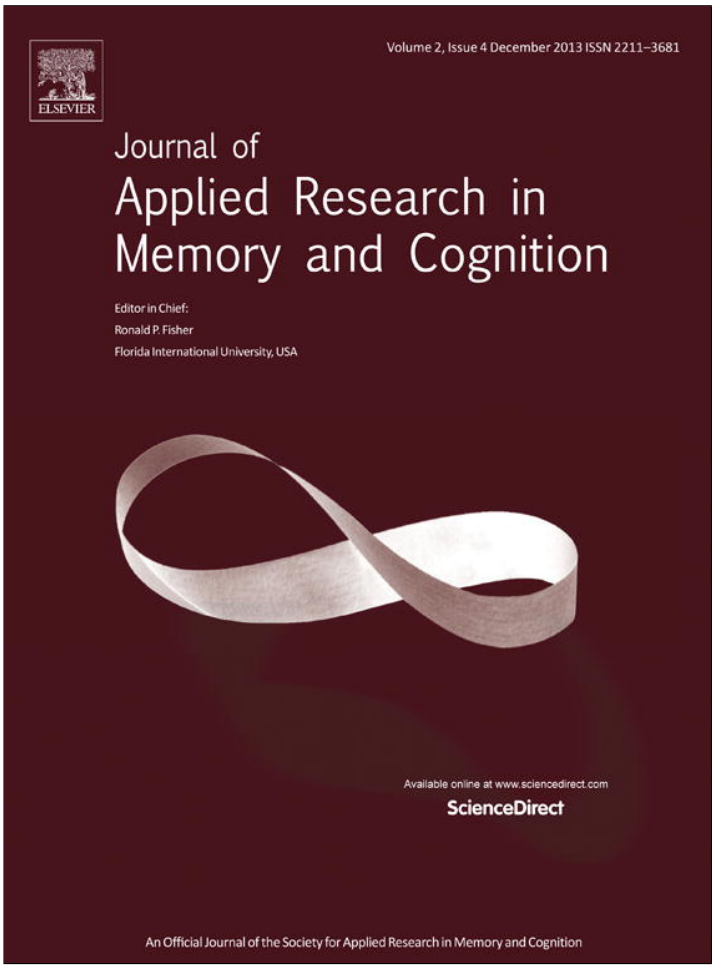

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Commentary

Memory-mediated simulations of the future: What are the advantages and pitfalls?

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Over the last 5 years, psychologists and neuroscientists have produced a wealth of data indicating that memory and future thinking are not only closely related to one another, but that memory plays an important role in future-oriented cognition (for a recent review, see Schacter et al., 2012; Szpunar, 2010). This basic idea is not new to the psychological literature. For instance, psychologists have long been interested in the directive function of specific memories of the personal past (e.g., Pillemer, 2003). Rather, the novel contribution of the emerging line of research is that details of various memories, either specific or abstracted from common experiences, can be used to simulate, among other things: alternative ways in which specific past experiences might play out in the future; novel events that have little or no basis in specific past experiences; and possible alternatives to novel future events (Schacter & Addis, 2007; Schacter, Addis & Buckner, 2008). Here, we discuss the efficacy with which healthy human adults are able to engage the reconstructive processes associated with these kinds of simulations. We then highlight the utility of evolutionary analyses of memory in directing researchers to questions regarding the adaptive value of memory. Finally, we conclude by pointing to studies that have begun to illuminate the adaptive value of memory-mediated simulation, and consider specific issues that warrant further investigation.

Perhaps one of the most interesting results to come out of recent studies of future thinking, and one that helps to support Klein's (2013) argument that humans are especially well equipped to use memory to simulate the future, has to do with how quickly people are able to pull together disparate details from their past into a coherent mental representation of the future. To help illustrate this point, we must first consider how future thinking is commonly studied in the laboratory. On a daily basis, people frequently and repeatedly simulate future events (e.g., D'Argembeau et al., 2011). This makes it difficult to bring future event simulations under direct experimental control. For instance, suppose one were interested in studying how well people remember their future simulations (see Szpunar, Addis, Mclelland, & Schacter, 2013). This question becomes difficult to answer when one considers that people may have simulated specific events dozens or even hundreds of times before they enter the laboratory, and that the frequency of repeated simulation may vary as a function of other variables (e.g., emotion; for a review of related issues, see Szpunar, Addis, & Schacter, 2012).

The *experimental recombination procedure* was designed to sidestep these kinds of issues, and allow researchers to study novel simulations of the future in the laboratory. Specifically, participants are first required to provide information about familiar people, places, and objects either on the basis of details gleaned from specific memories (Addis, Musicaro, Pan, & Schacter, 2010; Addis, Pan, Vu, Laiser, & Schacter, 2009) or self-generated lists (Szpunar et al., 2012; Szpunar & Schacter, 2013). This information is then used to create a series of random person–location–object triads that serve as simulation cues. For instance, consider the following elements from your own personal past: your neighbor, your local grocery store, and an umbrella. Now imagine a future interaction with your neighbor that integrates each of these elements, and that this interaction transpires in a way that leaves you feeling good about yourself. In all likelihood, you have not previously grouped these

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specific details in the context of a simulated event. Nonetheless, a coherent mental image comes to mind, and rather quickly. In fact, studies using this technique have shown that people are typically able to generate a coherent mental image in response to these kinds of cues in approximately 6.5 s (e.g., Addis et al., 2009).

These simple but provocative data highlight the fact that people are rather adept at taking details from their past experiences and using them to generate possible futures. It is important to note, however, that people can just as quickly simulate hypothetical scenarios that do not take place in the future (De Brigard, Szpunar, & Schacter, 2013). Nonetheless, the point that Klein (2013) argues is that memory-mediated simulations of hypothetical events can be used to prepare for the future, regardless of whether those simulations are imagined as occurring in the past, present, future, or in an atemporal manner (e.g., de Vito, Gamboz, & Brandimonte, 2012).

Of course, the fact that people are quick to pull together details of their past in the service of simulating hypothetical scenarios, and that these simulated scenarios may help to anticipate future courses of action, does not provide evidence that memory evolved for this function. The data merely support the hypothesis that this could be the case. Indeed, arguments based on evolutionary analyses can only take us so far. Perhaps, as Klein (2013) points out, the most important contribution of an evolutionary analysis of the function of memory is to help re-frame the questions we ask about memory. And herein, we believe, lays an important next step in the study of memory-mediated simulation. From the perspective of adaptive behavior and function, how exactly do memory-mediated simulations benefit the individual in the real world?

As it turns out, considerable work has already identified how memory-mediated simulations can benefit behavior. To name just a few examples, imagining the process of accomplishing a desired goal (e.g., resolving a dispute with a romantic partner) can help people to identify possible contingencies and better prepare for the task at hand (e.g., Taylor, Phan, Rivkin, & Armor, 1998); comparing a desired goal with present circumstances can help people to fine tune goal pursuit (e.g., identifying which goals are realistic and which ones are not; Oettingen, 2012); and simulations of the future can be used to adaptively guide decision-making in terms of financial spending (e.g., Benoit, Gilbert, & Burgess, 2011; see also Boyer, 2008) and attitudes toward members of outgroups (e.g., Crisp & Turner, 2009; for a more comprehensive review, see Schacter, 2012).

Notably, research into the adaptive value of memory-mediated simulation has also identified instances in which simulation of the future can impede goal attainment. As one example, simulating positive outcomes without relating those outcomes to one's present circumstances can lead people to pursue goals in vain (for a review, see Oettingen, 2012). Such findings are important because they highlight important nuances related to the adaptive value of memory-mediated simulation, and future research will need to more clearly delineate the associated advantages and pitfalls.

For instance, one common argument for the adaptive value of future event simulation is that it allows people to consider alternative courses of action before they ever experience the event in question. Although this line of reasoning is fairly intuitive, to our knowledge, next to nothing is known about the extent to which people naturally entertain alternative simulations as a means of making decisions about their future in daily life. As one example, a student may contemplate the pros and cons of staying in to study or going out with friends. To what extent do these alternative simulations influence their behavior? How are the various alternatives weighted? To what extent does weighting of alternatives depend on the individual's present circumstances (e.g., time left before the test; cf. Oettingen, 2012)? To take a more extreme example, anxiety disorders are commonly characterized as disorders of future thinking in which the individual is overly concerned with negative future outcomes (Barlow, 2000). Put another way, anxious individuals do not properly weight neutral or positive alternative outcomes of future events. Interestingly, recent research has demonstrated that people with a predominantly negative outlook about the future can be trained to focus on more levelheaded alternative future outcomes (e.g., Murphy, Hirsch, Mathews, Smith, & Clark, 2007; Bentz et al., 2009). Hence, it is easy to see how alternative simulations of the future can benefit the individual. Nonetheless, future research will be needed to more fully delineate the extent to which people simulate alternative futures, how they weight those simulations in making decisions, and how holding alternative views of the future can benefit psychological adjustment.

In sum, Klein (2013) has done the important task of directing researchers interested in memory-mediated simulation toward questions that focus on how such processes, which people are highly capable of engaging, benefit real-world behavior. To this point, we believe that assessing the extent to which people actually make use of various instantiations of memory-mediated simulation in their daily lives, and how memory-mediated simulation can not only benefit but also impede behavior that will be necessary in order to better understand the adaptive value of this important cognitive faculty.

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