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Remembering the past and imagining the future: Identifying and enhancing the contribution of episodic memory

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Abstract

Recent studies have shown that imagining or simulating future events relies on many of the same cognitive and neural processes as remembering past events. According to the constructive episodic simulation hypothesis (Schacter and Addis, 2007), such overlap indicates that both remembered past and imagined future events rely heavily on episodic memory: future simulations are built on retrieved details of specific past experiences that are recombined into novel events. An alternative possibility is that commonalities between remembering and imagining reflect the influence of more general, non-episodic factors such as narrative style or communicative goals that shape the expression of both memory and imagination. We consider recent studies that distinguish the contributions of episodic and non-episodic processes in remembering the past and imagining the future by using an episodic specificity induction – brief training in recollecting the details of a past experience – and also extend this approach to the domains of problem solving and creative thinking. We conclude by suggesting that the specificity induction may target a process of scene construction that contributes to episodic memory as well as to imagination, problem solving, and creative thinking.

Keywords

episodic memory; episodic simulation; imagining the future; episodic specificity induction

Decades of research in psychology and neuroscience have revealed much about how memory connects individuals to the past, but researchers have increasingly realized that memory is also important for connecting the present with the future (Szpunar et al., 2014). This realization has been fueled in part by demonstrations of striking similarities in the cognitive and neural processes involved in remembering the past and imagining or simulating possible future experiences (for recent reviews, see Klein, 2013; Schacter et al., 2012; Szpunar, 2010). These similarities include phenomenal characteristics (e.g. similar sensory and contextual features; D'Argembeau and Van der Linden, 2004; Szpunar and McDermott, 2008), a common tendency to reflect major concerns of the self (e.g. Rathbone et al., 2011), and reliance on a common core network of brain regions (e.g. Benoit and Schacter, 2015; Buckner and Carroll, 2007; Schacter et al., 2007; Spreng et al., 2009). Some

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differences between remembering the past and imagining the future have also been documented (for discussion, see MacLeod, 2016; Schacter et al., 2012), but the similarities are striking nonetheless.

A number of researchers have argued that these similarities arise, at least in part, because remembering past experiences and imagining future experiences both rely heavily on a particular form of memory known as *episodic memory*. According to Tulving (2002), episodic memory supports our ability to recollect specific personal experiences – events that happened to us at particular times and places in the past. Episodic memory allows the remembering self to engage in “mental time travel” and to consciously re-experience a past happening. Episodic memory is thus distinguished from other kinds of memory, such as *semantic memory*, which supports general knowledge and retrieval of factual information, and *procedural memory*, which supports the acquisition of skills, as well as related forms of nonconscious or *implicit memory* (e.g. Schacter and Tulving, 1994).

Evidence that episodic memory plays an important role in imagining future experiences comes from various sources. For example, amnesic patients, who have severe deficits in episodic memory as a consequence of damage to brain regions including the hippocampus, also have difficulties imagining their personal futures or novel scenes (e.g. Conway et al., 2016; Hassabis et al., 2007; Klein et al., 2002; Race et al., 2011; but see also, Squire et al., 2010). A striking example comes from the profoundly amnesic patient KC: he could not remember a single specific episode from his past, nor could he imagine a single specific episode that might occur in his personal future (Rosenbaum et al., 2005; Tulving, 1985). Similarly, other patient populations that exhibit reduced recall of episodic details about their personal pasts also imagine relatively few episodic details about their personal futures, including patients with temporary amnesia (Juskenaitė et al., 2014), depression (Williams et al., 1996), schizophrenia (D’Argembeau et al., 2008), post-traumatic stress disorder (Brown et al., 2014), and Alzheimer’s disease (Addis et al., 2009).

These and related observations led Schacter and Addis (2007) to put forth the *constructive episodic simulation hypothesis*: a critical function of episodic memory is to support the construction of imagined future events by allowing the retrieval of information about past experiences, and the flexible recombination of elements of past experiences, into simulations of possible future scenarios. This flexibility of episodic memory makes it well suited to supporting simulations of different ways that future experiences might unfold, but according to the constructive episodic simulation hypothesis, this very flexibility can also result in memory errors from miscombining elements of past experiences or confusing imagined and actual events (Schacter and Addis, 2007; for recent evidence, see Devitt et al., 2016, and for related ideas, see Dudai and Carruthers, 2005; Dudai and Edelson, 2016; Schacter, et al., 2011; Suddendorf and Busby, 2003).

It is important to note that while the constructive episodic simulation hypothesis focuses on the contribution of episodic memory to imagining future experiences, it is clear that general knowledge or semantic memory also contributes importantly to future thinking (e.g. Irish et al., 2012). While a discussion of the contribution of semantic memory to future thinking is beyond the scope of the present article, several recent articles summarize and discuss

relevant evidence (Klein, 2013; MacLeod, 2016; Merck et al., 2016; Schacter et al., 2012; Szpunar et al., 2014).

A Challenge to the Constructive Episodic Simulation Hypothesis

In line with the evidence discussed above, several studies have shown that healthy older adults provide fewer episodic details than young adults both when they remember the past and imagine the future (see Schacter et al., 2013, for a recent review). This pattern was first reported in a study from our laboratory by Addis et al. (2008) where young and older adults performed an adapted version of the Autobiographical Interview (AI; Levine et al., 2002), which distinguishes between the “internal” and “external” details that comprise autobiographical memories. Internal details reflect episodic information: what happened during an experience, who was there, and when and where the event occurred. By contrast, external details are mainly comprised of semantic information: related facts, reflections on and inferences about the meaning of what happened, or references to other events. Addis et al. (2008) reported that older adults provided significantly fewer internal/episodic details and more external/semantic details about both remembered past events and imagined future events compared with young adults. These and subsequent similar findings (e.g. Addis et al., 2010; Cole et al., 2013; Rendell et al., 2012) suggest that age-related differences in remembering the past and imagining the future may be primarily attributable to changes in episodic memory mechanisms, and thus support the constructive episodic simulation hypothesis.

However, this conclusion was challenged by further research in our laboratory showing that when older adults simply describe a picture of a complex scene, a task that should not recruit episodic memory mechanisms, they also exhibit reduced internal details (i.e. details referring to elements present in the picture) and increased external details (i.e. commentary and inferences about the picture; Gaesser et al., 2011). These findings raise the possibility that age-related changes in remembering the past and imagining the future reflect primarily the operation of non-episodic mechanisms, such as changes in narrative style or communicative goals that occur with aging and could affect performance similarly on memory, imagination, and picture description tasks. For example, some studies suggest that older adults employ a more general narrative style and have different communicative goals than young adults (e.g. Adams et al., 1997; Labouvie-Vief and Blanchard-Fields, 1982). If older adults communicate in a more general way than do young adults, then they may report fewer internal details and more external details than young adults when asked to remember the past and imagine the future not because of age-related differences in episodic memory mechanisms, but because of differences in descriptive ability, narrative style, or other non-episodic processes that produce similar patterns on a picture description task (for general discussion of narrative and memory, see Fivush and Merrill, 2016).

These findings also raise broader questions about interpreting similarities between remembering the past and imagining the future, even in studies that are not focused on aging. Contrary to the central idea of the constructive episodic simulation hypothesis that these similarities reflect mainly the operation of episodic memory processes, such similarities might reflect primarily or entirely the operation of more general, non-episodic

processes, such as communicative goals or narrative style, that similarly influence remembering the past, imagining the future, and describing a picture in the present. Observations of cultural effects on remembering the past and imagining the future (see Wang, 2016) also suggest a role for general influences. These observations raise an important question: Can we identify the contribution of episodic memory to performance on a particular cognitive task and distinguish it from the influences of non-episodic processes?

Distinguishing Episodic from Non-Episodic Processes: An Episodic Specificity Induction

We (Madore et al., 2014) recently developed an experimental approach to distinguish episodic from non-episodic influences that relies on what we call an *episodic specificity induction*: brief training in recollecting details of a recent experience (cf. Maestas and Rude, 2012; Neshat-Doost et al., 2012; Raes et al., 2009). The logic of our approach is straightforward: if a cognitive task relies at least in part on episodic memory, then performance on that task should be affected by a prior episodic specificity induction. By contrast, if performance on a cognitive task does not rely on episodic memory, then task performance should not be influenced by a prior episodic specificity induction. Thus, we use the specificity induction as an experimental tool for targeting episodic memory.

Our episodic specificity induction is based on a well-established procedure known as the Cognitive Interview (CI; Fisher and Geiselman, 1992), a protocol that encourages people to focus on specific details of past experiences during retrieval attempts, and that is useful for increasing detailed episodic recall in eyewitnesses (for review, see Memon et al., 2010). In our first study using this induction (Madore et al., 2014), both young and older participants viewed a video of people interacting in a kitchen. For the specificity induction, participants were then guided to recall the video in specific episodic detail with procedures adapted from the CI: generating a mental picture and reporting everything they remember about the scene in as much detail as possible, including what people looked like and did, how objects were arranged, and so forth. For a control induction, the same participants watched a video similar to the one shown before the specificity induction and were then instructed to provide their general impressions of the video, but were not asked to recall specific details. Shortly after each induction, participants viewed pictures of everyday scenes, and either remembered past experiences or imagined future experiences related to each picture, or simply described the contents of the pictures, as in the earlier work from our laboratory (Gaesser et al., 2011).

Compared with the control induction, the episodic specificity induction produced an increase in the number of internal (episodic) details that young and older participants provided when they remembered past experiences and imagined future experiences. In sharp contrast, however, the specificity induction had no effect on the number of external (semantic) details that participants produced on these memory and imagination tasks. Critically, the specificity induction had no effect on the number of internal or external details that participants produced on the picture description task. We replicated this pattern of results in a second experiment using a different control induction (Madore et al., 2014).

These findings suggest that the specificity induction selectively targets and enhances episodic retrieval, dissociating it from both semantic retrieval and narrative description. We therefore argued that, in line with the constructive episodic simulation hypothesis, these data provide strong evidence that remembering the past and imagining the future (but not describing a picture) depend heavily on episodic memory. However, another interpretation is that whereas the memory and imagination tasks require participants to generate details that are not present in the picture cues, describing a picture is more directly constrained by the properties of the presented picture and does not require such generative retrieval. Perhaps the specificity induction impacts *any* task that requires generative retrieval, whether or not that task involves episodic memory in particular (for discussion of generative retrieval, see Addis et al., 2012; Conway and Pleydell-Pearce, 2000). Therefore, it is important to determine whether an episodic specificity induction still selectively affects memory and imagination tasks compared with a non-episodic control task that also requires generative retrieval.

To address the issue, Madore and Schacter (2016) conducted an experiment that is similar to the one described above with two important differences. First, we used words instead of pictures as cues for memory and imagination. Second, for the non-episodic task we used a *word comparison* task in which participants receive a word cue, generate a size sentence that included the word cue as well as related words (e.g. for the cue word “Apple”, a size sentence would be “Tree is larger than Pie is larger than Apple”), and then generate definitions for the three nouns. For this task, the critical measure is the amount of detail in the definitions that participants generate.

The results showed again that the episodic specificity induction, compared with control inductions, boosted the number of internal details that people provide when remembering past experiences and imagining future experiences. Critically, the specificity induction had no effect on the word comparison task: the definitions that participants generated contained similar amounts of detail following the episodic specificity induction and the control inductions.

These findings are important because 1) they indicate that the specificity induction selectively impacts episodic retrieval during remembering and imagining even when the non-episodic task (i.e. word comparison) requires generative search and retrieval; and 2) along with the results of our previous experiments, these data show that the specificity induction increases the amount of detail contained in episodic simulations of future experiences. In light of the many adaptive functions supported by episodic simulation (Schacter, 2012), specificity inductions may be useful for enhancing performance on tasks that benefit from detailed episodic simulations (e.g. Beaman et al., 2007; Gaesser and Schacter, 2014; MacLeod, 2016; Sheldon et al., 2011). We elaborate on this point in the next section.

Using the Specificity Induction to Identify Contributions of Episodic Memory to Means-End Problem Solving and Divergent Creative Thinking

The foregoing results suggest that we can use the specificity induction to identify and enhance possible contributions of episodic memory to other cognitive tasks that do not

require episodic memory, but may nonetheless be influenced by it. One such task is Means-End Problem Solving (MEPS; Platt and Spivack, 1975), where people are presented with hypothetical social problems, such as difficulties with friends or handling a situation at work, and are asked to generate steps or means that lead to problem solutions. For example, a step that is relevant to solving a problem involving difficulties with friends would be to ask a friend about what is wrong. Several studies suggest that episodic memory may contribute to performance on the MEPS task in depressed and anxious individuals (e.g. Raes et al., 2005), as well as in healthy young and older adults (e.g. Beaman et al., 2007; Sheldon et al., 2011).

In light of these results and our previous specificity induction studies, we predicted that our episodic specificity induction would enhance performance on the MEPS task. We tested the prediction in an experiment where young and older adults received either an episodic specificity induction or a control induction, and then performed the MEPS task (Madore and Schacter, 2014). Consistent with our prediction, participants in both groups generated a greater number of steps relevant to solving MEPS problems following the episodic specificity induction than following a control induction, and their solution steps contained more episodic details after the specificity induction. By contrast, type of induction had no effect on the number of irrelevant steps that participants generated, indicating again that the effects of the specificity induction are selective.

Recent evidence also suggests a link between episodic memory and a component of creativity known as *divergent thinking* or the ability to generate creative ideas by combining diverse types of information (Guilford, 1967). For example, amnesic patients with episodic memory deficits also exhibit impairments in divergent thinking (Duff et al., 2013) and brain regions associated with episodic memory become active during a divergent thinking task (e.g. Benedek et al., 2014). Moreover, a study from our laboratory showed that performance on a divergent thinking task is positively correlated with the amount of episodic detail that young and older adults generate when they imagine future experiences (Addis et al., 2016).

These findings led us to predict that performance on a divergent thinking task would be enhanced by a prior episodic specificity induction. We tested this hypothesis on the Alternate Uses Task, where participants attempt to generate unusual and creative uses of common objects (e.g. try to think of different ways in which a newspaper could be used; Guilford, 1967). In line with our hypothesis, participants generated significantly more unusual uses on this task after an episodic specificity induction than after a control induction (Madore et al., 2015). Once again, the effects of the specificity induction were selective: type of induction had no effect on performance on an object association task in which participants were given the names of common objects and attempted to think of related objects. The object association task is thought to involve little divergent thinking or episodic imagery (Abraham et al., 2012), and thus we expected that performance on this task would not benefit from a prior specificity induction, in line with observed results.

Concluding Comments

The findings reviewed in this article support two broad conclusions. First, the specificity induction can help to distinguish episodic retrieval processes that are important for memory and imagination tasks from non-episodic processes that are important for tasks such as picture description and word comparison. These findings support the constructive episodic simulation hypothesis (Schacter and Addis, 2007) by specifically linking episodic memory with imagining future experiences. Second, the specificity induction can be used to identify and enhance the contribution of episodic retrieval to a range of cognitive tasks, including imagining the future, solving means-end problems, and divergent creative thinking.

An important challenge for future research is to characterize more precisely what processes common to memory, imagination, problem solving, and divergent thinking tasks are impacted by the specificity induction. We think that the specificity induction biases the way in which participants approach cognitive tasks by encouraging them to focus on episodic details related to places, people, or actions, which in turn impacts subsequent performance on tasks that involve creating mental events containing details like those emphasized during the specificity induction. Thus, the specificity induction may impact primarily what Hassabis and Maguire (2007) have called *scene construction*: assembling and maintaining a coherent mental scene or event. Scene construction is closely related to episodic memory. As Hassabis and Maguire (2007) observed, “A rich recollective experience is a key feature of episodic memory recall...Here, we have put forward the case for scene construction as a well-defined and key component process in supporting that recollective experience. Scene construction provides the stage on which the remembered event is played...” We agree with this assessment, and further hypothesize that some degree of scene construction is involved when people remember a past experience, imagine a future experience, simulate ways to solve everyday means-end problems, or generate alternative uses of objects. The induction, by biasing an episodic retrieval orientation toward specificity, may facilitate subsequent scene construction by encouraging people to focus their retrieval attempts on details of the key elements that comprise a mental scene (i.e. people, objects, or settings). By contrast, we suggest that scene construction plays little or no role in tasks such as picture description, word comparison, or object association, which are not impacted by the specificity induction and should not require mental scene building. While it will be important for future studies to test this hypothesis experimentally, note that research on scene construction has focused especially on the *spatial coherence* of constructed scenes; indeed, one of the key measures of scene construction, the spatial coherence index, assesses the spatial integrity of a constructed scene (Hassabis et al., 2007). We do not claim that the specificity induction selectively impacts the spatial coherence of a constructed scene. Instead, we suggest that the induction could potentially impact the details associated with both elements of a scene and their relations, including spatial relations. Thus, we use the term “scene construction” in a broad sense that is roughly similar to the notion of “event construction” discussed by others (e.g. Romero and Moscovitch, 2012).

If the specificity induction does indeed impact primarily a scene or event construction process, questions arise concerning whether the induction selectively or exclusively impacts episodic memory processes associated with such constructions. As noted earlier, scene

construction and episodic retrieval are closely related, and therefore it makes good sense that an episodic specificity induction would impact scene construction. But according to Hassabis and Maguire (2007), scene construction is also involved in imagining scenes that are not, strictly speaking, “episodic” in the sense that they do not refer to a particular personally experienced episode from the past or to a possible personal future episode (e.g. “imagine a jungle”; for discussion, see Hassabis and Maguire, 2007). Although episodic memories may contribute to such seemingly generic scenes (e.g. when imagining a jungle I may remember a jungle scene from a recently seen movie), it remains to be determined whether the effects of the specificity induction observed in our studies indicate that heightened focus on *episodic* details during the induction enhances subsequent scene construction during memory, imagination, problem solving, and divergent thinking tasks, or whether the induction increases focus on both episodic and more generic scene details that selectively impact performance on these and related tasks. Experiments that address such issues will allow us to determine how to best characterize the nature and effects of specificity inductions on subsequent tasks.

Finally, we suggest that disentangling the contributions of episodic and non-episodic processes to memory, imagination, and related functions should also provide a stronger foundation for understanding how these processes contribute to related constructs, such as psychological well-being (e.g. MacLeod, 2016; MacLeod and Conway, 2005). For example, several studies have linked reduced specificity of autobiographical memory and future thinking with reduced psychological well-being (e.g. Brown et al., 2014; Williams et al., 1996, 2007) and some evidence indicates that training aimed at increasing autobiographical memory specificity can enhance psychological well-being (e.g. Neshat-Doost et al., 2013; Raes et al., 2009). Yet little is known about which features of specificity training contribute to observed improvements in psychological well-being (e.g. episodic retrieval processes, non-episodic narrative processes, or both). Future research aimed at pinpointing the processes that support training effects should enhance our understanding of how remembering the past and imagining the future support a variety of psychological functions.

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