Episodic Future Thinking and Cognitive Aging

Daniel L. Schacter, Department of Psychology, Harvard University, Aleea L. Devitt, Department of Psychology, Harvard University, and Donna Rose Addis, School of Psychology, University of Auckland

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Summary

Episodic future thinking refers to the ability to imagine or simulate experiences that might occur in an individual's personal future. It has been known for decades that cognitive aging is associated with declines in episodic memory, and recent research has documented correlated age-related declines in episodic future thinking. Previous research has considered both cognitive and neural *mechanisms* that are responsible for age-related changes in episodic future thinking, as well as effects of aging on the *functions* served by episodic future thinking. Studies concerned with mechanism indicate that multiple cognitive mechanisms contribute to changes in episodic future thinking during aging, including episodic memory retrieval, narrative style, and executive processes. Recent studies using an episodic specificity induction—brief training in recollecting episodic details of a recent experience—have proven useful in separating the contributions of episodic retrieval from other non-episodic processes during future thinking tasks in both old and young adults. Neuroimaging studies provide preliminary evidence of a role for age-related changes in default and executive brain networks in episodic future thinking and autobiographical planning. Studies concerned with function have examined age-related effects on the link between episodic future thinking and a variety of processes, including everyday problem-solving, prospective memory, prosocial intentions, and intertemporal choice/delay discounting. The general finding in these studies is for age-related reductions, consistent with the work on mechanisms that consistently reveals reduced episodic detail in older adults when they imagine future events. However, several studies have revealed that episodic simulation nonetheless confers some benefits for tasks tapping adaptive functions in older adults, such as problem-solving, prospective memory, and prosocial intentions, even though age-related deficits on these tasks are not eliminated or reduced by episodic future thinking.

Keywords: cognitive aging, episodic future thinking, episodic memory, Autobiographical Interview, default network

Subjects: Cognitive Psychology/Neuroscience

Episodic Future Thinking as a Form of Prospection

Numerous studies have established that cognitive aging is associated with changes in various forms of memory (for recent reviews, see Devitt & Schacter, 2016; Park & Festini, 2017). In contrast to the vast amount of research into how aging impacts remembering past experiences, until recently there has been much less research concerning how aging impacts the ability to think about and imagine future experiences. However, during the past decade psychologists and neuroscientists have focused increasing research attention on the human capacity for thinking about the future or *prospection* (cf., Buckner & Carroll, 2007; Gilbert & Wilson, 2007; Seligman, Railton, Baumeister, & Sripada, 2013; Suddendorf & Corballis, 2007; Szpunar, Spreng, & Schacter, 2014). This new focus on future thinking has had a notable impact on research in cognitive aging: a rapidly growing number of studies have begun to examine how aging impacts prospective abilities such as imagining future experiences (Schacter, Gaesser, & Addis, 2013).

According to a recently proposed taxonomy of prospection (Szpunar et al., 2014), it is useful to distinguish among several distinct though related forms of future thinking, including *episodic future thinking*, the ability to imagine experiences that might occur in one's personal future, and *semantic future thinking*, the ability to imagine abstract or general future states of the world (cf., Atance & O'Neil, 2001). Because most recent research on future thinking and aging has investigated episodic future thinking, this article focuses on this form of prospection. Note also that according to the taxonomy proposed by Szpunar et al. (2014), episodic future thinking can be further subdivided into four basic forms: *simulation* (construction of a specific mental representation of the future), *prediction* (estimation of the likelihood of a future outcome), *intention* (setting of a goal), and *planning* (organization of steps for achieving a goal). Recent studies of episodic future thinking and aging have focused mainly on episodic simulation, as does this article, though other forms of episodic future thinking are touched on briefly when relevant research is available.

Schacter, Benoit, and Szpunar (2017) distinguished between studies that have yielded insights into the *mechanisms* that support episodic future thinking and those that have addressed the *functions* that it serves. This distinction is also useful for organizing the literature on cognitive aging and episodic future thinking. Accordingly, we begin by examining studies that have illuminated the cognitive and neural mechanisms that are relevant to age-related changes in episodic future thinking and then turn our attention to studies that have focused on how cognitive aging affects the functions served by episodic future thinking.

Cognitive Aging and Episodic Future Thinking: Mechanisms

One of the main drivers of recent research on prospection has been the observation of striking similarities between remembering past experiences and imagining future experiences: behavioral studies have demonstrated that remembering the past and imagining the future depend on similar cognitive processes, whereas neuropsychological and neuroimaging studies have shown that many of the same neural processes that are important for remembering past experiences are also important for imagining future experiences (for reviews, see Klein, 2013; Schacter et al., 2012, 2017; Ward, 2016). These striking similarities helped to set the stage for research on cognitive aging and episodic future thinking. Studies that have focused on cognitive mechanisms are considered first, followed by discussion of those focused on neural mechanisms. Unless otherwise specified, "young adults" are individuals in their 20s and 30s, whereas "older adults" are individuals in their 60s and older, in line with standard usage in the cognitive aging literature.

Cognitive Mechanisms

Age-Related Changes in Episodic Future Thinking and Remembering

The first study to document a cognitive similarity between remembering past experiences and imagining future experiences in older adults was reported by Spreng and Levine (2006). They asked young, middle-aged, and older adults to remember a specific past experience or imagine a specific future experience in response to a word cue and then date when the remembered or imagined experience had occurred or would occur. Earlier studies of autobiographical remembering had shown that people recall many events from the recent past, with a systematic decline in event frequency for more remote memories that is well described by a power function (e.g., Crovitz & Schiffman, 1974). Spreng and Levine replicated these findings and also found that an inverse of this power function fit the temporal distribution when young and old adults imagined future experiences: most events were imagined in the near future, with a systematic decline in event frequency for increasingly distant future experiences. These results led Spreng and Levine to conclude that the same mechanism supports remembering past experiences and imagining future experiences in both young and old populations.

Addis, Wong, and Schacter (2008) took a different approach to exploring the relation between past and future events in young and older adults by building on earlier work from Levine, Svoboda, Hay, Winocur, and Moscovitch (2002) concerning autobiographical memory and aging. Levine et al. (2002) developed a procedure referred to as the Autobiographical Interview (AI) in which young and older adults recalled past personal events and the resulting protocols were scored for two main kinds of details: internal or external. Internal details correspond to episodic information: who, what, where, and when details. External details involve semantic knowledge, related facts, commentary, or references to other events. Using this scoring procedure, Levine et al. reported that during autobiographical recall, older adults remembered fewer internal and more external details than did younger adults.

Addis et al. (2008) extended this approach to imagined future events using an adapted version of the AI in which participants either recalled a past event or imagined a future event in response to a word cue and tried to generate as much detail as possible within three minutes. The event generated had to be temporally and contextually specific, occurring over minutes or hours but not more than one day. If needed, general probes were given to encourage further description of details. Recordings of remembered and imagined events were transcribed and then scored by three raters blind to group membership, using the standardized AI scoring procedure in which details were categorized as internal or external (interrater reliability was high for both past and future events; Cronbach's alpha: internal, .96; external, .92). As shown in Figure 1, older adults produced fewer internal and more external details than young adults for remembered past events, thereby replicating previous results from Levine et al. (2002). Critically, the identical pattern was observed for imagined future events. Note that these age differences in internal and external detail cannot be explained by age differences in the temporal distance of events: age groups did not differ significantly for temporal distance (in weeks) from the present for either past or future events. In addition to the similar effects of aging on remembering and imagining, past and future scores were highly positively correlated with each other for both internal and external details.

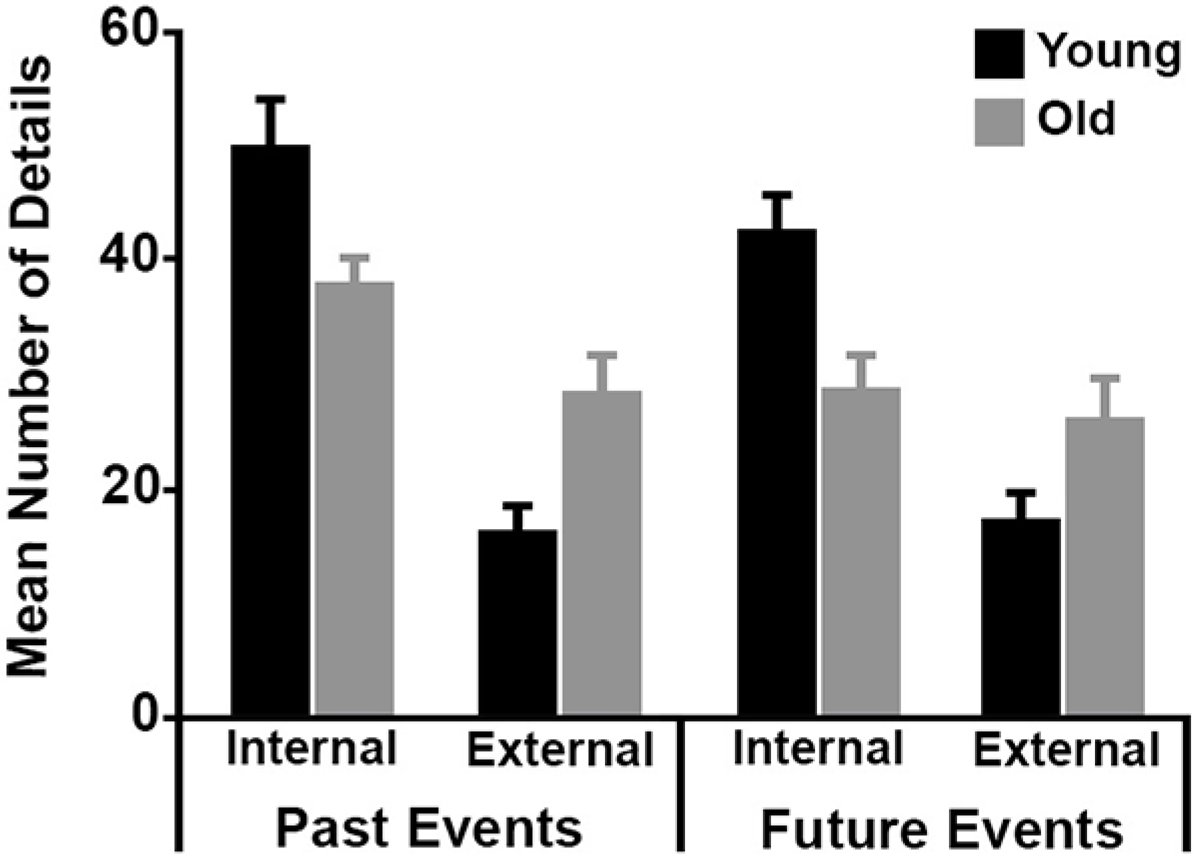

Figure 1. Mean number of internal and external details produced by young and older adults when they remembered past events or imagined future events in response to word cues. Young adults produced significantly more internal and significantly fewer external details than did older adults.

Adapted from Addis, Wong, and Schacter (2008).

Although in the adapted AI paradigm used by Addis et al. (2008) participants were instructed to produce novel future events, the paradigm did not fully control whether participants generated novel events via recombination or were simply "recasting" entire memories of past events into the future. For example, when asked to imagine a future event involving a "vacation," a participant might remember a vacation from last year and then imagine the identical vacation occurring next year. Subsequent research indicated that such recasting can occur in both old and young adults, particularly for events imagined in the near future, which are often quite similar to recent memories (Gamboz et al., 2010). Addis, Musicaro, Pan, and Schacter (2010) used a different method of eliciting remembered and imagined events called *the experimental recombination paradigm* to rule out the possibility that similar patterns for remembering and imagining are attributable to younger and older adults "recasting" memories of past events into the future. Here, participants first provide a set of autobiographical memories, each comprised of a person, place, and object; then the experimenter recombines these elements across memories to provide novel stimuli for imagination trials. In a subsequent session, participants were instructed to imagine in as much detail as possible a novel event involving the recombined person, place, and object elements, and on other trials they were instructed to remember some of the original episodes in as much detail as possible. This procedure yielded a very similar pattern of results to that obtained by Addis et al. (2008): older adults again produced fewer internal and more external details for both remembered and imagined events.

The experimental recombination procedure allows greater control over what is imagined and thus provides stronger evidence that older adults show reduced internal and increased external details when they are imagining *novel* future events, just as they do when remembering past events. Other studies have manipulated the kinds of cues presented to participants yet still report similar patterns of results to those initially reported by Addis et al. (2008, 2010). For example, Lapp and Spaniol (2017) manipulated cues to be more or less relevant to personal goals of young and older adults and asked participants to imagine future events in response to these cues. As in the earlier work, they found that older adults produced fewer internal and more external details for both goal-relevant and goal-irrelevant cues. Jumentier, Barsics, and Van der Linden (2018) reported reduced specificity of episodic future thinking for both positive and negative cue words in old compared with middle-aged adults.

Interpreting Age-Related Changes in Episodic Future Thinking: Multiple Mechanisms?

In discussing possible mechanisms underlying the effects they observed, Addis et al. (2008, 2010) interpreted their findings, as well as those of Spreng and Levine (2006), in the context of the *constructive episodic simulation hypothesis* advanced by Schacter and Addis (2007). This hypothesis maintains that episodic retrieval plays a critical role in the construction of imagined future experiences by supporting recombination of stored episodic details into a simulation of a novel future event. From this perspective, well-documented age-related declines in episodic retrieval are primarily responsible for reduced episodic detail in simulations of future experiences by older adults and also for the positive correlation between internal details for past and future events.

However, this seemingly straightforward interpretation was challenged by a subsequent study from Gaesser, Sacchetti, Addis, and Schacter (2011), who noted that performance on the AI could be influenced by nonepisodic processes such as narrative style or communicative goals that change with age (see also Levine et al., 2002). For example, older adults may be more concerned with conveying the general significance and meaning of experiences than younger adults (e.g., LaBouvie-Vief & Blanchard-Fields, 1982), resulting in more external and fewer internal details during both memory and imagination. Similarly, older adults might produce more “off-topic” speech (e.g., Trunk & Abrams, 2009) that is irrelevant to the main task of remembering or imagining an event than do younger adults, perhaps as a consequence of well-known deficits in inhibitory control that accompany cognitive aging (e.g., Zacks & Hasher, 1994). Such off-topic comments would be coded as external details on the AI for both past and future events.

To address the possible role of such nonepisodic factors, Gaesser et al. (2011) used pictures of complex scenes as cues for young and older adults to generate related imagined future events or remembered past events. Critically, they also included a picture description condition in which participants were instructed to describe a picture in as much detail as possible. The AI was used as before to code descriptions of remembered and imagined experiences into internal and external details. For the picture description task, details present in descriptions of the depicted scene were classified as internal, and commentary or inferred details not physically present in the picture were classified as external. Gaesser et al. reasoned that if previously documented age-related declines in internal details during memory and imagination reflect the influence of nonepisodic processes (e.g., inhibitory deficits or changes in narrative style), then similar patterns should be observed on the picture description task, which does not require and should not recruit episodic retrieval. Moreover, no effects of aging should be observed in imagination and memory conditions after controlling for picture description performance.

Results of two experiments indeed revealed similar age-related patterns on all three tasks: older adults generated fewer internal and more external details than younger adults when remembering past experiences, imagining future experiences, and describing pictures. These results support the idea that the age-related changes during memory and imagination observed in previous studies cannot be entirely attributed to age-related change in episodic retrieval mechanisms and instead reflect the influence of nonepisodic processes that impact picture description task as well as memory and imagination. However, there was still a small but significant contribution of aging to memory and imagination performance even after controlling for picture description performance. Thus while the results of this study highlight that nonepisodic factors contribute to age-related changes in remembering the past and imagining the future, they also suggest that not all age-related reductions during memory and imagination can be accounted for by these nonepisodic factors.

Consistent with the foregoing, Cole, Morrison, and Conway (2013) found that older adults produced fewer internal and more external details on the AI than younger adults when imagining a future experience and that greater episodic specificity on this task (i.e., a higher proportion of internal vs. external details) in older adults but not younger adults was predicted by performance on both an episodic measure (source memory) and a nonepisodic measure of executive function (Trail Making Test). More recently, Zavagnin, De Beni, Borella, and Carretti (2016) used an adapted version of the AI that employed sentence cues and reported as in previous studies that older adults produced fewer internal and more external details for past and future events. In addition, their study produced some evidence for a contribution of nonepisodic processes to future imagining. They examined possible links between AI performance and inhibitory ability (as indexed by intrusion errors on a working memory task) and found an association between reduced inhibitory ability and increased production of external details with aging for imagined future events but not for remembered past events and also did not observe any association between inhibitory ability and reduced production of internal details for either future or past events. Additional evidence indicating that older adults might have special problems imagining future events comes from a study by Rendell et al. (2012) showing that older adults performed more poorly when asked to imagine future experiences than when asked to imagine atemporal scenes (cf., Hassabis, Kumaran, Vann, & Maguire, 2007). Rendell et al. attributed this differential effect to the requirement for autonoetic consciousness (Tulving, 1985) in the future condition, which is considered to be a characteristic of episodic processing.

Distinguishing Among Mechanisms Underlying Age-Related Changes in Episodic Future Thinking

According to the constructive episodic simulation hypothesis, the nonepisodic processes that appear to be responsible for a significant portion of age-related changes in remembering past experiences and imagining future experiences when using the AI should be dissociable from the episodic processes that are hypothesized to contribute to remembering and imagining in both older and younger adults. To examine this idea, Madore, Gaesser, and Schacter (2014) developed an *episodic specificity induction*—brief training in recollecting the details of a recent experience—that was designed to selectively impact the operation of episodic processes that are thought to contribute similarly to remembering past experiences and imagining future experiences but not to picture description. According to the logic of this approach, the episodic specificity induction should only increase performance on a subsequent cognitive task if that task relies on episodic retrieval processes. Consistent with the prediction, Madore et al. (2014) found that both young and old adults produced more internal but not more external details when they remembered past experiences and imagined future experiences following an episodic specificity induction than following a control induction that did not involve detailed episodic retrieval. By contrast, the specificity induction had no effect on the number of internal or external details that participants produced on a picture description task. These and related follow-up experiments (for replication, see Madore & Schacter [2014], and for further discussion, see Schacter & Madore [2016]) clearly reveal an episodic retrieval process that is common to remembering and imagining in both young and old adults and that is dissociable from semantic retrieval and narrative description.

Relationship Between Episodic and Semantic Retrieval

Studies that have used the AI to assess episodic remembering and future thinking have typically found that older adults produce fewer internal and more external details than younger adults. This finding raises the question of whether the age-related increase in external or semantic details might reflect a compensatory response to the reduction in internal or episodic information. Devitt, Addis, and Schacter (2017) recently explored this question by examining the relationship between the amount of internal and external details produced by young and older adults within remembered past events and imagined future events. The reasoning behind this approach was that if older adults rely on semantic information to embellish remembered and imagined events that are low in episodic detail, a negative relationship should be observed between the number of internal and external details generated in an event. While previous studies had found no relationship between internal and external details (e.g., Addis et al., 2008, 2010), these analyses were limited by aggregating data across all events generated by a participant (i.e., between-participants correlation), which obscures the underlying relationship within the events themselves. A between-participants correlation reveals whether individuals who generate many internal details also generate more or less external details, but a more critical question is whether, for each participant, *events* with many internal details contain more or less external details. A multilevel analysis circumvents this limitation by examining relationships at both the event and participant levels (see Wright, 1998).

Using a multilevel approach, Devitt et al. (2017) found a negative relationship between the number of internal and external details produced when remembering past experiences and imagining future experiences, meaning that events with less episodic detail contained more semantic information. This negative trend was stronger and more consistent for older compared with younger adults. If this negative relationship reflects a reduced ability to inhibit irrelevant information, leaving less time or cognitive resources available for retrieving episodic information, a similar pattern should be seen between internal and external details generated in a picture description task; however, Devitt et al. found no relationship between internal and external details produced during picture description. Because the negative trend is specific to remembering and imagining tasks that rely on episodic retrieval, it is likely that extra semantic information is generated to fill in the gaps of events that are lacking in episodic detail. Relative preservation of semantic memory coupled with subjective concerns about age-related episodic memory deterioration may mean older adults more readily recruit semantic information to compensate for reductions in episodic recall.

Neural Mechanisms

There has been less research concerning neural mechanisms of episodic future thinking and aging than cognitive mechanisms, but relevant observations have been provided by several recent neuroimaging studies.

Remembering Past Experiences Versus Imagining Future Experiences

Strong evidence linking episodic future thinking and memory comes from neuroimaging studies that have revealed that a common core brain network is recruited when people remember past experiences and imagine future experiences (e.g., Addis, Wong, & Schacter, 2007; Szpunar, Watson, & McDermott, 2007; for a recent meta-analysis, see Benoit & Schacter, 2015). This common core network (Schacter, Addis, & Buckner, 2007), comprising regions in the medial prefrontal cortex, posterior cingulate including retrosplenial cortex, medial temporal lobe including hippocampus, and lateral temporal and parietal regions, overlaps substantially with the well-studied default network (cf., Buckner, Andrews-Hanna, & Schacter, 2008; Raichle, 2015). Neuroimaging studies have also shown that some core network regions, including the left posterior inferior parietal lobe, posterior dorsolateral prefrontal cortex, and hippocampus, show greater activity when for imagining than remembering (see Benoit & Schacter, 2015).

While numerous neuroimaging studies have examined brain activity in older adults when they remember past experiences, only a handful have examined episodic future thinking (for a meta-analysis, see Viard, Desgranges, Eustache, & Piolino, 2012). In an functional magnetic resonance imaging (fMRI) study by Viard et al. (2011), older adults were scanned while they either remembered personal experiences from the past 12 months or thought about planned future events in response to event cues provided by a family member. Compared with a control condition, older adults showed activity in major core network regions for both past and future events (see also Sasse, Peters, & Brassen [2017] for similar observations regarding future thinking in older adults during a delay discounting task). Older adults also showed increased activity for future relative to past event in a few brain regions, but in contrast to previous findings with young adults, the hippocampus did not exhibit increased activity for future compared with past events. Importantly, however, in this study participants imagined future events that they had already planned out, rather than constructing novel events as in most prior neuroimaging studies of episodic future thinking, an important consideration given that re-imagining events is associated with less activity than initial construction (van Mulukom, Schacter, Corballis, & Addis, 2013). Another limitation of the Viard et al. (2011) study is that it did not include a comparison group of young adults.

Addis, Roberts, and Schacter (2011) addressed both of the aforementioned issues in an fMRI study that compared brain activity in young and old adults while they remembered past experiences or imagined novel future experiences, adapting the procedures initially used by Addis et al. (2007). Both young and old adults activated core network regions during the past and future tasks, but some important age differences emerged as well. First, during the initial construction of past and future events, older adults showed less activation than young adults in regions that previously linked with retrieval of episodic details, including hippocampus, parahippocampal cortex, and precuneus. Second, later in the trial, when they were elaborating on the contents of remembered or imagined experiences, older adults showed heightened engagement of left lateral temporal regions that have been previously linked with semantic or conceptual autobiographical information (e.g., Graham, Lee, Brett, & Patterson, 2003). These observations fit well with the behavioral data indicating that older adults produce fewer episodic and more semantic details than younger adults when they remember past events or imagine future events. However, there is a need for additional work that directly relates neuroimaging and behavioral findings.

Autobiographical Planning and Aging

Other studies have used fMRI to investigate age-related changes in the neural underpinnings of autobiographical planning (i.e., organizing steps for goal attainment, as opposed to simulating a specific mental representation of the future; Spreng & Schacter, 2012; Spreng, Stevens, Viviano, & Schacter, 2016). In these studies, participants are scanned while mentally constructing personal plans to achieve a specified future goal (e.g., exercise) by incorporating relevant steps (e.g., make a routine, walk more) and avoid potential obstacles (e.g., avoid injury). Compared with a visually matched visuospatial planning task, autobiographical planning engaged the default network in both young and old adults; moreover, the default network coupled with a distinct frontoparietal control network during autobiographical planning in both groups. Older adults, in contrast to young adults, failed to deactivate the default network during visuospatial planning and also showed default-control network coupling during visuospatial planning, reflecting a reduced ability to modulate network activity in response to different task demands (for further analyses, see Spreng et al., 20l6).

In summary, then, while there is still relatively little neuroimaging evidence regarding episodic future thinking in aging, the evidence that does exist indicates that older adults recruit the core/default when thinking about their personal futures while at the same time revealing age-related reductions in the involvement of regions contributing to episodic retrieval and differences in the modulation of large-scale networks.

Cognitive Aging and Episodic Future Thinking: Functions

Research focused on the mechanisms of episodic future thinking has established age-related changes at both the cognitive and neural levels. These changes are important not only because they provide theoretically useful insights into cognitive aging but also because episodic future thinking serves important adaptive functions (cf., Ingvar, 1979; Lyons, Henry, Rendell, Corballis, & Suddendorf, 2014; Schacter, 2012; Schacter et al., 2017). In the studies considered in the preceding sections on cognitive and neural mechanisms, age-related deficits were typically observed on tasks that require simply imagining a future event, without any functional consequences, but it is important to examine whether the adaptive functions of episodic future thinking are reduced or otherwise compromised with aging. This section discusses evidence from four domains where the kinds of episodic processes that change with age have been linked with adaptive functions—everyday problem-solving, prospective memory, prosocial intentions, and intertemporal choice/delay discounting—and considers the impact of age-related changes on the functions associated with episodic future thinking.

Everyday Problem-Solving

Noting that previous research on episodic future thinking and cognitive aging had focused on characterizing phenomenological aspects of imagined events, Lyons et al. (2014) attempted to come up with a task that required using episodic future thinking in the service of solving everyday problems. To do so, they devised an electronic board game task (an extension of the widely used Virtual Week board game/prospective memory task; see Rendell & Henry, 2009) that presents participants with realistic everyday problems (e.g., finding food for a hungry pet when the cupboard is empty) that they can solve by generating appropriate future behaviors (i.e., acquiring and using relevant items). Lyons et al. found that older adults were significantly less likely than younger adults to acquire and use items that allowed a problem to be solved.

These results are consistent with studies that have examined everyday social problem-solving in young and old adults using the means-ends problem-solving task (MEPS) established by Platt and Spivack (1975). Here, participants are given hypothetical social problems encountered by fictional individuals, such as meeting new people, along with solutions to those problems, and they attempt to generate steps or means that produce problem solutions (e.g., “J noticed that her friends seemed to be avoiding her. J wanted to have friends and be liked. The story ends when J’s friends like her again. You begin the story where J first notices her friends avoiding her”). Sheldon, McAndrews, and Moscovitch (2011) found that older adults generated fewer relevant problem steps than did younger adults on the MEPS task and, critically, that the solutions generated by older adults contained fewer episodic details than those of younger adults, thus implicating reduced episodic retrieval in the age-related functional change. Madore and Schacter (2014) replicated these findings and further showed that both older and younger adults generated more relevant problem steps, and more episodic details, after receiving an episodic specificity induction than a control induction. More recently, Leahy, Ridout, Mushtaq, and Holland (2018) provided additional evidence that a related kind of memory specificity training also leads to improved social problem-solving on the MEPS task. These results further implicate episodic retrieval abilities that are strongly associated with episodic future thinking in everyday problem-solving, for both younger and older adults.

Prospective Memory

Prospective memory refers to remembering to carry out future intentions and actions (for an overview, see Kliegel, McDaniel, & Einstein, 2007). There has been considerable research on prospective memory and aging, dating to classic early research showing that aging has negative effects on the performance of *time-based* prospective memory tasks, where people need to remember to perform an action at a specific future time, and little impact on event-based prospective memory tasks, where people need to remember to perform an action in response to specific cue (Einstein & McDaniel, 1990). Subsequent research has confirmed the existence of prospective memory deficits in aging (for reviews and meta-analyses, see Uttl, 2008, 2011), with large impairments on tasks that require strategic retrieval and minimal impairments on tasks that rely on environmental cues while requiring little strategic retrieval (McDaniel & Einstein, 2011). Indeed, prospective memory abilities were tapped in the Lyons et al. (2014) study of everyday problem-solving, which focused on the ability to self-generate and later execute future-oriented intentions to solve everyday problems, and likely contributed to the observed age-related deficits.

Studies of young adults have shown that episodic future thinking can boost performance on a subsequent prospective memory task. This line of research was initiated by studies of *implementation intentions*: if–then plans that link an intention to a future situation in which the plan is to be executed (e.g., “when situation *x* arises, I will perform response *y*”; Gollwitzer, 1999). Forming an implementation intention enhances subsequent prospective memory performance by increasing the likelihood that when the future situation is encountered, the intended action is triggered (e.g., McDaniel, Howard, & Butler, 2008). Cognitive aging research has consistently shown that prospective memory performance in older adults benefits from forming implementation intentions (Chasteen, Park, & Schwarz, 2001; McFarland & Glisky, 2011; Zimmerman & Meier, 2010). In a related vein, several studies have shown that creating episodic simulations of a future event, where one imagines oneself carrying out an intention, enhances prospective memory performance in young adults (Altgassen, Kretschmer, & Schnitzspahn, 2017; Brewer & Marsh, 2010; Neroni, Gamboz, & Brandimonte, 2014; Paraskevaides et al., 2010). However, there is conflicting evidence regarding whether imagining carrying out the intention boosts performance more than a simple verbal if–then statement (Chasteen et al., 2001) or is similarly effective to a verbal if–then statement alone (McFarland & Glisky, 2011). Thus, while it is clear that episodic future thinking benefits prospective memory performance, it is unclear whether imagining an action is more beneficial than a verbal if–then statement.

Recent studies have attempted to characterize the nature of the relationship between episodic future thinking and prospective memory in older compared with younger adults. Altgassen et al. (2015) examined performance on the Dresden Breakfast Task (DBT), a computerized simulation in which participants prepare a breakfast for four people. This complex task taps both time-based prospective memory (e.g., remember to take out a tea-bag after four minutes) and event-based prospective memory (e.g., remember to prepare the tea immediately after the water boils). Prior to carrying out the DBT, half of the young and old participants practiced episodic future thinking with respect to situations unrelated to the DBT (e.g., imagine calling a friend at a specific time, or imagine buying bread on the way home) and were instructed to apply this strategy to the DBT tasks. The other half of the participants carried out unrelated cognitive tasks for the same amount of time. Although older adults performed more poorly overall than younger adults on the DBT prospective memory tasks, Altgassen et al. (2015) found that future thinking instructions improved prospective memory performance to a similar degree in both old and young participants.

Terrett et al. (2016) also examined the relation between episodic future thinking and prospective memory in a sample of 125 young and 125 old adults. To assess episodic future thinking, Terrett et al. administered a task similar to that used previously by Addis et al. (2008) and others, where participants imagined future events and details were scored as internal or external according to standard AI procedures. To assess prospective memory, the investigators administered the Virtual Week board game task, which presents a variety of prospective memory tasks. Consistent with earlier studies, older adults were impaired on both the episodic future thinking and prospective memory measures. Terrett et al. also documented significant positive correlations between episodic future thinking and prospective memory measures in both age groups. Interestingly, a regression analysis further revealed that episodic future thinking ability accounted for unique variance in prospective memory performance above and beyond other cognitive measures in young adults but in not old adults. These findings are important because they raise questions about what mechanisms underlie the differential relation between episodic future thinking and prospective memory as a function of age.

Prosocial Intentions

Recent evidence indicates that episodic future thinking can increase intentions to behave in a prosocial manner toward other people. Gaesser and Schacter (2014) presented young adults with hypothetical situations in which people were in need of help and assessed willingness to help the individual. They found that after participants imagined a specific future event in which they helped the individual in need, participants showed increased willingness to help compared with control conditions (i.e., a conceptual helping condition where participants estimated ways in which the person could be helped and a no-helping control condition). Moreover, subjective measures of the detail and coherence of the imagined event predicted willingness to help (for replication and extension, see Baumsteiger, 2017; Gaesser, Horn, & Young, 2015).

Gaesser, Dodds, and Schacter (2017) asked whether the effects observed by Gaesser and Schacter (2014) could be observed in older adults. Similar to young adults, old adults showed significant increases in willingness to help after imagining a specific helping event compared with the no-helping control condition. Unlike young adults, however, older adults did not show increased willingness to help after imagining helping compared with estimated ways in which the person could be helped, perhaps reflecting that the effect on prosocial intentions in older adults was driven more by conceptual or semantic rather than episodic processing. Nonetheless, in the imagine condition, willingness to help in both old and young was predicted by subjective detail and vividness of the imagined episode, suggesting that aspects of episodic future thinking contributed to prosocial intentions in the elderly group.

Intertemporal Choice and Delay Discounting

One of the most robust findings in the emerging literature on episodic future thinking in young adults comes from studies of intertemporal choice. Here, people choose between two reward options that differ in magnitude and delay until delivery, such as a smaller reward in the near future versus a larger reward in the more distant future. Future rewards are typically discounted according to the length of delay, leading to shortsighted choices of the smaller but more immediate reward option. There is evidence that older adults show reduced temporal discounting of future rewards compared with younger adults (i.e., they make less shortsighted choices; for reviews, see Löckenhoff [2011] and Samanez-Larkin & Knutson [2015]). However, when young adults simulate a future episode of consuming the larger reward, they become more patient and instead favor the more farsighted choice (e.g., Benoit, Gilbert, & Burgess, 2011; Peters & Büchel, 2010). By contrast, Sasse et al. (2017) reported that episodic simulation had no effect on discounting behavior in a sample of old adults. Variability in older adults' discounting rates was correlated with cognitive and neural measures of cognitive control ability but not with measures of episodic detail for simulated events or with separate measures of general memory capacity.

In summary, the general trend of studies concerned with functional consequences of episodic future thinking is for age-related reductions, which is consistent with earlier work on mechanisms that consistently reveals reduced episodic detail in older adults when they imagine future events. These findings might lead one to expect reduced benefits of episodic future thinking on adaptive functions in old compared with young adults. However, although episodic future thinking does not eliminate age differences, several studies have revealed that episodic simulation confers at least some benefits for tasks tapping adaptive functions in both younger and older adults, such as problem-solving, prospective memory, and prosocial intentions, suggesting that age-related reductions in imagined episodic detail are not critical to the benefits of episodic future thinking on these tasks. Future studies should more closely examine this issue and attempt to clarify why a reduced capacity for episodic future thinking in older adults produces comparable benefits to young on several tasks with functional consequences.

Concluding Comments

This article has summarized research considering the cognitive and neural mechanisms responsible for age-related changes in episodic future thinking, as well as the effects of healthy aging on the adaptive functions that episodic future thinking serves. Multiple cognitive mechanisms contribute to changes in episodic future thinking with age, including both episodic and nonepisodic processes. Research concerning age effects on neural mechanisms is limited, though the available evidence reveals age-related reductions in the recruitment of regions involved in episodic retrieval and differences in large-scale network modulation during episodic future thinking. Last, while the adaptive functions of episodic future thinking are reduced with age, invoking episodic future thinking often improves performance on tasks tapping adaptive functions in both younger and older adults.

This article focused on healthy aging, but research has also explored the effects of abnormal or pathological aging on episodic future thinking. For instance, compared with healthy older adults, deficits in generating episodic information when remembering past events and imagining future events are observed in patients with Alzheimer's disease (Addis, Sacchetti, Ally, Budson, & Schacter, 2009; El Haj, Antoine, & Kapogiannis, 2015), semantic dementia (Irish & Piguet, 2013), amnesic mild cognitive impairment (Gamboz et al., 2010), frontotemporal dementia (Irish, Hodges, & Piguet, 2013), and Parkinson's disease (de Vito et al., 2012), further demonstrating a link between episodic retrieval and future thinking.

Gaps in our knowledge concerning aging and episodic future thinking remain, such as how a reduced capacity for episodic future thinking in older adults produces comparable benefits as young for adaptive functions such as prospective memory and social problem-solving and the specificity of age-related changes in the mechanisms and functions of episodic simulation to future experiences as opposed to imagined atemporal past experiences. Nevertheless, research exploring the effects of healthy aging on episodic future thinking and the adaptive functions it serves continues to enrich and broaden our understanding of cognitive aging.

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