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An Episodic Specificity Induction Enhances Means-End Problem Solving in Young and Older Adults

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Episodic memory plays an important role not only in remembering past experiences, but also in constructing simulations of future experiences and solving means-end social problems. We recently found that an episodic specificity induction—brief training in recollecting details of past experiences—enhances performance of young and older adults on memory and imagination tasks. Here we tested the hypothesis that this specificity induction would also positively impact a means-end problem-solving task on which age-related changes have been linked to impaired episodic memory. Young and older adults received the specificity induction or a control induction before completing a means-end problem-solving task, as well as memory and imagination tasks. Consistent with previous findings, older adults provided fewer relevant steps on problem solving than did young adults, and their responses also contained fewer internal (i.e., episodic) details across the 3 tasks. There was no difference in the number of other (e.g., irrelevant) steps on problem solving or external (i.e., semantic) details generated on the 3 tasks as a function of age. Critically, the specificity induction increased the number of relevant steps and internal details (but not other steps or external details) that both young and older adults generated in problem solving compared with the control induction, as well as the number of internal details (but not external details) generated for memory and imagination. Our findings support the idea that episodic retrieval processes are involved in means-end problem solving, extend the range of tasks on which a specificity induction targets these processes, and show that the problem-solving performance of older adults can benefit from a specificity induction as much as that of young adults.

Keywords: episodic specificity induction, means-end problem solving, autobiographical memory, imagination, aging

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A large number of recent studies have shown striking neural and cognitive similarities between remembering the past and imagining the future (for reviews, see Klein, 2013; Schacter et al., 2012; Szpunar, 2010). Some of those similarities have been documented in studies of cognitive aging, which have revealed that age-related changes in remembering past experiences are paralleled by comparable age-related changes in imagining future or hypothetical experiences (for review, see Schacter, Gaesser, & Addis, 2013). For example, in a study by Addis, Wong, and Schacter (2008), participants completed an adapted version of the Autobiographical Interview (AI; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002), which includes a scoring procedure that distinguishes between the "internal" and "external" details that comprise either remembered or imagined personal experiences. Internal details consist of specific information concerning who, what, where, and when features of the retrieved experience, and are thought to draw largely on episodic memory, whereas external details involve related facts, elaborations, or references to other events, and are thought to draw largely on semantic memory. Addis et al. (2008) found that older adults reported significantly fewer internal details and more external details about both remembered past experiences and imagined future experiences compared with young adults, a result that has been replicated and extended in more recent studies (Addis, Musicaro, Pan, & Schacter, 2010; Cole, Morrison, & Conway, 2013; Gaesser, Sacchetti, Addis, & Schacter, 2011; Madore, Gaesser, & Schacter, 2014; Rendell et al., 2012; Romero & Moscovitch, 2012).

Addis et al. (2008, 2010) interpreted these findings in the context of the *constructive episodic simulation hypothesis* (Schacter & Addis, 2007, 2009), which holds that remembering past experiences and imagining future experiences recruit many of the same underlying processes, and that episodic memory supports the construction of imagined future events by allowing individuals to flexibly retrieve and recombine details of past experiences into a novel scenario or episodic simulation. From this perspective, impaired episodic memory mechanisms are the primary source of age-related changes in remembering the past and imagining the future. However, the results of a study by Gaesser et al. (2011) suggest an alternative interpretation. Gaesser et al. (2011) showed

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that older adults reported fewer internal and more external details not only when remembering the past and imagining the future, but also when describing a picture of an everyday scene—a task that should draw minimally if at all on episodic memory. These findings thus suggest a role for nonepisodic mechanisms in driving age differences on memory and imagination tasks using the AI or similar procedures, such as changes in communicative goals, narrative style, or inhibitory control (cf., Adams, Smith, Nyquist, & Perlmutter, 1997; Arbuckle & Gold, 1993; Labouvie-Vief & Blanchard-Fields, 1982; Trunk & Abrams, 2009; Zacks & Hasher, 1994; for further discussion, see Gaesser et al., 2011; Schacter et al., 2013).

In a more recent study, we (Madore et al., 2014) were able to distinguish between episodic and nonepisodic mechanisms involved in memory, imagination, and picture description tasks by using an *episodic specificity induction*: brief training in recollecting the details of a recent experience. Our induction is based on the Cognitive Interview (CI; Fisher & Geiselman, 1992), which has proven useful for increasing detailed episodic recall in eyewitnesses in written or verbal form (e.g., Gawrylowicz, Memon, Scoboria, Hope, & Gabbert, 2014; for review, see Memon, Meissner, & Fraser, 2010). As described in Madore et al. (2014), participants first viewed a video of an everyday scene (people interacting in a kitchen) and were then guided to recall the video in specific episodic detail with procedures adapted from the CI, such as generating a mental picture and reporting everything they remembered about the scene in as much detail as possible, including what people looked like and did, how objects were arranged, and so forth (see Method for more details). Following the induction, participants were given separate tasks in which they were asked to remember past experiences, imagine future experiences, or describe a picture, using the same materials, instructions, and AI procedure as in Gaesser et al. (2011). We compared the effects of the episodic specificity induction on these three tasks with the effects of a control induction in which the same participants watched a video similar to the one shown during the specificity induction and then provided general impressions of the video without recalling specific details. Compared with this control induction, the episodic specificity induction produced an increase in the number of episodic (internal)—but not semantic (external)—details that young and older participants provided on the memory and imagination tasks. In sharp contrast, however, the specificity induction had no effect on picture description performance in either age group. We obtained similar findings in a follow-up experiment in which the control induction involved completing math problems after viewing the video. Based on the overall pattern of results, we argued that the specificity induction selectively targets and enhances episodic retrieval, dissociating it from both semantic retrieval and narrative description.

A potentially important implication of these results for cognitive aging is that an episodic specificity induction may enhance the performance of older adults on other tasks that rely on episodic memory in addition to the remembering and imagining tasks used by Madore et al. (2014), and where differences between young and older adults' performance reflect, at least in part, age-related impairments in episodic retrieval. Given the variety of cognitive tasks on which episodic retrieval plays some role (e.g., Schacter, 2012; Sheldon & Moscovitch, 2012), the use of an episodic specificity induction could have wide ranging beneficial consequences for older adults. One such cognitive task is Means-End Problem Solving (MEPS; Platt & Spivack, 1975). On this task, participants are presented with a series of hypothetical social problems encountered by fictional individuals, such as meeting new people or handling a situation at work, along with solutions to those problems, and are asked to generate steps or means that lead to the problem solutions (e.g., "J is having trouble getting along with the boss on his job. J is very unhappy about this. The story ends with J's boss liking him. You begin the story where J isn't getting along with his boss"). Standardized scoring procedures (Platt & Spivack, 1975) provide methods for characterizing participants' responses as relevant means (i.e., steps or events that move the protagonist toward reaching an identified solution), irrelevant means (i.e., steps or events that move the protagonist toward reaching a different solution), or no means (i.e., off-topic information, commentary, or repetitive information; see Method for further details). Some investigators have also attempted to rate the effectiveness of solutions provided on the MEPS (e.g., Anderson, Goddard, & Powell, 2011; Brown, Dorfman, Marmar, & Bryant, 2012). Several studies have demonstrated that performance on the MEPS is positively correlated with the specificity of episodic or autobiographical memory retrieval in depressed and anxious individuals (Goddard, Dritschel, & Burton, 1996; Maccallum & Bryant, 2010; Raes et al., 2005; Sidley, Whitaker, Calam, & Wells, 1997; Sutherland & Bryant, 2008; Williams et al., 2006), and with measures of everyday problem solving in such individuals (Anderson et al., 2011; Marx, Williams, & Claridge, 1992). Most important for the present study, Sheldon, McAndrews, and Moscovitch (2011) recently extended the link between episodic memory and MEPS performance to cognitive aging: they reported that older adults generated fewer relevant means (i.e., steps that led to solving the problem) on the MEPS task than did young adults, but generated similar numbers of irrelevant means. Moreover, they also found that the solutions generated by older adults contained fewer episodic (internal) details than those of young participants, along with no differences in semantic (external) details, and that the number of internal (but not external) details in the autobiographical memories of older adults was positively correlated with the number of relevant means produced on the MEPS task (but see Beaman, Pushkar, Etezadi, Bye, & Conway, 2007, for a lack of age differences on the MEPS task). Vandermorris, Sheldon, Winocur, and Moscovitch (2013) replicated these results and also showed that the positive correlation between relevant steps on the MEPS task and internal details on the memory task was exhibited in young adults (along with older adults) even after executive processes were controlled for.

Overall, then, these data strongly support the idea that episodic retrieval contributes importantly to performance on the MEPS task and that impairments in episodic retrieval contribute to age deficits documented on the MEPS task. While there are situations in which the everyday problem-solving performance of older adults can exceed that of young adults (e.g., Blanchard-Fields, Mienaltowski, & Seay, 2007; see Discussion), the observations of Sheldon et al. (2011) and Vandermorris et al. (2013) are consistent with results from previous cognitive studies indicating that older adults retrieve fewer episodic details than do young adults when they remember past experiences and imagine future experiences (Addis et al., 2010, 2008; Cole et al., 2013; Gaesser et al., 2011; Madore et al., 2014; Rendell et al., 2012; Romero & Moscovitch, 2012), and also with neuroimaging evidence indicating that older adults, compared with young adults, exhibit reduced activity in brain regions linked with retrieval of episodic detail, including medial temporal lobes and precuneus, when they remember the past and imagine the future (Addis, Roberts, & Schacter, 2011). More broadly, these findings also fit with views of cognitive aging that hold that a key source of age-related memory deficits stems from difficulties with self-initiated or reconstructive retrieval (e.g., Craik, Routh, & Broadbent, 1983; Jacoby & Rhodes, 2006; Lindenberger & Mayr, 2014). The evidence of aging effects on MEPS and future imagining tasks indicates that these retrieval problems are not confined to episodic memory tasks, but also include a variety of cognitive tasks that draw on reconstructive episodic retrieval abilities.

The Present Study: Overview and Predictions

Given the role of episodic processes on a range of cognitive tasks, in the current study older and young adult participants completed a MEPS problem-solving task and AI-based memory and imagination tasks after receiving an episodic specificity induction that targeted these processes or a control induction. As done previously (e.g., Addis et al., 2008; Sheldon et al., 2011), performance on the MEPS task was measured via standardized step scoring (i.e., relevant, irrelevant, and no step) and detail scoring (i.e., internal and external), and performance on the AI-based memory and imagination tasks was measured via detail scoring (i.e., internal and external). Our initial predictions are age-related. We hypothesized that older adults would provide fewer relevant steps than young adults on the MEPS task—with no difference in other types of steps—and that their solutions would also contain fewer internal details—with no difference in external details. These hypotheses were driven by the findings of Sheldon et al. (2011) and Vandermorris et al. (2013). We also expected to replicate typical age-related differences on the memory and imagination tasks, with fewer internal details and more external details generated by older adults compared with young adults (e.g., Addis et al., 2008).

Our main predictions are induction-related. Critically, we expected that older and young adults would generate more relevant steps and internal details on the MEPS task when they received the specificity induction compared with the control induction. If the specificity induction targets episodic processes (Madore et al., 2014) and these processes are recruited when participants complete a MEPS task (e.g., Sheldon et al., 2011), then participants should see a boost in performance on the MEPS task after the specificity induction compared with a control induction. In light of our previous findings that the episodic specificity induction produced similar performance increases in young and older adults on memory and imagination tasks, we also predicted that MEPS performance in young and older adults would benefit similarly from the specificity induction. Likewise, we expected to replicate our basic specificity induction effect for memory and imagination in both age groups (in particular, an increase in internal details following the specificity induction compared with the control induction).

The primary reason for including the memory and imagination tasks in the current study was to allow direct comparison of older and young adults' performance on these tasks with their performance on the MEPS task. In this vein, we expected to replicate findings (e.g., Sheldon et al., 2011) pointing to positive correlations between episodic indices of problem solving and memory (e.g., relevant steps with internal details for memory, and internal details for problem solving with internal details for memory), and extend these findings to episodic indices of problem solving and imagination (e.g., relevant steps with internal details for imagination). We did not expect relevant steps in problem solving or internal details on the three tasks to positively correlate with the other step or external detail measures. We also did not expect to find age-related differences in the correlational analyses because all three tasks should recruit episodic processes in both age groups.

Moreover, because the scenarios on the MEPS involve fictional individuals, they may or may not have been relevant to the concerns of study participants. Previous evidence indicates that the relevance of problems to older adults' goals and concerns can influence problem-solving performance (e.g., Artistico, Cervone, & Pezzuti, 2003; Artistico, Orom, Cervone, Krauss, & Houston, 2010; Hoppmann, Coats, & Blanchard-Fields, 2008; Thornton, Paterson, & Yeung, 2013). In light of this research, it was important to assess whether age-related impairments on the MEPS were reduced or eliminated with relevant problems, and also to determine whether any effects of the episodic specificity induction differed for self-relevant problems versus the standard MEPS problems. Accordingly, we included a condition using means-end social problems involving goals and steps that were deemed relevant to both young and older adults in an independent sample.

Method

Participants

Forty-eight young adults (age = 18–24 years, M = 20.10, SD = 1.56, 34 women) and 48 older adults (age = 65–83 years, M = 72.23, SD = 5.62, 34 women) participated in the study. Young adults were recruited via postings at Harvard University and Boston University, and older adults were recruited via postings around the Greater Boston area. Participants were paid or received course credit for their participation. All participants had normal or corrected-to-normal vision and no history of neurological impairment. Older adults were screened with an extensive neuropsychological battery and were considered cognitively healthy: they had a mean Mini-Mental Status Examination (Folstein, Folstein, & McHugh, 1975) score of 28.63 (SD = 1.27, range = 26–30). Older adults had completed significantly more years of education (M = 15.67, SD = 2.37) than young adults (M = 14.77, SD = 1.29) and had a mean verbal fluency (i.e., phonemic FAS test; Lezak, 1995) score of 41.69 (SD = 15.37, range = 8–86). Educational level and verbal fluency did not predict performance on any of our main tasks, and neither factor correlated significantly with any of our dependent variables of interest. All participants provided written consent before completing the study and were treated in accordance with guidelines established by the Committee on the Use of Human Subjects in Research at Harvard University.

Experimental Design

Participants completed the study in two sessions, with session two occurring approximately a week after session one (M = 7.80 days, SD = 2.20, *median* and *mode* = 7.00). In each session, participants (a) watched a video of two adults performing routine activities in a kitchen, (b) received questions about the video's contents in the form of the episodic specificity induction or the control induction, and (c) completed the MEPS problem-solving task and the AI-based memory and imagination tasks. Participants viewed different stimuli in each session in terms of the video, induction, and task cues. The video-induction sequence used in each session was counterbalanced across participants. Participants generally took 1.5 to 2 hr to complete each session. Figure 1 illustrates the experimental design and how the main variables were measured.

Materials and Procedure

Inductions. As in our previous study (Madore et al., 2014), the episodic specificity induction was a modified version of the CI (Fisher & Geiselman, 1992). At the start of the induction, participants were told that they were the chief expert about the video, and they were asked to recall details about the setting, people, and actions in the video they had seen using mental imagery probing; they were also asked to report everything they could remember and to be as detailed as possible (e.g., "Please close your eyes and get a picture in your mind about the setting of the video you saw . . . After you have a really good picture I want you to tell me everything you remember about the setting. Try to be as specific and detailed as you can"). For the setting probe, participants were asked to report about the environment, the objects in it, and how they were arranged; for the people probe, participants were asked to report about what the people looked like and what they were wearing; and for the actions probe, participants were asked to report about what the people had done in the video and how they did these things, starting with the first action and ending with the last action. Follow-up probes asked participants to elaborate on details they had mentioned and were framed in as open-ended a manner as possible (e.g., "You said the man had on a shirt with pants. Tell me more what his shirt and pants looked like"). One follow-up probe was generally asked for each category.

The control induction consisted of an impressions interview (as in Madore et al., 2014). This induction focused on participants' opinions, impressions, and thoughts about the video. Participants were first asked to express their opinions of the video as a whole and were then asked to respond to several different questions from a question bank. These included questions about participants' impressions of the environment, people, and actions, along with adjectives they would use to describe each. Participants were also asked questions such as when they thought the video was made, if they liked the video, and if it reminded them of anything from their own lives. After answering these questions, participants were asked if they had any other opinions or thoughts about the video and if there was anything else they wanted to say about it. Like the episodic specificity induction, the control induction required participants to think and speak about the video in both sessions. The main difference was that the specificity induction instructed participants to discuss episodic details about the video whereas the control induction instructed participants to discuss their general impressions of the video.

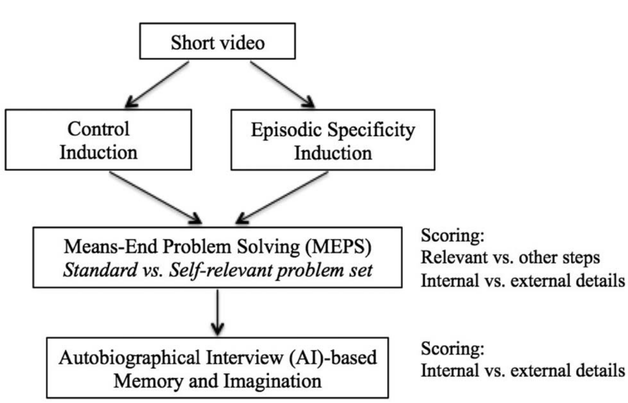

Figure 1. Schema of experimental design.

Problem-solving task. After working through the induction phase, participants completed the problem-solving task. They viewed 5 different problem stories in each session, each of which contained a beginning problem and an ending solution. Participants were asked to write down on lined paper the steps they would take to reach the solution in each story. They were instructed to write down as many steps as they could in as much detail as they could, without reference to omitting off-topic steps or details. Participants had 5 min to generate solution steps for each story, and they completed this task without any input or probing from the experimenter to minimize environmental support (as done in Sheldon et al., 2011). The order of stories was randomized across participants.

Half of the young adults and half of the older adults viewed standard MEPS stories (Platt & Spivack, 1975). Each of the stories introduced a different third-person, fictional character and identified a problem they had at the beginning of the story and a successful solution they came to at the end of the story. The stories contained problems such as making new friends, finding a watch, and becoming a leader in a community organization. Each story contained either a male or female character, and participants viewed stories containing characters of each gender. See Appendix A in the online supplemental materials for the MEPS task instructions and story stimuli.

The other half of young and older adults viewed self-relevant MEPS stories we created drawing on data collected from an independent sample (Spreng & Schacter, 2012), where young and older adults had identified goals they found personally relevant in their own lives and could generate solution steps to solve. For the current study, we chose a subset of these goals that members from both age groups deemed personally relevant and could supply solution steps to solve. We matched the personal goals in story form to the standard MEPS format with a beginning problem and an ending solution. The stories contained self-relevant problems such as exercising more, making more time for family, and managing personal finances better. The stories introduced the problems in first-person form rather than third-person, fictional form (e.g., "You would like to exercise more" as opposed to "J would like to exercise more"). See Appendix B in the online supplemental materials for the self-relevant task instructions and story stimuli.

Participants were randomly assigned to one of the two problem sets and there were no significant differences at the $p < .05$ level in terms of age, educational level, Mini-Mental Status Examination score, verbal fluency, or gender between the two groups. The standard prompts had slightly more details attached to them compared with the self-relevant prompts, which could have assisted participants in the former group by providing more environmental support (Lindenberger & Mayr, 2014). Nonetheless, participants who completed the self-relevant problems rated them as significantly less difficult ($M = 2.00$, $SD = 0.74$, on a 5-point Likert scale where 1 = *least difficult* and 5 = *most difficult*) than those participants who completed the standard problems ($M = 2.54$, $SD = 0.80$), $t(94) = 3.40$, $p = .001$, $d = 0.70$. This pattern of significance held in both young and older adults. This finding was not surprising, because the self-relevant problems were created so that participants would have an easier time identifying with them compared with the standard MEPS problems. Young and older adults also did not differ significantly in how difficult they perceived the problems to be overall.

Adapted AI. After finishing the problem-solving task, participants moved to the adapted AI task, where they viewed 8 different pictures and were asked to write down a personal memory or imagined future experience that was related to some aspect of the picture. Each remembered experience had to have occurred within the past few years and each imagined experience had to occur within the next few years. Participants were asked to focus on a single event on a single day that lasted a few minutes to a few hours, and to think about the event from their own perspective. They were instructed to write down everything they could remember or imagine about the event in as much detail as they could, including actions, people, and feelings, without reference to omitting off-topic details. Participants had 3 min to generate a response for each picture. The picture stimuli showed scenes common to both young and older adults, such as an airport, a museum, and a park. Pictures were blocked by task, and the order of the two tasks was counterbalanced across participants (i.e., sometimes memory preceded imagination and sometimes memory followed imagination). Pictures were randomized across tasks and participants. As in the problem-solving task, there was no experimenter input or probing here to minimize the effects of environmental support on performance (as done in Sheldon et al., 2011).

Coding. Participants' responses for the problem-solving and AI tasks were transcribed and scored. Responses for both the standard and self-relevant problem-solving tasks were scored according to the step categories set forth by Platt and Spivack (1975) and used by other research teams (e.g., Sheldon et al., 2011). A response containing a step or event that moved the protagonist toward reaching the identified solution state was coded as a *relevant step*. A response containing a step or event that moved the protagonist toward a different solution state was coded as an *irrelevant step*. A response containing other types of off-topic information, commentary, or repetitive information from the story prompt was coded as a *no step*. For example, in the standard MEPS story asking participants to generate solution steps for resolving J's conflict with their boss, a *relevant step* could be J scheduling a meeting with their boss, an *irrelevant step* could be J quitting their job, and a *no step* could be a participant's commentary on J (such as "I feel bad for J"). Irrelevant steps and no steps were collapsed into a single *other steps* category. Responses for the standard and self-relevant problem-solving tasks were also scored with the internal and external categories typically used in AI tasks. Internal details were any bits of episodic information that corresponded to a *relevant* step and external details were any bits of semantic, off-topic, or repetitive information that corresponded to an *other* step. As in our previous study (Madore et al., 2014), responses for the memory and imagination tasks were also scored for internal and external details (see Levine et al., 2002). Internal details were any bits of episodic information about the central memory or imagination (e.g., actions, people, thoughts, feelings, setting, time, objects, etc.) and external details were any bits of semantic, off-topic, or repetitive information. Hypothetically, external details could also include episodic information that was off-topic in nature on each task (e.g., episodic details about an event other than the central event for a memory or imagination trial, or episodic details contained in an irrelevant step toward a different solution state for a problem-solving trial) though this happened very infrequently.

One of five raters scored the responses of each participant. Before coding for the experiment commenced, raters independently completed training and attained high interrater reliability on a practice set of 20 responses from young and older adults (standardized Cronbach's alpha = .92 for steps, .95 for internal details, and .94 for external details). All raters were blind to all experimental hypotheses and to which induction had been received. Table 1 contains excerpts that both young and older participants gave in response to the same cues for the problem solving, memory, and imagination tasks, and illustrates how the raters categorized these excerpts in terms of steps and details. We also conducted additional analyses based on procedures that have been developed in the event segmentation literature (e.g., Kurby & Zacks, 2011; Zacks, Tversky, & Iyer, 2001). Although these analyses did not change any of our main conclusions, the interested reader is referred to Appendix C in the online supplemental materials.

Results

To address our hypotheses, we conducted a series of mixed-factorial analyses of variance (ANOVAs), which involved the between-subjects factors of age (young vs. older) and problem set (standard vs. self-relevant MEPS) and the within-subjects factors of induction (control vs. specificity), task (problem solving vs. memory vs. imagination), step type (relevant vs. other), and detail type (internal vs. external). For each analysis, we tested for main effects and interactions. Results reported here focus on the interactions found because they most directly addressed our hypotheses and trumped the main effects. Post hoc tests conducted were two-tailed and Bonferroni corrected at the $p < .05$ level. We first present the age-related findings, followed by the induction effects and correlational evidence.

Age-Related Differences

Steps. We first examined whether young and older adults differed in the number of relevant steps and other steps generated on the problem-solving task as a function of age and problem set, irrespective of which induction they initially received. We found that the Age × Step Type interaction was significant, $F(1, 92) = 25.52$, $p < .001$, $\eta_p^2 = .22$, but the Age × Problem Set × Step Type interaction was not, $F(1, 92) = 0.83$, $p = .37$, $\eta_p^2 = .01$. For the Age × Step Type interaction (Figure 2), post hoc tests indicated that older adults generated significantly fewer relevant steps than young adults when responding to the problems, whether they were standard MEPS or self-relevant ones, $t(94) = 5.16$, $p < .01$,

Table 1
Excerpts From Different Young and Older Adults Categorized by Step and Detail Type

Task/Cue	Age	Relevant steps/Internal details	Other steps/External details
Problem solving/Plan a day trip (story cue)	Young	"I first gauge everyone's interest in the trip . . . and decide on a day that fits in everyone's schedule. Then I research the hiking trail we want to take . . . I go to the grocery store and buy snacks to take on the hike, such as granola, bananas, dried fruit, and energy drinks . . . I pack everything into the car . . ."	"Trip is planned . . ."
	Older	"Look into the train schedule having decided to go to Portsmouth . . . I get us some lunch food . . . inquire about a city bus tour . . ."	"The train ride is always pleasant . . ."
		Internal details	External details
Memory/Dancing (picture cue)	Young	"I had a [sorority] formal in November. I wore a beige/pale pink dress with a strapless sweetheart neckline and had rhinestones at the top. I had a date . . . who wore a dark gray suit with a plaid black and gray and white tie . . ."	"I joined . . . for one year and then quit . . ."
	Older	"A wedding I attended last January. People were dressed lovely, the music was great, and I danced the night away . . ."	"Kind of wish we could do this more often . . ."
Imagination/Museum (picture cue)	Young	"I am at the MET museum. After I have exited the classics exhibition and enjoyed all the statues . . . I would find myself sitting down . . . to check out Impressionist paintings. I would note the colors of the shadows . . . there would be guards looking for cameras . . ."	"When I was in high school I loved art, especially sculptures . . ."
	Older	"I got to the new exhibit at the MFA. I got there at 10:30am . . . off to the cafeteria for lunch . . . busy . . ."	"I like to go frequently . . . because too long there does not seem to suit me . . ."

$d = 1.05$; older adults and young adults did not significantly differ in the number of other steps generated across problem set, $t(94) = 0.16$, $p = .87$, $d = 0.03$. This pattern of results indicates that there are age-related differences in generating relevant steps on means-end problem solving that are of similar magnitude regardless of whether the problem set is comprised of standard or self-relevant MEPS problems, thereby replicating and extending the results of Sheldon et al. (2011) and Vandermorris et al. (2013).

Internal and external details for steps. We next examined whether young and older adults differed in the number of internal and external details provided on the problem-solving task as a function of age and problem set, irrespective of which induction they initially received. We found that the Age × Detail Type interaction was significant, $F(1, 92) = 19.21$, $p < .001$, $\eta_p^2 = .17$, whereas the Age × Problem Set × Detail Type interaction approached but did not attain significance, $F(1, 92) = 3.72$, $p = .057$, $\eta_p^2 = .04$. For the Age × Detail Type interaction (Figure 2), post hoc tests indicated that older adults' solutions to the MEPS problems contained significantly fewer internal details than young adults', whether they were generated in response to the standard or self-relevant MEPS, $t(94) = 3.95$, $p < .01$, $d = 0.81$ (though there was a nonsignificant trend for a greater age difference with the standard than self-relevant problems). Older and young adults' solutions did not differ in the number of external details they contained across problem set, $t(94) = 0.25$, $p = .81$, $d = 0.05$. This pattern suggests that there are age-related differences in the number of internal details contained in means-end problem-solving solutions irrespective of whether the MEPS problems are standard or self-relevant, again replicating and extending previous results from Sheldon et al. (2011) and Vandermorris et al. (2013).

Internal and external details for memory and imagination. We next examined whether young and older adults differed in the number of internal and external details provided on the memory and imagination tasks as a function of age and problem set, irrespective of which induction they initially received. Consistent with previous findings (e.g., Addis et al., 2008, 2010; Gaesser et al., 2011; Madore et al., 2014), we found a significant interaction of Age × Detail Type, $F(1, 92) = 37.01$, $p < .001$, $\eta_p^2 = .29$,

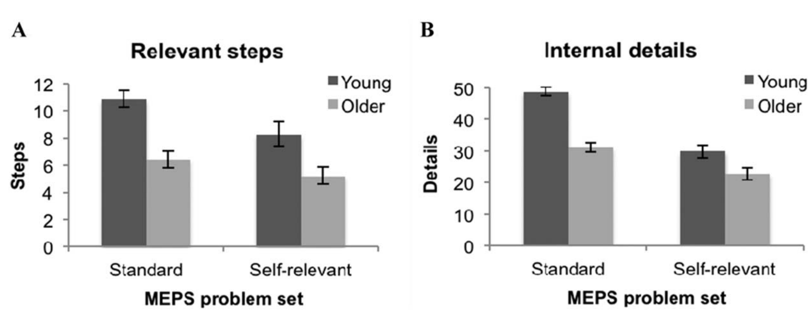

Figure 2. Mean relevant steps (A) and internal details (B) reported by young and older adults in problem solving across inductions as a function of problem set. Error bars represent 1 *SE*.

which did not interact with the Task and/or Problem Set variables (*F*s < 2.08, *p*s $> .15$). For the Age × Detail Type interaction (Table 2), post hoc tests indicated that older adults provided significantly fewer internal details for memory and imagination tasks than young adults irrespective of whether participants first generated solutions to standard or self-relevant MEPS, $t(94) = 5.98$, $p < .01$, $d = 1.22$; older and young adults did not significantly differ in the number of external details provided for memory and imagination, $t(94) = 1.96$, $p = .106$, $d = 0.40$. This pattern indicates that there are age-related differences in the number of internal details provided for memory and imagination after completing a MEPS task with either standard or self-relevant problems.

Induction Effects

Steps. Given that we found the expected age-related differences for relevant steps and internal details on the problem-solving task, and internal details on the memory and imagination tasks, we next examined the critical issue of how the episodic specificity induction impacted steps generated on the problem-solving task as a function of age, problem set, and step type. Participants spent slightly longer discussing the contents of the video under the specificity induction (*M* = 3 min, 56 s, *SD* = 1 min, 26 s) compared with the control induction (*M* = 3 min, 8 s, *SD* = 1 min, 19 s), $t(95) = 5.70$, $p < .001$, $d = 0.58$. When the difference score in time between inductions was added as a covariate for the analyses below involving the induction variable, it did not significantly affect any results.

We found a significant interaction of Induction × Step Type, $F(1, 92) = 29.61$, $p < .001$, $\eta_p^2 = .24$, but this was qualified by a significant interaction of Induction × Age × Step Type, $F(1, 92) = 5.77$, $p < .05$, $\eta_p^2 = .06$. These combinations of variables did not interact with Problem Set (*F*s < 0.19, *p*s $> .67$). Irrespective of problem set, post hoc tests indicated that young adults generated significantly more relevant steps after receiving the specificity induction compared with the control induction, $t(47) = 4.54$, $p < .01$, $d = 0.66$, and significantly fewer other steps after receiving the specificity induction compared with the control induction, $t(47) = 3.20$, $p < .01$, $d = 0.46$. Critically, older adults also generated significantly more relevant steps after receiving the specificity induction compared with the control induction, $t(47) = 3.25$, $p < .01$, $d = 0.47$. However, they did not differ in the number of other steps generated after receiving the specificity or the control induction, $t(47) = 0.37$, $p = .71$, $d = 0.05$. As seen in Figure 3, this pattern of results points to the efficacy of the specificity induction in boosting the production of relevant steps during means-end problem solving in both young and older adults irrespective of whether the problems are standard or self-relevant MEPS.

Internal and external details for steps. We also examined how the episodic specificity induction affected the number of internal and external details provided as part of solutions to the problem-solving task in young and older adults as a function of age, problem set, and detail type. Like our previous analysis with steps, we found a significant interaction of Induction × Detail Type, $F(1, 92) = 41.36$, $p < .001$, $\eta_p^2 = .31$, but this was qualified by a significant interaction of Induction × Age × Detail Type, $F(1, 92) = 4.18$, $p < .05$, $\eta_p^2 = .04$. There were no further interactions with Problem Set (*F*s < 0.38, *p*s $> .54$). Irrespective of problem set, post hoc tests indicated that young adults' solutions contained significantly more internal details after receiving the specificity induction compared with the control induction, $t(47) = 5.28$, $p < .01$, $d = 0.76$, and significantly fewer external details after receiving the specificity induction compared with the control induction, $t(47) = 3.22$, $p < .01$, $d = 0.47$. Critically, older adults' solutions also contained significantly more internal details after receiving the specificity induction compared with the control induction, $t(47) = 3.91$, $p < .01$, $d = 0.56$. However, their solutions did not differ in the number of external details as a function of induction, $t(47) = 0.68$, $p = .50$, $d = 0.10$. As seen in Figure 3, this pattern of findings highlights the efficacy of the specificity induction in boosting the number of internal details contained in the problem-solving solutions of young and older adults.

Internal and external details for memory and imagination. We also examined how the episodic specificity induction affected internal and external details provided for memory and imagination as a function of age, problem set, task, and detail type. We found a significant interaction of Induction × Detail Type, $F(1, 92) = 58.39$, $p < .001$, $\eta_p^2 = .39$. The Induction × Detail Type interaction was nonsignificant with any combination of the Age, Problem Set, and Task variables (*F*s < 0.49, *p*s $> .48$). Post hoc tests indicated that young and older adults provided significantly more internal details on the memory and imagination tasks after receiving the specificity induction compared with the control induction, $t(95) = 7.47$, $p < .01$, $d = 0.76$, and significantly fewer external details for memory and imagination after receiving the specificity induction compared with the control induction, $t(95) = 5.52$, $p < .01$, $d = 0.56$. This pattern of findings (Table 2) replicates and extends the findings of our previous study concerning the effects of the specificity

Table 2
Mean Details Generated by Young and Older Adults in Memory and Imagination

	Young			Older		
	Control	Specificity	Collapsed	Control	Specificity	Collapsed
Memory internal details	26.70 (1.64)	31.44 (1.49)	29.07 (1.45)	15.93 (1.47)	21.41 (1.46)	18.67 (1.34)
Imagination internal details	25.20 (1.41)	30.22 (1.13)	27.71 (1.06)	15.17 (1.39)	20.41 (1.43)	17.79 (1.31)
Memory external details	1.37 (0.21)	0.77 (0.15)	1.07 (0.15)	1.59 (0.20)	0.98 (0.18)	1.29 (0.16)
Imagination external details	1.05 (0.17)	0.52 (0.11)	0.79 (0.12)	1.63 (0.24)	1.15 (0.25)	1.39 (0.22)

Note. *SE* in parentheses.

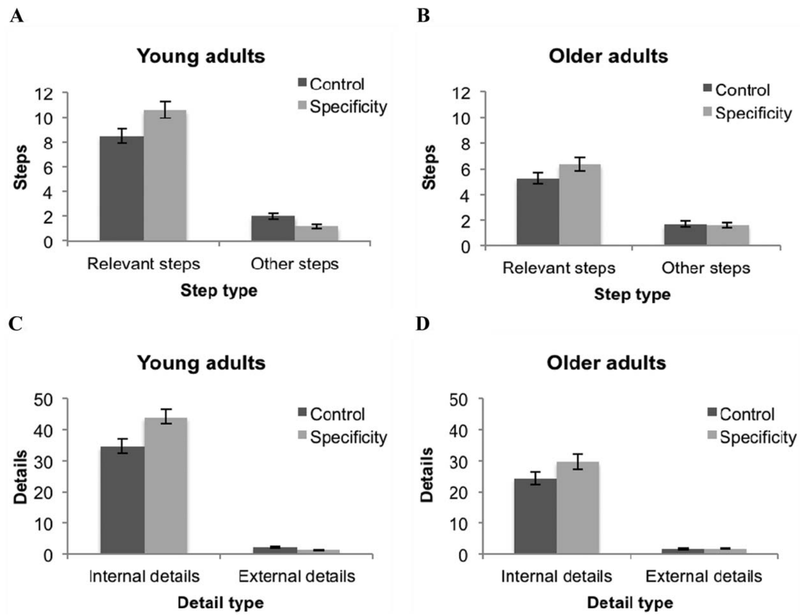

Figure 3. Mean steps reported by young (A) and older adults (B) in problem solving as a function of induction and step type, and mean details corresponding to steps reported by young (C) and older adults (D) in problem solving as a function of induction and detail type. Error bars represent 1 *SE*.

induction on memory and imagination tasks (Madore et al., 2014).

Correlations between problem solving and memory/imagination performance. We also ran a series of bivariate correlational analyses to investigate further the degree to which episodic processes are involved in the problem solving, memory, and imagination tasks. We computed averages of the different step measures and detail measures for each participant collapsed across induction and problem set. In the analyses we also collapsed across age (i.e., all 96 participants were included; the same general patterns were found when we performed these analyses separately for the two induction types, age groups, and problem sets, with some minor variations that do not affect our main conclusions). The correlations were tested at a two-sided significance level of $p < .05$. As Table 3 displays, the contrasting patterns for significant positive correlations between internal details and relevant steps on the one hand versus significant positive correlations between external details and other steps on the other provide additional evidence that coming up with task-relevant solution steps on the problem-solving task tapped into episodic processes that are also involved in memory and imagination. The correlations between age itself and the different step and detail measures are included in Table 3 for the interested reader.

Discussion

The results of the present experiment both extend the range of tasks on which our CI-based episodic specificity induction enhances performance in both young and older adults, and also adds to our knowledge of the contribution of episodic retrieval processes to means-end problem solving. Consistent with our predictions, the specificity induction selectively increased the number of relevant steps produced by young and older adults on means-end problem solving with both standard and self-relevant problems, and increased the number of internal details contained in those solution steps. This pattern of findings is consistent with the

Table 3
Correlations Between Step Measures, Detail Measures, and Age

Variable	1	2	3	4	5	6	7	8	9
1. Relevant steps	—								
2. Step internal details	.80***	—							
3. Memory internal details	.49***	.66***	—						
4. Imagination internal details	.46***	.57***	.79***	—					
5. Other steps	−.25*	−.16	.08	.02	—				
6. Step external details	−.18	−.16	.09	.03	.98***	—			
7. Memory external details	.14	.09	−.28**	−.18	.27**	.29**	—		
8. Imagination external details	.13	.19	−.07	−.40***	.35**	.35**	.57***	—	
9. Age	−.47***	−.39***	−.51***	−.54***	.03	−.01	.13	.24*	—

* $p < .05$. ** $p < .01$. *** $p < .001$.

constructive episodic simulation hypothesis (Schacter & Addis, 2007), in that it shows that an induction that targets episodic processes can impact performance on a cognitive task, means-end problem solving, that does not nominally require episodic retrieval, but where previous evidence (e.g., Sheldon et al., 2011) suggests an important role for retrieving and recombining episodic details. Correlational analyses confirmed that means-end problem solving draws on episodic mechanisms: relevant steps and internal details, which were both significantly increased by the specificity induction, were positively associated with one another; by contrast, other steps and external details, which were not increased by the induction, were positively associated with each other but not with relevant steps or internal details. Overall, the pattern of results observed here is consistent with, and provides a basis for expanding on, the results and theoretical account offered by Sheldon et al. (2011) and Vandermorris et al. (2013), who also emphasized the contribution of episodic memory and simulation processes to means-end problem solving in both young and older adults.

It should be noted that several previous studies of means-end problem solving have failed to find benefits of manipulations that in some respects resemble the specificity induction used in the present study (e.g., Beaman et al., 2007; Dennis, Astell, & Dritschel, 2012; Goddard, Dritschel, & Burton, 2001). While these studies suggest that a specificity induction may not always be useful for improving means-end problem solving, they differ from the current study in at least two important respects. First, they all used a between-subjects design for the specificity manipulation, where participants were assigned to either a control or a specificity condition. By contrast, we used a within-subjects design, where participants received the control induction and the specificity induction in separate sessions (the order of which was counterbalanced across participants; there was no effect of induction order on the main results). This design feature allowed us to test for change in performance as a function of the induction at both the participant and group level, and reduced variability unrelated to the experimental manipulation. When we examined induction effects between-subjects (e.g., participants who had the specificity induction first vs. control induction first), we found that the specificity induction significantly boosted relevant steps in young adults but showed only a trend for such an effect in older adults. Thus, within- versus between-subjects designs may play some role in differences across studies. Second, not all specificity manipulations incorporate the same techniques for targeting episodic processes. The specificity induction used here, based on the principles of the CI, provides participants with online feedback, multiple prompts for mental imagery, and a report everything instruction that encourages participants to recall all aspects of the experienced event in as open-ended a framework as possible (Memon et al., 2010). These features of the induction are different from those used in other studies where participants are asked to retrieve specific memories without much further instruction or with more rigid demands about when and how they should do so.

While the specificity induction used here did enhance performance for problem solving, memory, and imagination, it should be noted that, consistent with predictions, the induction did not reduce or eliminate age-related differences on these tasks. Older adults provided fewer relevant steps and fewer internal details on the three tasks compared with young adults, whether they received the specificity induction or not. This finding replicates and extends our previous work with memory and imagination tasks (Madore et al., 2014), and leaves open the question of what sort of training conditions could boost older adult performance to young adult levels—if such conditions exist at all. Based on previous studies cited earlier indicating that personal relevance can affect problem-solving performance in older adults (Artistico et al., 2003, 2010; Hoppmann et al., 2008; Thornton et al., 2013), we had suspected that making the means-end problems self-relevant might differentially improve the performance of older adults. However, we found that making MEPS problems more self-relevant had little effect overall and did not differentially impact performance across age groups. While there may be age-related differences on episodic tasks that cannot be reduced by a specificity induction, future work should continue to test ways of doing so.

It should also be noted that irrespective of induction, young and older adults did not differ in the number of other steps or external details that they generated in problem solving, memory, and imagination. Sheldon et al. (2011) also found that age had no effect on the number of other steps and external details that participants generated in problem solving. Nonetheless, previous research has also found that when older adults provide fewer internal details on memory and imagination tasks, they typically provide a greater number of external details on these tasks compared with young adults (Addis et al., 2010, 2008; Cole et al., 2013; Gaesser et al., 2011; Madore et al., 2014). The pattern of findings we obtained with external details for memory and imagination is important, because it suggests that an age-related decrease in internal details on these tasks is not necessarily a secondary by-product of increased external details. One difference between the current study and others involving memory and imagination is that we required participants to write out their answers rather than verbalizing them aloud (as had Sheldon et al., 2011). Participants also worked on the tasks without any input or probing from the experimenter. The act of writing and generating answers to oneself may have triggered self-regulatory processes that helped participants stay on topic and on task, thereby reducing the number of external details that older adults in particular might have otherwise produced.

It is worth noting that our specificity induction effects were obtained in comparison with a control induction that required participants to provide general impressions of the video they watched prior to the induction. We think that this is an appropriate control for the specificity induction because it requires participants to think and speak about the video, just like the specificity induction, but does not require retrieval of episodic details. It is possible, however, that the impressions control induction results in a suppression of internal details on subsequent tasks relative to a neutral baseline, rather than the specificity induction producing an increase. To address this possibility, in our previous study (Madore et al., 2014) we compared the specificity induction to a neutral baseline in which young adult participants completed math problems prior to completing memory and imagination tasks. We found a nearly identical pattern of results as with the impressions control: there was a significant increase in internal details on memory and imagination tasks following the specificity induction compared with the math problems control, indicating that our effects reflect an increase above baseline from the specificity induction rather than a suppression below baseline produced by the impressions control. However, because we ran the math problems control only with young adults, it is conceivable that the effects with older adults are attributable to suppression below baseline from the impressions control rather than an increase from the specificity induction. We think that this possibility is highly unlikely because in the present study and in our previous experiment (Madore et al., 2014), the specificity induction has had parallel effects on the performance of young and older adults: nothing in the pattern of data obtained so far would indicate that there is a fundamentally different basis for the effects obtained in the two groups. Moreover, we are not aware of any plausible theoretical rationale for why the basis of the effects should differ fundamentally in young and old. Nonetheless, it would be useful for a future study to examine the effects obtained here using a control condition such as the math problems control we used previously instead of the impressions control.

Taken together, our finding here and in our previous study (Madore et al., 2014) that the specificity induction boosts memory, imagination, and problem-solving internal details in both age groups offers evidence that the specificity induction could be targeting a process that is involved in all three tasks. The constructive episodic simulation hypothesis (Schacter & Addis, 2007) indicates that both remembering and imagining require retrieving episodic details from the past, though imagining also requires recombining elements of past experiences into novel scenarios (see Schacter et al., 2012, for review). The process of retrieving episodic details appears to be common to memory, imagination, and problem solving, and thus may be the mechanism that is affected by the specificity induction.

This point may also be relevant to studies conducted by Blanchard-Fields and colleagues noted earlier (e.g., Blanchard-Fields et al., 2007) showing that older adults can sometimes exhibit more effective everyday problem solving than young adults. These studies have two major methodological differences from the current one. The first involves a procedure that is frequently used to measure everyday problem solving. For example, in the study by Blanchard-Fields et al. (2007), older and young adults endorsed particular strategies for dealing with various everyday situations among various strategic options that were presented to them, and their responses were correlated with effectiveness ratings of judges for the selected strategies; more effective problem solving was inferred from stronger correlations between the responses of older adults and judges than young adults and judges (for related studies, see Blanchard-Fields, Chen, & Norris, 1997; Cornelius & Caspi, 1987; Hoppmann & Blanchard-Fields, 2010). Such tasks likely place much less demand on episodic retrieval processes than does a generative task such as the MEPS or other problem-solving tasks that require a combination of selection and generation (e.g., Lyons, Henry, Rendell, Corballis, & Suddendorf, 2014), perhaps accounting for the differing patterns of results.

The second difference concerns the scoring criteria for what makes an effective problem solver. Some studies have characterized older adults as more effective problem solvers than young adults even when step generation is examined rather than step endorsement. However, these studies have typically used different coding schemes than the one we used (e.g., Blanchard-Fields, Jahnke, & Camp, 1995; Blanchard-Fields, Stein, & Watson, 2004; Hoppmann et al., 2008). In these studies, raters scored how well participants' generated responses fit under different predetermined and qualitative strategic styles (e.g., "problem focused action" or "avoidant thinking and denial") rather than tabulating quantitative fluency or detail. Here, emphasis is often placed on solution diversity for different types of problems as measured by these strategic styles (see Blanchard-Fields, 2007, and Mienaltowski, 2011, for relevant reviews). Future work should continue to examine what facets of problem-solving scoring are the most useful for measuring effectiveness in young and older adults, and whether different patterns of age-related findings can be explained by which cognitive processes are being targeted and measured via the paradigm, stimuli, and scoring criteria used.

Future work should also examine whether our episodic specificity induction can influence problem-solving performance in everyday life. The effects from our induction appear to be short-lived (i.e., specificity vs. control induction effects were observed on a within-participants basis, and order of induction had no effect on performance), so an important task will be to determine how the induction effect can be strengthened, perhaps through additional booster sessions.

In summary, the current research highlights how episodic specificity can positively impact performance on cognitive tasks ranging from means-end problem solving to memory and imagination in both young and older adults. The efficacy of the specificity induction observed here, together with our previous evidence that the induction can dissociate episodic retrieval from nonepisodic processes (Madore et al., 2014), calls for further use of the specificity induction as a tool to isolate contributions of episodic retrieval processes across a range of cognitive domains, and also to examine the ways in which malleable episodic processes in young and older adults can enhance functioning on tasks that are important in everyday life.

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