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Constructive episodic simulation: Dissociable effects of a specificity induction on remembering, imagining, and describing in young and older adults

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Abstract

According to the constructive episodic simulation hypothesis (Schacter & Addis, 2007), both remembered past and imagined future events rely heavily on episodic memory. An alternative hypothesis is that observed similarities between remembering and imagining reflect the influence of broader factors such as descriptive ability, narrative style, or inhibitory control. We attempted to distinguish between these two hypotheses by examining the impact of an episodic specificity induction on memory, imagination, and picture description in young and older adults. In Experiment 1, participants received the specificity induction or a control induction prior to the memory, imagination, and description tasks. Older adults provided fewer internal (i.e., episodic) and more external (i.e., semantic) details than young adults across the three tasks irrespective of induction. Critically, however, the specificity induction selectively increased internal but not external details for memory and imagination in both age groups compared with the control induction. By contrast, the induction did not affect internal (or external) details for picture description. Experiment 2 replicated these results in young adults using a different control induction. Our findings point to a dissociation between episodic processes involved in memory and imagination and non-episodic processes involved in picture description.

Keywords

episodic specificity induction; autobiographical memory; imagination; picture description; aging

Much recent research has revealed striking cognitive and neural similarities between remembering past events and imagining future events. For example, remembering past events and imagining future events include many similar phenomenological features, exhibit parallel declines in various psychopathological and neuropsychological populations, and draw to a large extent on a common core network of brain regions (for recent reviews, see Klein, 2013; Schacter, Addis, Hassabis, Martin, Spreng, & Szpunar, 2012; Szpunar, 2010). Although a number of important differences between remembering the past and imagining the future have also been documented (see Schacter et al., 2012, for review), the striking similarities that have been documented led to the postulation of the *constructive episodic simulation hypothesis* (Schacter & Addis, 2007), which holds that a) a critical function of

episodic memory is to support the construction of imagined future events, b) remembered past and imagined future events rely on many of the same underlying cognitive processes, and c) episodic memory supports the construction of imagined future events by flexibly retrieving and recombining stored information into a novel scenario. The constructive episodic simulation hypothesis also holds that this flexibility of episodic memory can sometimes result in memory distortions, such as confusions between imagined and actual events (for further discussion, see Dudai & Carruthers, 2005; Gerlach, Dornblaser, & Schacter, in press; Schacter, 2012; Schacter, Guerin, & St. Jacques, 2011; Suddendorf & Busby, 2003).

One important source of support for the constructive episodic simulation hypothesis stems from studies with young and older adults showing that age-related changes in remembering the past extend to imagining the future (see Schacter, Gaesser, & Addis, 2013, for a recent review). In an initial study, Addis, Wong, and Schacter (2008) had young and older adults participate in an adapted version of the Autobiographical Interview (AI), a procedure initially developed by Levine, Svoboda, Hay, Winocur, and Moscovitch (2002) for distinguishing between the “internal” and “external” details that comprise autobiographical memories. Internal details are episodic in nature, consisting of specific information concerning the who, what, where, and when of the retrieved experience. By contrast, external details are primarily semantic in nature, and involve related facts, elaborations, or references to other events. In the study by Addis et al. (2008), young and older adults were given cue words and either remembered a personal experience from the past few weeks or years related to the word, or imagined a related personal experience that could plausibly occur in the next few weeks or years. Addis et al. (2008) found that older adults reported significantly fewer internal details and more external details about both remembered past events and imagined future events compared with young adults. The number of internal details reported about remembered events was strongly positively correlated with the number of internal details reported about imagined events, and positive correlations were also observed for external details concerning remembered and imagined events. A similar pattern of results was reported in a subsequent study by Addis, Musicaro, Pan, and Schacter (2010) that combined the AI with an experimental recombination paradigm in which young and older adults initially reported autobiographical memories involving a person, place, and object and then were asked to create imagined future scenarios comprised of novel combinations of the people, places, and objects from their actual memories (for related findings, see Romero & Moscovitch, 2012).

These initial findings support the constructive episodic simulation hypothesis because they suggest the correlated age-related differences in memory and imagination are primarily attributable to changes in episodic memory mechanisms. However, this conclusion has been called into question by more recent research suggesting that changes in non-episodic mechanisms are primarily responsible for age-related changes in memory and imagination (Gaesser, Sacchetti, Addis, & Schacter, 2011). For example, some studies from the verbal discourse literature suggest that age-related differences in inhibitory control can affect verbal production of the kind exhibited in AI tasks (e.g., Arbuckle & Gold, 1993). Other studies from this literature also indicate that compared with young adults, older adults employ a more general narrative style and have different communicative goals (Adams,

Smith, Nyquist, & Perlmutter, 1997; Labouvie-Vief & Blanchard Fields, 1982). These differences can result in the production of more “off-topic” speech that is irrelevant to an assigned task in older than young adults (Trunk & Abrams, 2009). Such differences could have important consequences for an AI task. If older adults communicate in a more general way than young adults do, or are more prone to including off-topic details in their narratives, then they may report fewer episodic details than young adults do on memory and imagination tasks not because of age-related differences in episodic memory mechanisms, but because of differences in descriptive ability, narrative style, inhibitory control, or other non-episodic processes.

To investigate how episodic and non-episodic mechanisms impact age-related changes in memory and imagination, Gaesser et al. (2011) had young and older adults view pictures of everyday scenes, and either remember an experience related to the picture, imagine a possible event related to the picture, or describe what was depicted in the picture. Gaesser et al. (2011) reasoned that describing pictures should not require retrieving or recombining episodic details from past experiences and thus could provide a measure of non-episodic processes such as narrative style that might impact age-related changes in memory and imagination. Older adults reported fewer internal and more external details across the memory, imagination, and picture description tasks compared with young adults, thus suggesting that previously observed findings of correlated age-related changes in memory and imagination may reflect broader changes in narrative style or related non-episodic processes. Results of a hierarchical regression analysis in which picture description and age were both entered into the model as predictors of memory and imagination performance revealed that picture description performance significantly predicted memory and imagination performance, along with a small effect attributable to age, above and beyond the effects accounted for by picture description performance (for related results, see also Rendell, Bailey, Henry, Phillips, Gaskin, & Kliegel, 2012).

The overall pattern of results from the studies by Gaesser et al. (2011) suggest that age differences in remembering the past and imagining the future are attributable, to a large extent, to changes in non-episodic mechanisms that are commonly involved in the picture description, memory, and imagination tasks. These findings thus also raise more general questions about the theoretical interpretation of similarities between remembering the past and imagining the future: rather than reflecting the operation of common episodic memory processes that contribute to remembering and imagining, as maintained by the constructive episodic simulation hypothesis, perhaps such similarities reflect the operation of much more general processes, such as communicative goals, inhibitory control, or narrative style. Most studies of remembering the past and imagining the future have not included tasks such as picture description that allow assessment of contributions from non-episodic processes, so it is possible that reported similarities between memory and imagination might also extend to picture description. For example, Zeman, Beschin, Dewar, and Della Sala (2013) reported that amnesic patients who exhibit deficits in imagining the future show similar deficits in picture description (but see Race, Keane, & Verfaellie, 2011, for evidence that picture description is intact in some amnesic patients who show deficits in imagination). Research to date does not allow for strong claims about the precise contributions of non-episodic processes to picture description. Descriptive ability, narrative style, communicative goals,

and inhibitory control are all non-episodic processes that picture description may tap into and which may contribute to age differences on this task. According to the constructive episodic simulation hypothesis, the shared episodic processes that are hypothesized to contribute to remembering the past and imagining the future should be dissociable from the non-episodic processes that contribute to picture description.

The present study

In the present study, we tested this hypothesis by using an *episodic specificity induction* designed to selectively enhance episodic processes that, according to the constructive episodic simulation hypothesis, contribute to memory and imagination but not to picture description. Picture description could, of course, draw on episodic memory (or perhaps working memory) in order to maintain information about what one has just said about a picture, but the same can be said about the memory and imagination tasks (i.e., one needs to maintain information about what one has reported about a remembered or imagined event). We hypothesize that a picture description task differs from memory and imagination tasks in that the latter two tasks draw on episodic memories of experiences that occurred prior to the experimental session to a much greater extent than picture description. Several previous studies have provided evidence that an episodic specificity induction can produce significant increases in episodic detail on subsequent tasks that tap either remembering (Maestas & Rude, 2012; Neshat-Doost, Dalgleish, Yule, Kalantari, Ahmadi, Dyregrov, & Jobson, 2012; Rudoy, Weintraub, & Paller, 2009) or imagining (Williams, Ellis, Tyers, Healy, Rose, & MacLeod, 1996), but no previous studies have compared the effects of a specificity induction on both memory and imagination, and none have included a picture description task in order to distinguish between effects on episodic and non-episodic processes.

Our episodic specificity induction was based on the Cognitive Interview (CI), a forensic protocol that has been used with eyewitnesses to boost accurate recall of experienced events (e.g., Fisher & Geiselman, 1992; Holliday, Humphries, Milne, Memon, Houlder, Lyons, & Bull, 2012; Memon, Meissner, & Fraser, 2010). The efficacy of the CI stems largely from its reliance on techniques that maximize the match between what participants experience at an event and what they later recall (e.g., Tulving & Thomson, 1973). Some of the cognitive techniques of the interview include mental imagery probing, which encourages the participant to close their eyes and mentally recreate episodic details such as people, objects, actions, and environments, and temporal order probing, which encourages the participant to discuss their memory in either a forward or reverse fashion (Memon et al., 2010). The CI also includes techniques such as transferring control to the participant by telling them that they are the chief expert about their experience, which lowers perceived expectations that the participant is undergoing a test where the interviewer knows the answers and the interviewee does not, as well as minimizing the tendency to interrupt the participant and asking mainly open-ended questions to support free recall (Memon et al., 2010). Several previous studies using different age groups have shown that the CI increases the amount of accurate information received in both older and young adults (Dornburg & McDaniel, 2006; Holliday et al., 2012; Prescott, Milne, & Clark, 2011; Wright & Holliday, 2007), although some studies have failed to find beneficial effects in either age group (e.g., McMahon, 2000; for discussion, see Holliday et al., 2012).

In the main experiment of the present study (Experiment 1), young and older adults watched a short film in two separate sessions and were asked to recall information about it in response to two different inductions; one induction was given in each session. The induction of main interest used an adapted version of the CI in an attempt to increase the episodic specificity with which participants recalled the video. However, because any possible effects of this episodic specificity induction could be attributable to the general requirement to talk about the previously viewed video, as opposed to an effect on episodic specificity per se, we also used a control induction comprised of questions focused on participants' general impressions and thoughts about the video. The control induction required participants to reflect on and talk about the video, but did not require them to retrieve specific episodic details about what they had viewed. Thus, we reasoned that effects of the episodic specificity induction on subsequent performance, compared with the control induction, could be attributed to reflecting on and retrieving episodic details, as opposed to reflecting on and talking about the video in more general terms. In each session, regardless of the induction, participants then completed separate memory, imagination, and picture description tasks using the AI paradigm employed by Gaesser et al. (2011) and others.

We expected to replicate the previous finding from Gaesser et al. (2011) that older adults report fewer internal details than young adults on memory, imagination, and picture description tasks. Critically, based on the constructive episodic simulation hypothesis, we predicted that the episodic specificity induction, compared with the control induction, would selectively increase internal (i.e., episodic) details on the memory and imagination tasks in both age groups compared with the control induction, but would not affect picture description performance. The data from the main experiment supported this prediction, but left open a question about whether the observed effects reflect a) an *increase* in internal detail from the episodic specificity induction relative to baseline conditions in which no specificity induction was used (e.g., Addis et al., 2008, 2010; Gaesser et al., 2011) or b) a *decrease* in internal detail (relative to baseline) produced by the control induction, which emphasized general impressions and thoughts. To address this question, we ran a brief follow-up study (Experiment 2) using only young adults where we compared the episodic specificity induction with a control condition that did not involve reflecting on or talking about the video, thereby allowing us to assess whether the differences observed in Experiment 1 do indeed reflect increases in episodic specificity.

Experiment 1

Method

Participants—Twenty-four young adults (age 18-24 years, $M = 19.96$, $SD = 1.61$, 13 female) and 24 older adults (age 64-85 years, $M = 76.21$, $SD = 6.86$, 10 female) participated. Young adults were recruited from Harvard University and Boston University, and older adults were recruited from community ads and newsletters. All participants received course credit or pay for participation. Young adults had completed significantly fewer years of education ($M = 13.38$, $SD = 1.31$) than older adults ($M = 16.58$, $SD = 2.81$) at the time of study, $t(46) = 5.07$, $p < .001$, $d = 1.46$. All participants had normal or corrected-to-normal

vision and no history of neurological impairment. All older adults had a Mini-Mental State Examination score of 28 or above ($M = 29.00$, $SD = 0.78$).

Materials and Procedure—Participants came in for two sessions, spaced at least 7 days apart ($M = 7.83$ days, $SD = 2.71$). In session one, participants watched a video of adults performing routine activities in a kitchen, completed a filler task with math problems, and then discussed the contents of the video they had seen. Participants were interviewed about the video with one of two sets of questions, which served as the induction manipulation. After this phase, participants transitioned to the main task (i.e., the AI paradigm) where they looked at different pictures and verbally reported a personal memory or imagination related to each, or a description of each. In session two, participants followed the same sequence with a new video, induction (i.e., whichever induction that had not been received in session one), and pictures. The video-induction pairing was counterbalanced across participants. Each session lasted approximately 1.5 to 2 hours, and involved two interviewers. One interviewer did the induction with the participant, and the second did the main task. This latter interviewer was always blind to which induction the participant had received earlier in the session.

Inductions—One induction was a modified CI protocol (i.e., the episodic specificity induction). In this interview, participants were told that they were the chief expert about the video, and they were then asked to report about the surroundings, people, and actions depicted in the video with mental imagery probes. With each probe participants were asked to close their eyes if they felt comfortable doing so and generate a picture in their head, and to report everything they remembered in as much detail as possible. For the surroundings probe specifically, participants were asked to think about what types of things were in the environment and how they were arranged; for the people probe, participants were asked to think about what they were wearing and what they looked like; and for the actions probe, participants were asked to think about what the people were doing and how they did these things, starting with the first action and ending with the last one. After responding to each probe, participants were asked follow-up questions about the different dimensions of the video they had mentioned (e.g., “tell me more about how the kitchen was arranged,” “tell me more about the man’s outfit”). Generally participants were asked one follow-up question about each of the categories (see Appendix A for the full protocol).

The other induction focused on the impressions, thoughts, and feelings participants had about the video (i.e., the control induction). Participants were first asked what their impressions were of the video as a whole, and they then answered a series of questions from a question bank. These questions included probes about what their thoughts were of the surroundings, people, and actions of the video respectively, as well as the adjectives they would use to describe each. Other questions included: “Did you like the video?”, “When do you think the video was made?”, “Did it remind you of anything?”, and so on. After finishing the questions from the question bank, participants were asked if they had any other thoughts or if they wanted to say anything else about the video (see Appendix B for the full protocol). On average participants spent a few seconds longer discussing the video they had seen under the specificity induction than the control induction ($M_{specificity} = 4$ minutes, 39

seconds, $SD = 1$ minute, 40 seconds; $M_{control} = 4$ minutes, 18 seconds, $SD_{control} = 1$ minute, 33 seconds) though this difference did not quite reach significance, $t(47) = 2.00$, $p = .052$, $d = 0.29$.

Adapted Autobiographical Interview—After the induction, participants transitioned to the second portion of the session where they completed memory, imagination, and picture description tasks (modeled on Gaesser et al.’s, 2011, adaptation of the AI paradigm). Here participants viewed 18 different pictures (6 per task) and for each picture either verbally recalled a personal memory from the past few years related to the picture, imagined a personal event in the next few years related to the picture, or described what was depicted in the picture (see Appendix C for the main instructions for each task). Pictures were randomized across tasks and depicted scenes that are common to both age groups, such as a grocery store, an airport, a museum, and a mall. For memory and imagination, participants were asked to report everything they could about one event occurring over the course of a few minutes to a few hours, including details about their actions, their feelings, and the people there. For picture description, participants were asked to describe everything they could about the picture as if they were talking to someone who couldn’t see it, including details about the people, objects, and environment. General follow-up probes were used if participants ran out of things to say or went off-topic (e.g., “Is there anything else you remember about the event?” or “Is there anything else you see in the picture?”). Participants had 3 minutes for each trial, and the three tasks were counterbalanced and grouped separately (e.g., all memory, followed by all imagination, followed by all picture description) to reduce demand on participants. Task instructions and follow-up probes encouraged participants to focus on generating relevant details that were on-topic to the task. Instructions and probes did not explicitly reference omitting irrelevant or off-topic details.

Coding—Interviews were audio-recorded, transcribed, and coded for internal details and external details. For memory and imagination, internal details were episodic in nature (e.g., the people, actions, objects, thoughts, feelings, and surroundings) and focused on the central event of interest. External details were semantic in nature, repetitive, or off-topic. For picture description, internal details were facts about the contents of the picture (e.g., people, objects, and environment). External details were based on inferences (e.g., describing what people were talking about in a picture when there was no basis for this), repetitive, or off-topic. Coding procedures were adapted from those used by Gaesser et al. (2011) and Levine et al. (2002). One of four independent raters coded each transcript for internal and external details after completing 20 practice responses from a different study under an intraclass correlation analysis (standardized Cronbach’s $\alpha = .98$ for internal details and $.90$ for external details). All raters were blind to which induction had been conducted before the main tasks. The three principal raters who coded the majority of the trials were also blind to all experimental hypotheses.

Results

We addressed our hypotheses by conducting a 2 (Induction: Control vs. Specificity) \times 2 (Age: Young vs. Older) \times 2 (Detail: Internal vs. External) \times 3 (Task: Memory vs. Imagination vs. Picture Description) mixed-factorial ANOVA. Induction, detail, and task

were within-subjects factors and age was the between-subjects factor. Main effects were tested for each of the variables, and interactions addressed the impact of induction on internal and external details across the three task types and two age groups respectively. We focused on the interactions found because they trumped the main effects and explicitly addressed our hypotheses. All post-hoc t-tests conducted were two-tailed and Bonferroni corrected at the .05 level.

We first examined whether the two age groups differed in the number of internal and external details they provided in the three tasks irrespective of induction, in line with previous research. We found that the interaction of Age \times Detail was significant, $F(1, 46) = 34.67, p < .001, \eta_p^2 = .43$, but the interaction of Age \times Detail \times Task was not, $F(2, 92) = 0.44, p = .65, \eta_p^2 = .01$. As predicted, post-hoc tests indicated that older adults reported significantly fewer internal details, $t(46) = 5.06, p < .01, d = 1.46$, and a greater number of external details, $t(46) = 4.45, p < .01, d = 1.29$, compared with young adults across the memory, imagination, and picture description tasks (see Figure 1). This pattern of findings is consistent with previous data (e.g., Gaesser et al., 2011) and suggests that there are age-related deficits in memory, imagination, and picture description.

We then examined whether the specificity induction impacted performance on the different tasks compared with the control induction, and whether differences emerged for both age groups and for both types of detail. The overall pattern of data shown in Figures 2-4, which display the induction results collapsed across age group and also split by age, appears to support our hypothesis that the episodic specificity induction increased internal but not external details on the memory and imagination tasks while having no effect on picture description performance. Consistent with this assessment, we found that the interaction of Induction \times Detail \times Task was significant, $F(2, 92) = 11.96, p < .001, \eta_p^2 = .21$, but the interaction of Induction \times Age \times Detail \times Task was not, $F(2, 92) = 0.36, p = .70, \eta_p^2 = .01$. We also found significant two-way interactions of Induction \times Detail, $F(1, 46) = 20.27, p < .001, \eta_p^2 = .31$, Induction \times Task, $F(1.69, 77.70) = 13.22, p < .001, \eta_p^2 = .22$, and Detail \times Task, $F(1.76, 81.00) = 9.50, p < .001, \eta_p^2 = .17$ (the Huynh-Feldt correction was used for the Induction \times Task and Detail \times Task interactions to correct for violations of sphericity assumptions in these analyses; sphericity assumptions were met in all other analyses in both experiments). No other two-way or three-way interactions approached significance ($F_s < .85$). Collapsed across age group, post-hoc tests showed that the specificity induction significantly boosted internal details on memory, $t(47) = 5.31, p < .01, d = 0.78$, and imagination, $t(47) = 4.88, p < .01, d = 0.70$, compared with the control induction without affecting picture description, $t(47) = 0.08, p = .94, d = 0.01$. Post-hoc tests also indicated that the induction manipulation did not affect the number of external details reported for memory, $t(47) = 0.69, p = .49, d = 0.10$, imagination, $t(47) = 0.77, p = .44, d = 0.11$, or picture description, $t(47) = 0.31, p = .76, d = 0.04$.

The foregoing data indicate that the episodic specificity induction dissociated performance on the memory and imagination tasks from performance on the picture description task. However, age differences were evident on picture description as well as memory and imagination tasks. In an earlier study from our laboratory, hierarchical regression analyses showed that picture description performance accounted for most of the variance in memory

and imagination tasks (Gaesser et al., 2011). To examine further the contributions of induction, picture description, and age in the present experiment, we used a linear mixed effects regression model that treated Induction (control or specificity) as a repeated-measures predictor variable and Picture Description internal details and Age as covariates. Internal details (for either memory or imagination) was used as the dependent variable.

We found that the induction manipulation significantly predicted internal details generated in memory and imagination, $F(1, 46.82) = 49.57, p < .001$. The parameter estimate showed that the induction manipulation accounted for a significant proportion of the variance in details generated, $b = 17.75, t(46.82) = 7.04, p < .001$. Picture description also significantly predicted internal details generated in memory and imagination, $F(1, 81.62) = 34.91, p < .001$. The parameter estimate showed that picture description accounted for a significant proportion of the variance in details generated, $b = .47, t(81.62) = 5.91, p < .001$. Age also significantly predicted details generated in memory and imagination, $F(1, 51.74) = 12.73, p < .01$. The parameter estimate showed that age accounted for a significant proportion of the variance in details generated, $b = .38, t(51.74) = 3.57, p < .01$. Overall, then, the linear mixed model showed that the induction manipulation and picture description independently and significantly contributed to internal details for both memory and imagination performance (as did age).

Discussion

Experiment 1 revealed two patterns of data that are critically relevant to our main hypotheses. On the one hand, older adults produced fewer internal details and more external details than young adults on memory, imagination, and picture description tasks, replicating the results of Gaesser et al. (2011). This pattern of results suggests that age-related changes may reflect primarily the operation of non-episodic processes common to all three tasks, such as communicative goals, inhibitory control, or narrative style. It also raises the possibility that previously documented commonalities between memory and imagination in young adults reflect the operation of such non-episodic processes, rather than the operation of episodic memory processes that contribute selectively to remembering and imagining, as maintained by the constructive episodic simulation hypothesis. To address this issue, we used an induction based on the CI that is thought to target episodic memory mechanisms based on evidence from independent studies noted earlier (e.g., Fisher & Geiselman, 1992; Holliday et al., 2012; Memon et al., 2010). Thus, the finding that the episodic specificity induction, compared with the control induction, increased the number of internal details on the memory and imagination tasks—but not the picture description task—in both age groups supports our hypothesis that the specificity induction would target episodic mechanisms related to memory and imagination, and not non-episodic mechanisms related to picture description. Moreover, the regression analysis revealed that the specificity induction and picture description task independently predicted internal details in both memory and imagination. These results are in line with the constructive episodic simulation hypothesis.

Because the control condition required participants to reflect on and talk about the video in general terms, we think that it is reasonable to attribute the effects of the specificity induction to the retrieval of episodic details. However, while our findings suggest that the

specificity induction *increased* performance on memory and imagination selectively compared with the control induction, implicit in our experimental design was the idea that the specificity induction represents an increase from a baseline represented by the control induction. Nonetheless, one could argue that the control induction does not necessarily represent a neutral baseline: because instructions in the control induction guide participants to describe the general impressions or global features of the previously viewed video, they might bias participants toward adopting a general or “gist-like” orientation during the subsequent memory and imagination trials, as in a similar “gist-based induction” used previously by Rudoy et al. (2009). Such a gist induction might actually decrease episodic specificity compared with a neutral baseline, that is, a condition that more closely resembles the conditions that have prevailed in previous studies that have used the AI to examine the relationship between memory and imagination in which no pre-AI induction is used (e.g., Addis et al., 2008, 2010; Gaesser et al., 2011; Rendell et al., 2012). Thus, it is not clear based on the results of Experiment 1 whether the specificity manipulation increased performance relative to a more neutral baseline, or whether the effects we observed stemmed from a decrease from this baseline produced by the control induction. It is critical to resolve this issue in order to characterize and understand the basis of the dissociation observed in Experiment 1 between memory and imagination on the one hand and picture description on the other. That is, to provide a firm foundation for further theorizing, we need to know whether this dissociation is produced by an increase in episodic details in the memory and imagination conditions as a result of the specificity induction, as we have suggested, or whether it instead reflects a decrease in episodic details on the memory and imagination tasks produced by a control condition in Experiment 1 that emphasized gist-based processing. We addressed this issue in Experiment 2.

Experiment 2

To investigate the possible contributions of the control condition to the effects observed in Experiment 1, we conducted a brief follow-up experiment in which we compared the episodic specificity induction from Experiment 1 with a control induction—carrying out math problems—that lacked any sort of episodic retrieval component, and hence should not result in participants adopting a gist-like orientation on subsequent memory and imagination tasks. Using such a control condition allows us to assess the possibility that the differences between the specificity induction and control condition in internal details for memory and imagination in Experiment 1 are attributable to a reduction in episodic specificity by a “gist orientation” associated with the control condition. To the contrary, we hypothesized that the effects on memory and imagination observed in Experiment 1 represent an increase from baseline produced by the episodic specificity induction, leading us to predict that a similar pattern of results will be observed in Experiment 2. Because young and older adults exhibited identical patterns of performance in Experiment 1, we used only young adults in Experiment 2. A power analysis (Faul, Erdfelder, Lang, & Buchner, 2007) based on effect sizes in Experiment 1 for the key predicted effect of interest – more internal details following the specificity than the control induction in both memory and imagination – revealed that a sample size of 12 would provide the ability to detect an overall effect across

memory and imagination conditions with power of $> .80$ (one-tailed test; two-tailed test yields power of $.80$). Thus, we included 12 participants in Experiment 2.

Method

Participants—Twelve young adults (age 18-22 years, $M = 19.50$, $SD = 1.38$, 8 female) were recruited from Harvard University and Boston University. All participants received course credit or pay for participation, and had completed an average of 13 years ($SD = 1.21$) of education at the time of study. All had normal or corrected-to-normal vision and no history of neurological impairment.

Materials and Procedure—Participants came in for two sessions again, spaced at least 7 days apart ($M = 7.33$ days, $SD = 1.15$). The materials and procedure were the same in Experiment 2 as in Experiment 1, except we replaced the control induction focusing on impressions and thoughts with a new baseline measurement. Here, after watching one of the videos and completing the math filler task, participants either received the specificity induction from Experiment 1 or an additional packet of math problems to do (i.e., the new control induction). Participants spent 3 minutes, 45 seconds ($SD = 35$ seconds) in the specificity induction and 3 minutes, 48 seconds ($SD = 0$ seconds) in the control induction to match the lengths of time spent in the inductions used in Experiment 1. Participants then verbally completed the memory, imagination, and picture description tasks in each session with 18 different pictures exactly as described in Experiment 1. One of three independent raters from Experiment 1 coded each transcript (standardized Cronbach's $\alpha = .98$ for internal details and $.90$ for external details). Again all raters were blind to which induction had initially been received and the two principal raters who coded the majority of task responses were blind to all experimental hypotheses.

Results and Discussion

The data were analyzed using a 2 (Induction: Control vs. Specificity) \times 2 (Detail: Internal vs. External) \times 3 (Task: Memory vs. Imagination vs. Picture Description) repeated-measures ANOVA. Main effects were tested for each of the variables, and interactions addressed the impact of induction on internal and external details across the three tasks respectively. We focused on the interactions found because they trumped the main effects and explicitly addressed our hypotheses. All post-hoc t-tests conducted were two-tailed and Bonferonni corrected at the $.05$ level.

As in Experiment 1, we examined whether the specificity induction boosted memory and imagination internal details without affecting picture description compared with the control induction (see Figure 5). Consistent with this hypothesis, we found again that the interaction of Induction \times Detail \times Task was significant, $F(2, 22) = 8.33$, $p < .01$, $\eta_p^2 = .43$. Similarly, we also found significant two-way interactions of Induction \times Detail, $F(1, 11) = 9.19$, $p < .05$, $\eta_p^2 = .46$, Induction \times Task, $F(2, 22) = 5.55$, $p < .05$, $\eta_p^2 = .34$, and Detail \times Task, $F(2, 22) = 5.63$, $p < .05$, $\eta_p^2 = .34$. Post-hoc tests showed that the specificity induction significantly increased internal details for memory, $t(11) = 4.06$, $p < .05$, $d = 1.17$, and imagination, $t(11) = 3.21$, $p < .05$, $d = 0.93$, compared with the control induction. Picture description performance was not affected by the induction manipulation, $t(11) = 0.59$, $p = .$

57, $d = 0.17$. Post-hoc tests also indicated that the induction manipulation did not impact the number of external details that participants provided for memory, $t(11) = 1.62$, $p = .14$, $d = 0.47$, imagination, $t(11) = 1.04$, $p = .32$, $d = 0.30$, or picture description, $t(11) = 0.17$, $p = .87$, $d = 0.05$. These findings are consistent with the results of Experiment 1, and indicate that an increase in internal details from the specificity induction, rather than a decrease in internal details produced by the control induction in Experiment 1, is responsible for the observed effects.

As in Experiment 1, we examined further the contributions of induction and picture description, using a linear mixed effects regression model that treated Induction (control or specificity) as a repeated-measures predictor variable and Picture Description internal details as a covariate. Internal details (for either memory or imagination) was used as the dependent variable. Again we found that the induction manipulation significantly predicted internal details generated in memory and imagination, $F(1, 10.71) = 36.32$, $p < .001$. The parameter estimate showed that the induction manipulation accounted for a significant proportion of the variance in details generated, $b = 25.13$, $t(10.71) = 6.03$, $p < .001$. Picture description also significantly predicted details generated in memory and imagination, $F(1, 17.70) = 22.41$, $p < .001$. The parameter estimate showed that picture description accounted for a significant proportion of the variance in details generated, $b = .55$, $t(17.70) = 4.73$, $p < .001$. These results replicate and extend the findings of Experiment 1.

One potential concern about Experiment 2 is that only 12 young participants were included, rather than 24 young and 24 older participants as in Experiment 1. As noted earlier, we did not include older participants in Experiment 2 because they exhibited identical patterns of performance to young adults in Experiment 1, and we included 12 rather than 24 young participants because a power analysis indicated that including 12 participants provides adequate power to test the key hypothesis examined in Experiment 2, i.e., that we should observe more internal details during the memory and imagination tasks following the episodic specificity induction than the revised, more neutral control induction. Despite the reduced sample size, the results of Experiment 2 provided strong support for this hypothesis; in fact, the specificity vs. control induction effect sizes in Experiment 2 for internal details in both memory and imagination were numerically larger than the corresponding effect sizes in Experiment 1.

Since the reduced sample size should, if anything, have worked *against* finding support for our key hypothesis, these considerations highlight that the sample size used in Experiment 2 does not undermine our conclusion that the effects of the episodic specificity induction in Experiment 1 reflect an increase in internal details produced by that induction rather than a decrease in internal details produced by the control induction in Experiment 1. However, some caution should be exercised when interpreting these results: because we did not include older adults in Experiment 2, further work using the control condition from Experiment 2 with older adults will be needed to determine definitively whether the effects of the episodic specificity induction observed for older adults in Experiment 1 are also observed when using the more neutral control condition in Experiment 2.

General Discussion

The two experiments reported here provide novel evidence in support of the constructive episodic simulation hypothesis. In both experiments, the specificity induction produced an increase in the number of internal but not external details provided on memory and imagination tasks without affecting picture description performance. This pattern of results demonstrates that episodic processes involved in memory and imagination can be dissociated from non-episodic processes involved in picture description, consistent with the constructive episodic simulation hypothesis (Schacter & Addis, 2007). If the induction manipulation had affected internal details on all three tasks, such an outcome would have added theoretical support to the alternative hypothesis that more general processes such as narrative style are by and large responsible for the similarities observed in remembering the past and imagining the future. Instead, the dissociation in internal details we observed between memory/imagination on the one hand and picture description on the other shows that episodic processes contribute to similarities observed in remembering and imagining above and beyond non-episodic processes alone, in line with the constructive episodic simulation hypothesis. This dissociation was documented when the specificity induction was compared with both a control induction focusing on general thoughts and impressions of a previously viewed video (Experiment 1) and a control task that did not make any reference to the video (Experiment 2), which demonstrates that the changes in episodic details we observed resulted from an increase from baseline produced by the specificity induction rather than a decrease from baseline produced by a possible “gist induction” in Experiment 1. Moreover, in both experiments regression analyses revealed that the specificity induction and picture description significantly and independently predicted internal details in both memory and imagination, consistent with the distinction between episodic processes targeted by the induction and non-episodic processes associated with picture description.

One potential concern about the observed dissociation between memory and imagination on the one hand and picture description on the other concerns the possible existence of ceiling effects on the picture description task: perhaps participants exhausted all possible internal details about each picture following both the episodic specificity and control inductions in both experiments, thereby precluding finding an effect of type of induction on picture description performance. Although it is difficult to establish definitively what constitutes a ceiling level of performance on the picture description task, there are two reasons to doubt a ceiling effect account of our data. First, the existence of significant differences between young and older adults on the picture description task in Experiment 1 indicates that older adults did not reach ceiling levels of performance because in principle they could have produced as many internal details as young adults did. Yet the episodic specificity induction did not increase the number of details produced by older adults despite their initially lower level of performance than young adults. Second, we observed that both groups of participants continued to produce details about the pictures throughout the time allowed, showing no signs of having reached a point where all internal details about the picture were exhausted. Further research will be needed to definitively address the issue of possible ceiling effects on picture description tasks, but we see no evidence on such effects in the present data.

While these findings support the constructive episodic simulation hypothesis and emphasize the distinctive contributions of episodic memory to imagining hypothetical or future events, we do not wish to imply that episodic memory is the only kind of memory that contributes to imagining. For example, it seems clear that semantic memory plays a key role in imagining future scenarios (for recent evidence and discussion, see D'Argembeau & Demblon, 2012; Irish, Addis, Hodges, & Piguet, 2012; Klein, 2013; Martin-Ordas, Atance, & Louw, 2012; Schacter et al., 2012). Indeed, semantic memory may be especially relevant to understanding the role of such factors as narrative style in contributing to age differences in remembering and imagining. Nonetheless, our findings illustrate that the contribution of episodic memory to imagining can be sharply distinguished from the influence of non-episodic processes.

It remains to be determined exactly which episodic processes are targeted by the specificity induction and are responsible for the observed increases in internal details on the memory and imagination tasks. One striking feature of the results that may provide some insight on this point concerns the fact that the magnitude of the effect produced by the specificity induction on internal details was very similar for the memory and imagination tasks in both experiments (although effect sizes were numerically larger for memory than imagination in both experiments, there were no differences in effect sizes for memory compared with imagination in Experiment 1, $z = 0.26$, $p = .40$, or Experiment 2, $z = 0.37$, $p = .36$). This pattern is striking because despite the fact that the constructive episodic simulation hypothesis holds that memory and imagination draw on a common underlying episodic memory system, the hypothesis also acknowledges that memory and imagination differ in some important respects. For example, imagining future events requires recombining episodic details into a novel scenario where remembering the past does not, and some of the observed neural differences between memory and imagination in neuroimaging studies (see Schacter et al., 2012, for a review) have been attributed to involvement of brain regions specifically associated with detail recombination (e.g., Addis, Wong, & Schacter, 2007; Addis, Pan, Vu, Laiser, & Schacter, 2009; Schacter & Addis, 2009). Yet even though the memory and imagination tasks used in the present experiments presumably drew on detail recombination to different degrees, and may have differed in other ways, the effects of the specificity induction on the two tasks were not significantly different.

This observation suggests that the specificity induction affected episodic processes that play a similar or identical role in memory and imagination. One process that should be strongly influenced by our episodic specificity induction is episodic retrieval orientation, which refers to a goal-directed processing strategy that individuals invoke when presented with a retrieval cue (e.g., Morcom & Rugg, 2012). Asking participants to close their eyes and generate a picture in their minds about the environment, people, and actions in the video should have led participants to adopt a more specific retrieval orientation than in the control inductions. This specific retrieval orientation would benefit participants on the later memory and imagination tasks, both of which involve retrieving episodic details. Thus, the retrieval orientation that our specificity induction invoked may have driven the similarities between memory and imagination observed in our two experiments. A related possibility is that using open-ended follow-up probing and “report everything” instructions benefited subsequent memory and imagination to the same degree because these techniques emphasize extending

the retrieval process in time so as to produce as much episodic detail as possible (Memon et al., 2010). Future studies should attempt to characterize in more detail which aspects of episodic retrieval common to memory and imagination are affected by our specificity induction. Note also that we did not include the rapport-building, context reinstatement, reverse order recall, and change perspective techniques of the CI in our specificity induction, but future studies could examine whether these techniques would equally benefit later memory and imagination performance as well.

The results of Experiment 1 also replicate previous work (e.g., Gaesser et al., 2011; Rendell et al., 2012) documenting age-related deficits on tasks involving a narrative about a scene, both in the presence and absence of tasks that involve episodic retrieval or recombining. While our induction manipulation did target episodic processes involved in memory and imagination selectively, and older adults showed robust increases in internal details during both memory and imagination tasks following the specificity induction, the induction did not eliminate or even reduce global differences between young and older adults in the number of internal or external details generated. This observation is consistent with previous studies of eyewitness memory that have used the CI with young and older adults: in studies that have found that the CI increases the number of details recalled in older and young adults, the CI did not eliminate age differences in memory (e.g., Dornburg & McDaniel, 2006; Holliday et al., 2012; Prescott et al., 2011; Wright & Holliday, 2007; though see Mello & Fisher, 1996, and Memon et al., 2010, for alternative evidence). This finding is also consistent with the idea that the main source of age differences in memory and imagination tasks of the kind used here—that is, AI tasks involving a significant narrative component—is not an age-related deficit in episodic memory per se. Given that age differences persisted to the same extent following an episodic specificity induction that benefited older adults, it seems likely that a key source of age differences on AI-based memory and imagination tasks derives from non-episodic processes. As discussed previously (Gaesser et al., 2011; Schacter et al., 2013), relevant non-episodic processes that may be responsible for observed age differences on the AI include age-related changes in narrative style and communicative goals when describing personal events (Adams et al., 1997; Labouvie-Vief & Blanchard Fields, 1982), or possibly age-related deficits in inhibitory control (e.g., Arbuckle & Gold, 1993; Zacks & Hasher, 1994) that result in the production of more off-topic or irrelevant speech during narrative tasks (Trunk & Abrams, 2009). Future work could examine whether inductions aimed at these non-episodic processes reduce or eliminate age differences in memory and imagination on AI tasks. Nonetheless, there is also some evidence that age differences in episodic memory do contribute to age effects on memory and imagination in the AI, even if only modestly (Gaesser et al., 2011). Thus, additional studies could examine whether more guided retrieval support throughout the memory and imagination process, or other techniques aimed at further bolstering episodic retrieval, could reduce age differences of the kind observed here and in previous studies (Addis et al., 2008, 2010; Gaesser et al., 2011; Rendell et al., 2012).

Our studies also have implications for studies concerning episodic specificity in patients with psychopathological conditions. Several studies have found reduced episodic specificity on memory and imagination tasks similar to those described here, including studies of patients with suicidal depression (Williams et al., 1996), schizophrenia (D'Argembeau,

Raffard, & Van der Linden, 2008) and post-traumatic stress disorder (Brown, Addis, Romano, Marmar, Bryant, Hirst, & Schacter, in press; Brown, Root, Romano, Chang, Bryant, & Hirst, 2013). In addition, several studies have reported increased episodic specificity in psychopathological populations as a result of specificity training manipulations that are similar in some respects to the one used here (e.g., Neshat-Doost et al., 2012; Raes, Williams, & Hermans, 2009).

However, none of these studies have used a picture description task like the one used by Gaesser et al. (2011) to assess whether differences in memory and imagination between patients with psychopathological conditions and controls, as well as effects of specificity training, are attributable to changes in episodic processes per se or to more global changes in communicative goals, descriptive ability, or inhibitory control. In light of our results, it will be critical to carry out such studies in order to inform theoretical accounts of episodic specificity reductions in psychopathological conditions (e.g., Sumner, 2012; Williams, Barnhofer, Crane, Hermans, Raes, Watkins, & Dalgleish, 2007). Moreover, if picture description is used as a task that measures non-episodic processes, future work should also try to pinpoint how descriptive ability, narrative style, communicative goals, inhibitory control, and related processes contribute to this task.

Finally, our findings may also have implications for other domains in which retrieving and recombining episodic details are important. For example, Sheldon, McAndrews, and Moscovitch (2011) found in a series of two experiments that open-ended social problem solving, as measured through the Means-End Problem Solving paradigm (Platt & Spivack, 1975), relies in part on the same cognitive mechanisms involved in memory and imagination. In their experiments, young adults, older adults, and patients with temporal lobe epilepsy retrieved and recombined episodic details to generate appropriate solutions to problems like making new friends, finding a watch, and courting a potential partner. Sheldon et al. (2011) found that older adults and epilepsy patients gave fewer relevant solutions to such open-ended social problems compared with young adults or healthy controls, and that the elderly and patient groups also provided fewer relevant details about these solutions as scored with the internal/external guidelines from the AI. Given the role of episodic processes in this type of problem solving, it will be important to determine whether our specificity induction can increase the number of relevant solution steps and the details of such steps that young and older adults provide. Even if a specificity induction does not reduce or eliminate observed age differences in open-ended problem solving, by producing a significant increase in episodic details and associated solutions, the induction could have a positive impact on a task with important functional implications for everyday life.

More generally, the foregoing considerations also serve as a reminder that the retrieval of episodic details is relevant not only to situations involving memory in the strict sense, but also to a range of cognitive functions where the ability to imagine or simulate specific scenarios is functionally useful, including problem solving (e.g., Gerlach, Spreng, Gilmore, & Schacter, 2011; Sheldon et al., 2011), autobiographical planning (e.g., Spreng, Stevens, Chamberlain, Gilmore, & Schacter, 2010), navigation (e.g., Spreng, Mar, & Kim, 2009), and inferences about other people (e.g., Buckner & Carroll, 2007; Ciaramelli, Bernardi, & Moscovitch, 2013; Hassabis, Spreng, Rusu, Robbins, Mar, & Schacter, in press). Further

study of the contributions of episodic specificity to a range of cognitive tasks should enhance our understanding of both the nature and functions of memory.

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Appendix A: Modified CI (i.e., specificity induction for Experiments 1 and 2)

Introduction

So now I'm going to ask you a few questions about the video you watched. I haven't seen the video myself, so you're the expert on that. I'm also going to use the audio-recorder and write down what you say to keep track if that's okay. How does that sound to you?

Mental imagery about the surroundings

Okay, so first I want you to close your eyes and get a picture in your head about the surroundings of the video you watched. I want you to think about what types of things were in the environment and how they were arranged and what they looked like. Once you have a really good picture in your head I want you to tell me everything you remember about the surroundings. Try to be as specific and detailed as you can.

General probing about the surroundings

- Tell me more about... (details mentioned)
- Tell me more about how the kitchen was arranged.
- Tell me more about what was in the kitchen.
- Were there any other rooms?

Mental imagery about the people

Now I want you to close your eyes and get another picture in your head, this time about the people in the video you watched. I want you to think about what the people looked like and what they were wearing. Once you have a really good picture in your head I want you to tell me everything you remember about the people in the video. Again, try to be as specific and detailed as you can.

General probing about the people

- Tell me more about... (details mentioned)
- Tell me more about the man/woman's outfit.
- Tell me more about the man/woman's face.

-What color hair did the man/woman have?

Mental imagery about the actions

Now I want you to close your eyes and get a picture in your head about the actions in the video you watched. I want you to think about what the people were actually doing in the video and how they did these things. Once you have a really good picture in your head I want you to tell me everything you remember about the actions starting with the first one and ending with the last one. Try to be as specific and detailed as you can.

General probing about the actions

-Tell me more about... (action mentioned)

Follow-up and repeat for actions

[only do this if participant doesn't give sequence of actions first time around]

-What happened after that?

-What was the next thing?

-What was the last thing that happened?

Appendix B: Impressions Interview (i.e., control induction for Experiment 1)

Introduction

So now I'm going to ask you a few questions about the video you watched. I'm also going to use the audio-recorder and write down what you say to keep track if that's okay. How does that sound to you?

Ok so now I want you to tell me what you thought about the video. What were your general impressions of it?

Question bank

-What adjectives would you use to describe the setting of the video? The people? The actions?

-What did you think about the setting of the video? What did you think about the people in the video? What did you think about the actions shown in the video?

-Can you describe the whole video in one or two words?

-Did you like the video?

-Did it seem old-fashioned? When do you think it was made?

-How do you think it was made?

- Did it remind you of anything?
- Can you guess how big the place was based on the video?
- Can you guess the people's occupations?

Concluding remarks

- Were there any other thoughts you had about the video? Is there anything else you wanted to say about the video?

Appendix C: Adapted AI Task Instructions

Memory

In this part of the experiment you are going to see 6 different pictures. For each picture you will be asked to remember an event from the past few years that the picture reminds you of. You should tell me about one event that happened in one place. The event should be one that lasted a few minutes to a few hours. You should think about the event through your own eyes and not as an outside observer. Try to tell me everything you remember about the event, what you did, who you were with, and what you were feeling. You will have 3 minutes to tell me as much detail as you can for each event.

Imagination

In this part of the experiment you are going to see 6 different pictures. For each picture you will be asked to imagine an event in the next few years that incorporates the general setting of the picture. You should imagine an event that hasn't happened yet. It should be one event that occurs in one place. It should also last a few minutes to a few hours. You should think about the event through your own eyes and not as an outside observer. Try to tell me everything you imagine about the event, what you will be doing, who you will be with, and what you might be feeling. You will have 3 minutes to tell me as much detail as you can for each event.

Picture Description

In this part of the experiment you are going to see 6 different pictures. For each picture you will be asked to describe what you see in the picture. Try to describe the people, objects, and environment in the picture as they are. You should describe the picture as if you were talking to someone who can't see it. You will have 3 minutes to describe the scene.

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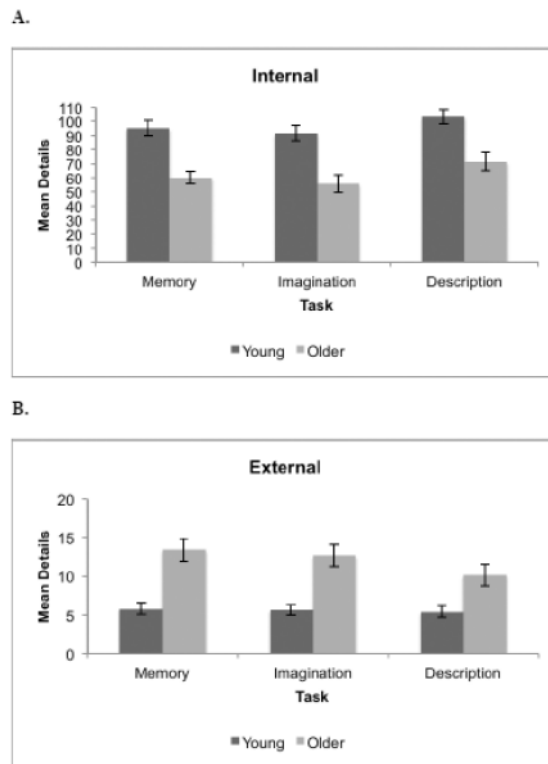
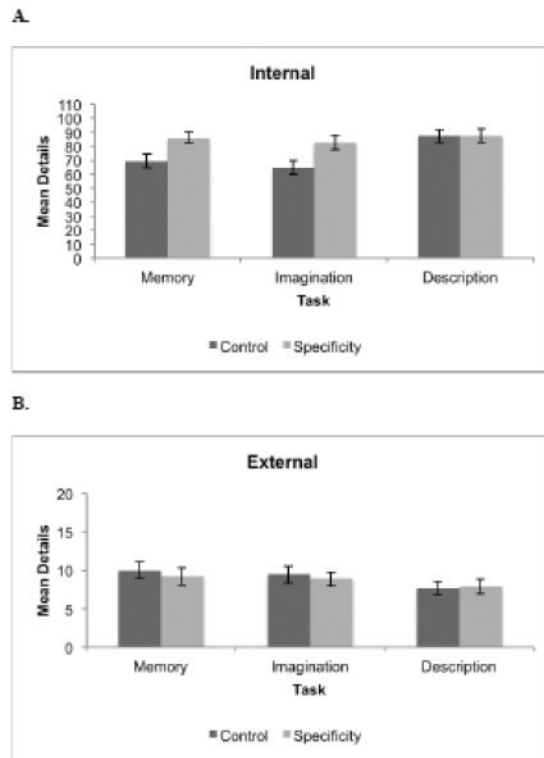


Fig. 1.

Mean internal (A) and external details (B) reported by young and older adults across inductions as a function of task in Experiment 1. Error bars represent one standard error.

**Fig. 2.**

Mean internal (A) and external details (B) reported across age groups as a function of induction and task in Experiment 1. Error bars represent one standard error.

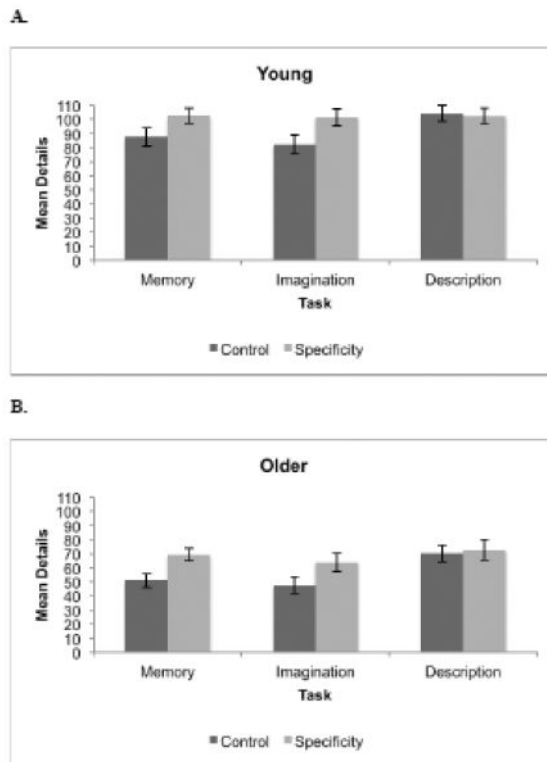


Fig. 3.

Mean internal details reported by young (A) and older adults (B) as a function of induction and task in Experiment 1. Error bars represent one standard error.

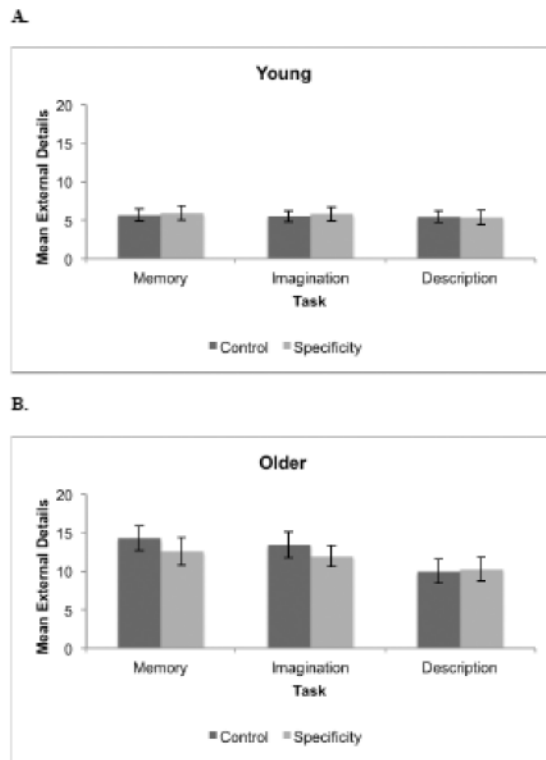
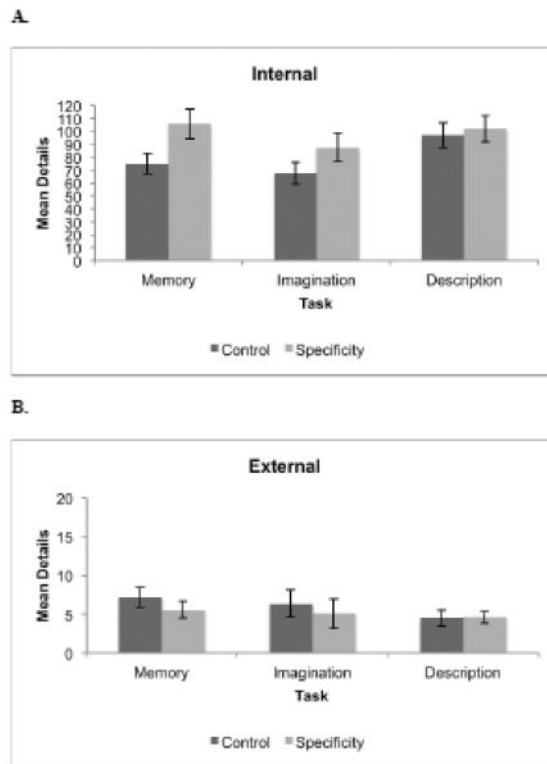


Fig. 4.

Mean external details reported by young (A) and older adults (B) as a function of induction and task in Experiment 1. Error bars represent one standard error.

**Fig. 5.**

Mean internal (A) and external details (B) reported by young adults as a function of induction and task in Experiment 2. Error bars represent one standard error.