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Adaptive constructive processes: An episodic specificity induction impacts false recall in the Deese-Roediger-McDermott paradigm

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Abstract

Numerous studies indicate that an episodic specificity induction (ESI) - brief training in recollecting the details of a past experience - enhances performance on subsequent tasks that rely on episodic retrieval, including autobiographical memory, imagination, problem solving, and creative thinking. In five experiments, we examined whether these benefits of the ESI extend to reducing susceptibility to false memory, or whether they are accompanied by a cost in the form of increased susceptibility to false memory. To assess how ESI impacts false memory generation, we used the Deese-Roediger-McDermott (DRM) paradigm, a reliable procedure for generating false memories. When an ESI was administered after DRM list presentation and just before a free recall test, rates of false recall for critical lures were significantly enhanced relative to a control induction. These findings support the hypothesis that ESI operates to boost recollection of illusory episodic details associated with critical lures in the DRM, and suggest that constructive rather than reproductive episodic retrieval processes support the wide-ranging effects of ESI on a range of cognitive tasks.

Keywords

episodic memory; recall; DRM; memory distortion; cognitive interview

A large number of experimental studies have examined cognitive and neural aspects of episodic memory retrieval (Moscovitch, Cabeza, Winocur, & Nadel, 2016; Tulving, 1983, 2002). Although these studies have focused mainly on retrieval of past episodes, recent research has implicated episodic retrieval in a variety of tasks that are not typically characterized as “episodic memory tasks”, including imagining or simulating future experiences (for reviews, see Schacter, Benoit, & Szpunar, 2017; Schacter et al., 2012), means-end social problem solving (Sheldon, McAndrews, & Moscovitch, 2011), prosocial (Gaesser & Schacter, 2014) and value-based decision making (Murty, Feldman Hall, Hunter,

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Phelps, & Davachi, 2016), and divergent creative thinking (Addis, Musicaro, Pan, & Schacter, 2016).

Episodic retrieval has been implicated in these and related tasks based on several different kinds of evidence. For example, neuroimaging studies consistently show that imagining future experiences and remembering past experiences elicit activity in the same core network of brain regions (for a meta-analysis, see Benoit & Schacter, 2015). Recent evidence reveals that applying inhibitory transcranial magnetic stimulation to the left angular gyrus, a core network region previously linked to episodic retrieval (for reviews, see Rugg & King, 2017; Sestieri, Shulman, & Corbetta, 2017), produces a selective reduction in the number of episodic, but not semantic, details that participants produce when imagining future experiences and remembering past experiences (Thakral, Madore, & Schacter, 2017).

During the past few years, our laboratory has developed a procedure that has proven useful for separating episodic from non-episodic influences across a number of the aforementioned tasks, which we refer to as an *episodic specificity induction* (ESI; for a review, see Schacter & Madore, 2016). We adapted this induction from the Cognitive Interview (CI), a forensic protocol used in numerous laboratory studies, as well as in actual legal cases, to increase the amount of detailed episodic information that eyewitnesses recall about a past event (Fisher & Geiselman, 1992; for a review and meta-analysis of CI studies, see Memon, Meissner, & Fraser, 2010a). In our experiments, participants typically view a brief video of everyday activities (people performing tasks in a kitchen) and then are either administered a CI-based ESI that focuses on retrieving specific details from the video (i.e., generating a mental picture and reporting everything participants remember about the setting, people, and actions) or a control induction that does not focus on detailed episodic retrieval (i.e., providing general impressions of the video). The key question concerns the impact of these inductions on *subsequent* cognitive tasks. We reasoned that if a cognitive task relies at least in part on episodic retrieval, then performance on that task should be boosted following ESI compared with a control induction. If, however, performance on a cognitive task does not rely on episodic retrieval, then task performance should not be influenced by a prior ESI.

In an initial experiment using this approach (Madore, Gaesser, & Schacter, 2014), after receiving either an ESI or a control induction, participants were given pictures of everyday scenes, and performed two tasks thought to draw on episodic retrieval: remembering a past experience or imagining a future experience related to the picture. Participants also performed a third task - describing the contents of the picture - that should not involve episodic retrieval. Following the ESI, participants produced more episodic details on the memory and imagination tasks than after the control induction. By contrast, ESI had no effect on the picture description task, and no effect on the number of semantic details produced on the memory and imagination tasks. Madore and Schacter (2016) also found that ESI boosted episodic details during subsequent remembering and imagining tasks that used word cues instead of picture cues, whereas ESI had no effect on a word generation control task. Several other studies using this same overall approach have extended the effects of the ESI to other tasks for which previous evidence suggested a possible role of episodic retrieval, including means-end social problem solving (Jing, Madore, & Schacter, 2016; McFarland, Primosch, Maxson, & Stewart, 2017; Madore & Schacter, 2014), generating alternative versions of possible future events (Jing, Madore, & Schacter, 2017), and producing novel but appropriate uses of common objects on the Alternate Uses Test of divergent creative thinking (Madore, Addis, & Schacter, 2015; Madore, Jing, & Schacter, 2016a). Moreover, neuroimaging evidence indicates that after receiving an ESI, compared with a control induction, core network regions including the hippocampus show increased activity when participants imagine future experiences (Madore, Szpunar, Addis, & Schacter, 2016b) and generate novel uses of objects (Madore, Thakral, Beaty, Addis, & Schacter, 2017).

Taken together, these studies show that increasing episodic retrieval via ESI produces beneficial effects on a range of tasks. Importantly, these tasks tap cognitive processes that serve adaptive functions. For example, when women experiencing first-time pregnancies imagined going into labor and arriving at the hospital on-time, more detailed episodic simulations were correlated with an increased subjective probability of a positive outcome and decreased worry about the future event (Brown, MacLeod, Tata, & Goddard, 2002). Jing et al. (2016) showed that when participants imagined steps they would take to deal with worrisome future experiences after receiving an ESI or a control induction, they produced more detailed episodic simulations, and showed larger decreases in anxiety and perceived likelihood of a bad outcome, after ESI (for additional discussion of related findings, see Schacter, 2012; Schacter et al., 2017).

However, previous research has shown that cognitive processes that support adaptive functions can also create distortions and illusions in memory (cf., Bartlett, 1932; Howe, 2011; Newman & Lindsay, 2009; Schacter, 2001; Schacter, Guerin, & St. Jacques, 2011). Examples of such *adaptive constructive processes* (Schacter, 2012) include gist memory processes that contribute to comprehension but also support semantic/associative false memories (e.g., Brainerd & Reyna, 2005) and retrieval or reconsolidation processes that support memory updating yet also contribute to contextual memory errors (e.g., Hupbach, Gomez, Hardt, & Nadel, 2007; St. Jacques, Olm, & Schacter, 2013; for a review, see Schacter et al., 2011). Moreover, according to the constructive episodic simulation hypothesis (Schacter & Addis, 2007, in press), the same flexible episodic retrieval and recombination processes that support the adaptive function of constructing novel event representations that are used for future event simulation and related processes can also contribute to memory errors (for recent evidence, see Carpenter & Schacter, 2017, 2018).

Although the detailed episodic retrieval that results from a prior ESI has not been directly linked with memory errors, it is important to note that most of the tasks that benefit from ESI, such as future and alternative event simulation, social problem solving, and generating alternate uses of objects, do not require accurate retrieval of details from a past experience. Therefore, an open question is whether the detailed episodic retrieval following an ESI reflects a boost in veridical episodic details, or whether the observed enhancements from ESI reflect the influence of constructed episodic details that may be inaccurate. According to Schacter and Madore (2016; see also Madore et al., 2014, 2016b), the tasks impacted by a prior ESI all benefit from constructing detailed mental events, and ESI biases the way that people approach such tasks by impacting their *retrieval orientation* (i.e., goal-directed retrieval cue processing that involves a focus on specific episodic detail; Rugg & Wilding,

2000) so as to enhance the event construction process. By contrast, the ESI may impact reproductive, rather than constructive, memory processes that bias retrieval towards accurate episodic detail. However, because the effects of ESI have been observed to-date on tasks in which issues of accurate or inaccurate episodic detail are either irrelevant (i.e., future imagining, means-end problem solving, divergent thinking) or difficult to assess (autobiographical memories for everyday events), there is little evidence to distinguish between these two possible mechanistic accounts of how the ESI impacts subsequent task performance, i.e., constructive vs. reproductive episodic retrieval (see Madore, Jing, & Schacter, 2018).

Research concerning the CI is relevant to thinking about the possible impact of ESI on true and false memories. As noted earlier, the ESI used in our laboratory is adapted from the CI, which was developed with the aim of selectively increasing *accurate* episodic retrieval (Fisher & Geiselman, 1992). Meta-analyses show that while the CI does indeed boost retrieval of accurate details from a recent event, it also produces a smaller but significant increase in retrieval of inaccurate details (e.g., describing a coat as black when it was red; Memon et al., 2010a; Köhnken, Milne, & Memon, 1999). However, only a few studies have examined whether the CI promotes the development of false memories of entire events, and there is little evidence that it does (cf., Centofanti & Reece, 2006; Memon, Zaragoza, Clifford, & Kidd, 2010b; Sharman & Powell, 2013). Indeed, there are conditions in which administering a CI appears to protect against the generation of misinformation-based false memories (Memon et al., 2010b; Holliday et al., 2012).

Accordingly, prior research concerning the CI suggests that the ESI would not necessarily lead to the creation of false memories. However, there are two reasons why we are hesitant to draw strong inferences about the impact of ESI on subsequent false memories based on the CI literature. First, there are notable differences between the two procedures. Although the ESI uses a number of key procedures from the CI (e.g., mental imagery probes regarding the people, actions, and setting depicted in the video, report everything probes, and tell me more probes), the ESI does not use the rapport-building, context reinstatement, reverse order recall, or change perspective techniques that are part of the CI (for the detailed ESI protocol, see Madore et al., 2014). Second, most studies of the CI have focused on how administering it impacts memory for an event experienced *prior* to the CI, whereas our work on the ESI examines the *downstream* impact of ESI on a range of subsequent cognitive tasks for which the CI is not explicitly invoked. In this regard, findings from a study by LaPaglia, Wilford, Rivard, Chan, and Fisher (2014) are of interest. Participants witnessed a crime video, and then completed either a CI, free recall test, or control distractor task before receiving misinformation presented in a narrative about the original event. LaPaglia et al. (2014) found that compared with the control condition, both free recall and the CI increased the likelihood that participants would incorporate misinformation from the narrative into their final recollections of the original event. Thus, completing a CI appeared to bias subsequent processing of the misinformation narrative in a way that increased inaccurate memories of the original event (see LaPaglia et al., 2014, for discussion of methodological differences between this study and Memon et al., 2010b, where the CI produced less susceptibility to misinformation). The findings of LaPaglia et al. (2014) are broadly consistent with the hypothesis that administering an ESI could bias subsequent processing in a way that increases false memories.

The Present Experiments

In the current study, we examined in five experiments whether the robust benefits of the ESI that we have observed in previous work extend to reducing susceptibility to false memory, indicating an impact of the ESI on reproductive episodic retrieval, or whether these benefits are accompanied by a cost in the form of increased susceptibility to false memory, suggesting an influence on constructive episodic retrieval. To assess how ESI impacts the generation of false memories, we used the well-studied Deese-Roediger-McDermott (DRM) paradigm, one of the most reliable procedures for generating robust false recall and recognition in the laboratory (Deese, 1959; Roediger & McDermott, 1995; for a review, see Gallo, 2010). In the DRM, participants study lists of semantic associates (e.g., *candy, sour, bitter, taste, tooth, honey*, etc.) that all converge on a non-presented critical lure word (e.g., *sweet*), and later show high rates of false recall and recognition for the critical lure word. We used the DRM paradigm because it provides measures of accurate and inaccurate retrieval of episodic detail in a way that the tasks used in previous studies evaluating the downstream impact of the ESI do not.

Previous research provides a basis for generating hypotheses regarding the impact of ESI on subsequent true and false memories. Several studies have shown that when people remember detailed information about the previously studied items, true recall and recognition are enhanced while DRM false recall and recognition are reduced. For example, when providing multiple presentations of a study list, there is increased memory for list items and reduced memory for critical lures (Benjamin, 2001; Kensinger & Schacter, 1999; McDermott, 1996; Schacter, Verfaellie, Anes, & Racine, 1998). Relatedly, presenting distinctive information during encoding (e.g., pictures accompanying individual DRM items) can induce participants to invoke a *distinctiveness heuristic* when evaluating their memories (i.e., participants demand access to specific, detailed information about an item before deciding that it comes from the study list; McCabe & Smith, 2006; Schacter, Cendan, Dodson, & Clifford, 2001; Schacter, Israel, & Racine, 1999). If administering an ESI leads participants to demand recollection of detailed, distinctive information about an item before judging it to be a studied list item, then the ESI could lead to a reduction in false memories compared with a control induction (i.e., critical lures would lack the distinctive information carried by studied items). Alternatively, if the main impact of ESI is to bias an event construction process to generate additional episodic details during subsequent tasks, it is possible that those details could increase false memories by making a non-experienced item or event feel more like an actual event. Indeed, we already know that imagining an event that might have occurred in one’s past increases the probability of false memory creation (e.g., Hyman & Pentland, 1996; Loftus, 2003).

We tested these hypotheses in Experiment 1 using a false recall paradigm in which either an ESI or control induction was given prior to encoding of DRM lists. We used recall rather than recognition primarily because all of our previous studies of ESI have examined its impact on subsequent tasks that involve generating target responses (i.e., remembering past experiences, imagining future experiences and alternatives to them, producing steps to solve problems, and generating novel uses of objects). Based on the findings of Experiment 1, we then adopted a critical alteration to our procedure - administering the ESI *after* rather than *before* presentation of study items - and tested further hypotheses that an ESI given under these conditions would decrease or increase false recall rates. Experiments 2–5 provided strong support for the latter hypothesis.

Experiment 1

Material and Methods

Participants—Thirty-six undergraduates from local colleges and universities received credit for a general psychology course or $10 for participation (mean age of 20.78 years (range 18–25), 25 females). All participants were native English speakers and had normal or corrected-to-normal vision, no history of neurological impairment, and were not currently taking any psychoactive medications. The experimental protocol was approved by the Institutional Review Board of Harvard University and informed consent was obtained prior to participation. The sample size was selected to be consistent with prior studies of DRM false recall and the distinctiveness heuristic (McCabe & Smith, 2006). A post-hoc power analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) conducted using the means and standard deviations reported in McCabe and Smith (2006; see Experiment 3) revealed that a minimum of 31 participants is sufficient for detecting at least a medium-sized effect ($d = 0.73$; power > 0.80, two-tailed, between-participants for distinctiveness manipulation on DRM false recall).

Stimuli and Task—Participants completed the experiment in a single session composed of two segments. In each segment, participants (a) watched one of two versions of a short video involving people carrying out various activities in a kitchen, (b) completed a short filler task where they solved simple math problems, (c) received either the ESI or control induction, (d) encoded 50 words from 5, 10-word DRM lists spoken out loud by the experimenter, (e) completed a filler task where they solved a different set of math problems, and (f) completed a recall task for the words. Following a 10 minute break, this procedure was repeated in the second segment using the video, induction, and 5 10-word DRM lists not employed in the first segment. This design was modeled after our previous experiments employing the ESI (for a review, see Schacter & Madore, 2016), as well as work on the distinctiveness heuristic and DRM false recall (McCabe & Smith, 2006).

Before encoding the DRM lists, participants received either the ESI or the control induction. The order of inductions was counterbalanced across participants, as were the word list-induction and video-induction pairing. For the ESI, after watching the video, participants were told that they were the chief expert on the video and were then asked to verbally recall different categories of episodic information pertaining to the video. Specifically, participants were guided through three mental-imagery exercises, during which they were asked to close their eyes and create a detailed picture in their mind about the setting, people, and actions (e.g., for the setting, participants were asked to focus on the environment, the objects in it, and how they were arranged). Once the mental image was created, they were asked to verbally describe everything that they remembered and to be as specific and detailed as possible. Following the initial verbal description, the experimenter probed the participant with open-ended questions about the information they had provided (e.g., “You mentioned there was a kitchen with a center island, can you tell me more about what was in the kitchen?”). For each category of information, participants were generally asked one follow-up question.

In the control induction, participants verbally described their general thoughts and impressions about the video. Then, participants were asked to provide separate opinions on the other aspects of the video including the setting, people, and actions. Participants also responded to a number of questions from a question bank (e.g., “When do you think the video was made?” and “What equipment do you think was used to make the video?”). The control induction required participants to reflect on and speak about the contents of the video, but in contrast to the ESI, did not require the retrieval of specific and detailed episodic information. For the scripts used for the ESI and control induction, see Madore et al. (2014).

Immediately following the induction, participants were auditorily presented 5 10-word DRM lists and were instructed to encode the words for a later memory test. Two sets of 5 10-word DRM lists were used in the study. One set comprised studied words corresponding to the following critical lures: sleep, chair, cold, river, and doctor. The other set comprised studied words corresponding to the following critical lures: slow, window, smell, soft, and sweet. The 10-word lists were shortened versions of the 15word lists of Stadler, Roediger, and McDermott (1999). The two sets of lists were statistically equated for the probability of eliciting false recall ($p > 0.20$; Stadler et al., 1999). Words were presented in a blocked fashion (i.e., all words of an associated set were presented together) and words within a block were ordered from highest to lowest backward associative strength. The order of the 5 10-word lists was randomized within a given block across participants. Words were spoken by the experimenter at a rate of one word every 5 seconds (McCabe & Smith, 2006).

Following word presentation, participants were given a math filler task for 9 minutes[1]. Participants were given multiple sheets of simple addition and subtraction problems and were asked to continually solve the problems for the allotted time. Immediately following the filler task, participants were given a memory test for the studied words. A blank sheet of paper was handed to the participant, and they were instructed to write down as many words as they could remember. The recall test lasted for 5 minutes (see McCabe & Smith, 2006). Following completion of the recall test, participants were given a 10 minute break (participants were free to use the time in any way they chose). After the break, participants began the second segment (i.e., starting with viewing the other video)[2].

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1. The delay interval was based on data where the induction was given after encoding (i.e., Experiment 2). It was determined that the mean delay across participants from the start of the video (i.e., after word presentation/encoding) to the end of the induction (i.e., before the recall test) was 9 minutes. Therefore, across the two studies the time interval between encoding and retrieval was consistent.
2. It should be noted that the current within-participant manipulation of induction may appear to deviate from prior studies of the distinctiveness heuristic that have documented that the distinctiveness heuristic is effective for reducing false recall and recognition in between- but not within-participant manipulations (McCabe & Smith, 2006; Schacter et al., 1999, 2000). For example, in Schacter et al. (1999, 2001) one group of participants encoded a list of DRM words (i.e., word encoding) and another group of participants encoded DRM words along with pictures corresponding to the studied items (i.e., pictorial encoding). False recognition was lower following pictorial relative to word encoding (i.e., evidence for distinctiveness heuristic). When encoding was manipulated within-participants, where half the DRM words were presented in isolation and another half were presented along with their corresponding

We addressed our hypotheses by conducting repeated measures analysis of variance (ANOVA) on rates of true and false recall with factors Induction (ESI and control) and Recall (true and false). Main effects were tested for each of the factors, and interactions addressed the differential impact of the ESI on Recall. Here, we focused on the interactions because they trumped the main effects. All follow-up comparisons were conducted with paired two-tailed t-tests and considered significant at the $p < 0.05$ level.

Results

Complete recall data from Experiment 1 are listed in Table 1. Rates of true recall (i.e., proportion of studied words recalled) and false recall (i.e., proportion of critical lures recalled) as a function of induction are illustrated in Figure 1. Overall rates of true and false recall are roughly similar to those reported in many previous DRM studies (for review, see Gallo, 2010), with true recall somewhat higher than false recall. However, rates of false recall were no lower after the ESI than the control induction; if anything false recall was slightly higher, and the difference between true and false recall somewhat smaller, after ESI. To test whether the ESI impacted recall, we conducted an ANOVA, with factors Induction and Recall. This ANOVA failed to reveal either an Induction by Recall interaction ($F(1, 35) = 2.26$, $p = 0.14$, partial $\eta^2 = 0.06$) or main effect of Induction ($F(1, 35) = 0.02$, $p = 0.88$, partial $\eta^2 < 0.001$). The main effect of Recall was significant (i.e., true > false; $F(1, 35) = 12.91$, $p < 0.001$, partial $\eta^2 = 0.27$)[3].

Experiment 2

In Experiment 1, we found no evidence for decreased false recall of DRM critical lures following an ESI relative to a control induction. These findings run counter to the idea discussed earlier that the ESI might boost memory strength or the relative distinctiveness of studied list items during encoding, which in turn should have produced a decrease in later rates of false recall. On the other hand, we likewise found little evidence that ESI administered prior to encoding increased false recall rates. Importantly, however, in Experiment 1 we administered the ESI *before* presentation of the study lists. As noted earlier, in previous discussions regarding the impact of the ESI, we have proposed that the

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pictures, false recognition did not differ as a function of encoding status (note that a single test session comprising inter-mixed study items was employed). McCabe and Smith (2006) reported the same pattern of results for false recall. It is generally argued that in a within-participants design, distinctive information, such as seeing a picture during encoding, is no longer diagnostic of prior study because some lists were studied as pictures and others as words (for a discussion, see Dodson & Schacter, 2001, 2002). In contrast, in a between-participant design, distinctive information is 100% predictive of prior study. The critical distinction between the current study and prior within-participant studies of the distinctiveness heuristic is that we employed separate encoding and recall tests for each induction. Because we used separate encoding and recall tests for each induction, a distinctiveness heuristic should be invoked when recalling all words encoded after the ESI but not the control induction. Therefore, issues concerning between- versus within-participant manipulations that have been critical in previous studies (McCabe & Smith, 2006; Schacter et al., 1999, 2001) are not applicable to the present study.

3. Akin to our prior ESI studies (for review, see Schacter & Madore, 2016), we counterbalanced the order of the ESI and control inductions across participants to remove the influence of carryover effects. To more directly examine if carryover effects were present, we conducted a follow-up ANOVA with the additional between-participant factor of induction order. This ANOVA failed to reveal any significant main effects or interactions associated with induction order in Experiment 1 ($Fs < 3.97$, $ps > 0.06$, partial $\eta^2 s < 0.10$). The same was true when the analogous ANOVAs were conducted for Experiment 2 ($Fs < 0.96$, $ps > 0.33$, partial $\eta^2 s < 0.03$), Experiment 3 ($Fs < 2.23$, $ps > 0.15$, partial $\eta^2 s < 0.06$), Experiment 4 ($Fs < 1.34$, $ps > 0.26$, partial $\eta^2 s < 0.04$), and Experiment 5 ($Fs < 0.82$, $ps > 0.37$, partial $\eta^2 s < 0.02$). These results indicate that participants performed similarly in all studies irrespective of whether they received the ESI in the first or second segment. Critically, these analyses indicate that any significant findings, or lack thereof, cannot be attributed to carryover effects. It should be noted that none of our previous ESI-related behavioral or neuroimaging studies have revealed carryover influences on induction-related patterns of performance.

ESI biases participants to adopt a more specific *retrieval orientation* (Rugg & Wilding, 2000) when they remember past experiences, imagine future experiences or alternatives to them, solve means-end problems, and engage in divergent creative thinking. The lack of impact of the ESI on false recall may thus simply indicate that ESI does not bias *encoding* of list items, or that any potential effects of the ESI on recall dissipated during study list presentation. In line with our previous theorizing regarding effects of the ESI, a more appropriate test of the impact of ESI on false recall would entail administering either the ESI or control inductions *after* list presentations and just prior to the recall test. We did so in Experiment 2.

Experiment 2 is identical in all respects to Experiment 1 except that the ESI and control inductions were given after presentation of the study lists. Under these conditions, we expect that ESI will bias retrieval orientation to be more specific. On the one hand, it is plausible that such a specific retrieval orientation would lead participants to more carefully scrutinize items that come to mind during the recall test for information that is diagnostic of prior study, thus resulting in a reduction in false recall. On the other hand, administering the ESI just prior to the recall test also suggests a mechanism that could produce increased false recall. It is known that DRM false memories are sometimes accompanied by illusory recollection of details that participants had initially provided as associative responses to list items during study, a process known as *content borrowing* (Lampinen, Meier, Arnal, & Leding, 2005). Similarly, *context borrowing* can occur when participants incorrectly attribute a contextual feature that had been linked to the initial presentation of a particular list of associates (e.g., sensory modality) to the non-presented critical lure item (O'Neil & Diana, 2017). In line with ideas about content and context borrowing, administering an ESI just before the recall test could enhance retrieval of episodic details that are then incorrectly linked to critical lure items, thereby increasing the incidence of false memories. Consistent with this idea, a recent individual differences study by Dewhurst, Anderson, Berry, and Garner (2018) showed that a specific retrieval style, as assessed by a sentence completion test of autobiographical memory (Raes, Hermans, Williams, & Eelen, 2007), is positively correlated with rates of DRM false recognition but not true recognition.

In Experiment 2, we test these competing hypotheses about false memory decreases versus increases via an ESI given after study presentations and before recall.

Material and Methods

Participants—Thirty-six undergraduates from local colleges and universities received credit for a general psychology course or $10 for participation (mean age of 20.22 years (range 18–24), 19 females). All participants were native English speakers and had normal or corrected-to-normal vision, no history of neurological impairment, and were not currently taking any psychoactive medications. The experimental protocol was approved by the Institutional Review Board of Harvard University and informed consent was obtained prior to participation. The sample size was selected to be consistent with Experiment 1.

Stimuli and Task—The experimental procedure was similar to Experiment 1, with the exception that the induction was given directly before the memory test. Specifically, (a) participants encoded 50 words from 5, 10-word DRM lists spoken out loud by the experimenter, (b) watched one of two versions of the video, (c) completed a short filler task, (d) received either the ESI or control induction, and (e) following either induction, completed a recall task for the words heard at the beginning of the segment. Note that the time between encoding of the DRM lists and subsequent recall was matched relative to Experiment 1.

Results

Complete recall data from Experiment 2 are listed in Table 1. Rates of true and false recall as a function of induction are illustrated in Figure 2. As is apparent from Figure 2, while rates of true recall were similar as a function of induction, false recall was greater following the ESI relative to the control induction. This observation was statistically confirmed by a repeated measures ANOVA, with factors Induction (ESI and control) and Recall (true and false), which revealed a significant Induction by Recall interaction ($F(1, 35) = 4.16$, $p = 0.049$, partial $\eta^2 = 0.11$). Follow-up t-tests revealed that false recall was significantly greater following the ESI relative to the control induction ($t(35) = 2.59$, $p = 0.01$, $d = 0.43$, 95% confidence interval (CI) = (0.02, 0.18); see Figure 2, compare bars 3 and 4), with rates of true recall statistically equivalent across inductions ($t(35) = 0.31$, $p = 0.76$, $d = 0.05$, 95% confidence interval (CI) = (−0.05, 0.07); see Figure 2, compare bars 1 and 2). The ANOVA also revealed a main effect of Induction (i.e., ESI > control; $F(1, 35) = 4.45$, $p = 0.04$, partial $\eta^2 = 0.11$), with no main effect of Recall ($F(1, 35) = 2.34$, $p = 0.14$, partial $\eta^2 = 0.06$).

Experiment 3

The results of Experiment 2 indicate that the ESI selectively increases false recall in the DRM paradigm with no effect on true recall. Given the markedly different results of Experiment 2 relative to Experiment 1, where the ESI, when given before encoding, failed to modulate false recall, we think that it is critical to conduct a third experiment in an attempt to directly replicate the findings of Experiment 2.

Material and Methods

Participants—Thirty-six undergraduates from local colleges and universities received credit for a general psychology course or $10 for participation (mean age of 20.44 years (range 17–24), 25 females). All participants were native English speakers and had normal or corrected-to-normal vision and no history of neurological impairment and were not currently taking any psychoactive medications. The study was approved by the Harvard ethics committee and sample size was based on Experiments 1 and 2.

Stimuli and Task—The experimental procedure was identical to Experiment 2.

Results

Complete recall data from Experiment 3 are listed in Table 1. Rates of true recall and false recall as a function of induction are illustrated in Figure 3. When visually comparing Experiments 2 and 3 (compare Figures 2 and 3), overall recall performance in Experiment 3 was more accurate (i.e., rates of true recall were numerically higher and rates of false recall were numerically lower). Despite the overall difference in recall performance across the two experiments, a repeated measures ANOVA, with factors Induction (ESI and control) and Recall (true and false), identified the same Induction by Recall interaction ($F(1, 35) = 4.70$, $p = 0.04$, partial $\eta^2 = 0.12$). Replicating Experiment 2, follow-up t-tests revealed that rates of false recall were significantly greater following the ESI relative to the control induction ($t(35) = 2.51$, $p = 0.02$, $d = 0.35$, 95% CI = (0.02, 0.15); see Figure 3, compare bars 3 and 4), with no statistical difference in rates of true recall ($t(35) = 0.21$, $p = 0.84$, $d = 0.03$, 95% CI = (−0.05, 0.07); see Figure 3, compare bars 1 and 2). The ANOVA also revealed a main effect of Recall (i.e., true > false; $F(1, 35) = 37.60$, $p < 0.001$, partial $\eta^2 = 0.52$), with no main effect of Induction ($F(1, 35) = 2.95$, $p = 0.09$, partial $\eta^2 = 0.08$).

To determine whether the effect of the ESI was equivalent across the two experiments, we first examined whether the effect sizes across the studies statistically differed. This was not case ($d = 0.43$ (Experiment 2) versus $d = 0.35$ (Experiment 3); $z = 0.61$, $p = 0.54$), meaning that ESI effects were statistically equivalent across Experiments 2 and 3 even though overall recall performance differed. To further test whether the effect of the ESI was equivalent, a follow-up ANOVA was conducted directly comparing Experiments 2 and 3 (i.e., an ANOVA with within-participant factors of Induction (ESI and control) and Recall (true and false), and between-participant factor of Experiment). As expected, the ANOVA revealed a Recall by Experiment interaction (i.e., true recall was higher in Experiment 3 relative to 2, with the reverse pattern for false recall; $F(1, 70) = 9.71$, $p = 0.003$, partial $\eta^2 = 0.12$). Critically, the ANOVA revealed an Induction by Recall interaction ($F(1, 70 = 8.69$, $p = 0.004$, partial $\eta^2 = 0.11$) and failed to reveal either a three-way interaction (i.e., Induction by Recall by Experiment; $F(1, 70) = 0.06$, $p = 0.81$, partial $\eta^2 = 0.001$) or an Induction by Experiment interaction ($F(1, 70) = 0.07$, $p = 0.79$, partial $\eta^2 = 0001$). Therefore, regardless of the more accurate overall recall performance in Experiment 3 relative to 2 (i.e., Recall by Experiment interaction), the significant Recall by Induction interaction, together with null three-way and Induction by Experiment interactions, suggest that the effect of the ESI to boost false but not true recall was equivalent across the two experiments. The ANOVA also revealed main effects of Induction ($F(1, 70) = 7.32$, $p = 0.009$, partial $\eta^2 = 0.10$) and Memory ($F(1, 70) = 28.46$, $p < 0.001$, partial $\eta^2 = 0.29$), with no main effect of Experiment ($F(1, 70) < 0.001$, $p = 0.99$, partial $\eta^2 < 0.001$).

Experiment 4

Experiments 2 and 3 revealed a significant increase in false recall in the DRM paradigm following an ESI after study presentation and before recall. However, it could be argued that the impressions control induction does not necessarily represent a neutral baseline. That is, in this induction, participants are asked to describe their general impressions of the previously viewed video. Forming such general impressions could conceivably lead participants to employ a retrieval monitoring strategy to reject critical lure items as studied and reduce false recall. Thus, it is not clear based on the results of Experiment 2 and 3 whether the ESI *increased* false recall relative to a “neutral” baseline, or whether the impressions control induction *decreased* false recall (i.e., the ESI effects might not differ from a neutral baseline). Importantly, we have observed similar ESI-related increases on episodic-dependent tasks in behavioral and neuroimaging paradigms regardless of whether the impressions control induction or a more neutral math control induction is used as the comparison (for a review, see Schacter & Madore, 2016), suggesting that choice of control induction is not critical to observed ESI effects. Nonetheless, given the novelty of ESI-related effects on false memory, in Experiment 4 we assessed the possible contributions of the control induction to the key results documented in Experiments 2 and 3 by comparing the ESI with a more neutral control induction - completing math problems – that does not involve any kind of episodic retrieval (for other studies employing this math control induction, see Jing et al., 2016; Madore et al., 2014, 2015, 2016a, 2016b 2018; Madore & Schacter, 2016). If the effects of ESI on false recall observed in Experiments 2 and 3 reflect an increase from baseline, then we should observe similar effects in Experiment 4 when using the math control induction rather than the general impressions induction.

Material and Methods

Participants—Thirty-six undergraduates from local colleges and universities received credit for a general psychology course or $10 for participation (mean age of 20.78 years (range 18–25), 31 females). All participants were native English speakers and had normal or corrected-to-normal vision and no history of neurological impairment and were not currently taking any psychoactive medications. The study was approved by Harvard's ethics committee and sample size was identical to our prior experiments above.

Stimuli and Task—The experimental procedure was identical to Experiments 2 and 3 with the exception that we replaced the impressions control induction with a math control induction (see Jing et al., 2016; Madore et al., 2014, 2015, 2016a, 2016b, 2018; Madore & Schacter, 2016). In Experiment 4, after watching one of the videos and completing the math filler task, participants either received the ESI or an additional packet of math problems to complete. Note that the time between encoding of the DRM lists and subsequent recall was matched relative to Experiments 2 and 3 (e.g., the timing of the control induction for Experiment 4 was based on the length of the impressions control induction in Experiments 2 and 3).

Results

Complete recall data from Experiment 4 are listed in Table 1. Rates of true recall and false recall as a function of induction are illustrated in Figure 4. A repeated measures ANOVA, with factors Induction (ESI and control) and Recall (true and false), identified an Induction by Recall interaction ($F(1, 35) = 7.86$, $p = 0.008$, partial $\eta^2 = 0.18$). Replicating Experiments 2 and 3, follow-up t-tests revealed that rates of false recall were significantly greater following the ESI relative to the control induction ($t(35) = 2.22$, $p = 0.03$, $d = 0.37$, 95% CI = (0.008, 0.18); see Figure 4, compare bars 3 and 4), with no statistical difference in rates of true recall ($t(35) = 1.29$, $p = 0.20$, $d = 0.22$, 95% CI = (0.03, −0.09); see Figure 4, compare bars 1 and 2). The ANOVA also revealed a main effect of Recall (i.e., true > false; $F(1, 35) = 5.79$, $p = 0.02$, partial $\eta^2 = 0.14$), with no main effect of Induction ($F(1, 35) = 1.30$, $p = 0.26$, partial $\eta^2 = 0.04$).

Experiment 5

Experiments 2 and 3 revealed a significant increase in false recall in the DRM paradigm following an ESI after study presentation and before recall, and Experiment 4 revealed that this increase in false memory reflects an increase from baseline produced by the ESI rather than a decrease from baseline produced by the impressions control induction. Together, these findings support the hypothesis that the ESI operates to boost the recollection of illusory episodic details associated with critical lures, in line with the content/context borrowing account (Lampinen et al., 2005; O'Neil & Diana, 2017). In contrast, we found no evidence that the ESI encourages more careful scrutiny of items produced on the recall test for information diagnostic of prior study, which would have led to a decrease in false recall (e.g., Gallo, 2010; McCabe & Smith, 2006; Schacter et al., 1999, 2001).

In Experiment 5, we used an experimental manipulation previously shown to increase the level of recall and recognition for studied list items in order to assess whether increasing such item-specific memory would reduce or possibly negate the observed impact of ESI to increase false recall. We accomplished this objective by increasing the number of presentations of study words during encoding. Specifically, one group of participants heard the DRM lists *once* (i.e., a replication of the procedure of Experiments 2–4), and another group of participants heard the DRM lists *three* times. We hypothesized that by increasing repetition of the study words (i.e., boosting their associated distinctiveness or memory strength), the previously observed effects of the ESI to boost false recall would be counteracted. This hypothesis is based on evidence discussed in the Introduction indicating that increasing the number of presentations during the encoding of DRM word lists leads to a reduction in subsequent false memories (Benjamin, 2001; Kensinger & Schacter, 1999; McDermott, 1996; Schacter et al., 1998). It has been argued that such repetition effects in the DRM reflect greater access to item-specific information, which is then used to not only remember more words that were actually presented on the study list, but to use this more detailed recollection to reject critical lures (e.g., Kensinger & Schacter, 1999; Schacter et al., 1998). It is also possible that by increasing the number of presentations during the encoding of DRM word lists, participants are more likely to notice the missing critical lure words, thereby engaging in a monitoring strategy during encoding. Regardless, we predicted that effects of the ESI would be reduced for DRM lists presented three times relative to those presented only once.

Material and Methods

Participants—Seventy-two undergraduates from local colleges and universities received credit for a general psychology course or $10–15 for participation (mean age of 21.32 years (range 18–25), 52 females). All participants were native English speakers and had normal or corrected-to-normal vision and no history of neurological impairment and were not currently taking any psychoactive medications. The study was approved by Harvard's ethics committee and sample size was identical to those in our prior experiments above.

Stimuli and Task—The experimental procedure was identical to Experiments 2 and 3 with the exception that we incorporated a between-participant factor of presentation (N of 36 in each group). That is, each participant was randomly assigned to either listen to the 5, 10-word DRM lists *once* (i.e., the one presentation group, a replication of Experiments 2 3) or *three* times (i.e., the three presentation group[4]). Given that we replicated the ESI effect in enhancing false memory when employing the neutral math control induction (i.e., Experiment 4), in Experiment 5, we employed the more stringent impressions control induction, which provides a stronger control for episodic retrieval processes than does the math induction.

Results

Complete recall data from Experiment 5 are listed in Table 1. Rates of true recall and false recall as a function of induction and presentation are illustrated in Figure 5. We first set out to determine whether we replicated the pattern of findings from Experiments 2–4 in the one presentation group. An ANOVA conducted on recall rates restricted to the one presentation group (Figure 5, see bars 1, 2, 5, and 6), with factors Induction (ESI and control) and Recall (true and false), did not reveal an Induction by Recall interaction (F(1, 35) = 3.10, p = 0.09, partial η^2 = 0.08). Despite the lack of an interaction, we conducted the follow-up paired t-tests given the significant interactions observed in Experiments 2, 3, and 4. Replicating Experiments 2, 3, and 4, false recall was once again significantly greater following the ESI relative to the control induction (t(35) = 2.76, p = 0.009, d = 0.46, 95% CI = (0.03, 0.16); see Figure 3, compare bars 5 and 6), with no statistical difference in rates of true recall (t(35) = 1.33, p = 0.19, d = 0.22, 95% CI = (−0.01, 0.0.07); see Figure 5, compare bars 1 and 2). The ANOVA also revealed significant main effects of Induction (i.e., ESI > control; F(1, 35) = 8.81, p = 0.005, partial η^2 = 0.20) and Recall (i.e., true > false; F(1, 35) = 10.26, p = 0.003, partial η^2 = 0.23).

We next assessed whether increasing the number of encoding presentations reduced false recall following the ESI. We conducted an ANOVA with the within-participant factor of Induction (ESI and control) and between-participant factor of Presentation (one and three) on the recall rates associated with critical lures (Figure 5, see bars 5, 6, 7, and 8). This ANOVA revealed a main effect of Induction (i.e., ESI > control; F(1, 70) = 5.44, p = 0.02, partial η^2 = 0.07) and no main effect of Presentation (F(1, 70) = 3.67, p = 0.06, partial η^2 = 0.05). Of critical importance, the Induction by Presentation interaction was significant (F(1, 70) = 4.30, p = 0.04, partial η^2 = 0.06). Follow-up t-tests revealed that for the ESI, false recall was significantly reduced when the DRM list was presented three times during encoding relative to only once (t(70) = 2.62, p = 0.01, d = 0.62, 95% CI = (0.03, 0.24); see Figure 5, compare bars 5 and 7), but there was no effect of Presentation for the control induction (t(70) = 0.92, p = 0.36, d = 0.22, 95% CI = (−0.06, 0.16); Figure 5, compare bars 6 and 8).

The previously described ANOVA was conducted ignoring rates of true recall because Experiments 2, 3, and 4 identified a specific role of the ESI in boosting false but not true recall in the DRM. For completeness, we also report the results of the analogous ANOVA conducted on rates of true recall (see Figure 5, bars 1–4). This ANOVA only revealed a main

4. The choice of three presentations was based on pilot data and prior work employing the identical number of DRM encoding presentations (Benjamin, 2001).

effect of Presentation (i.e., rates of true recall were significantly higher in the three presentation group relative to the one presentation group ($F(1, 70) = 30.35$, $p < 0.001$, partial $\eta^2 = 0.30$), with no main effects of Induction ($F(1, 70) < 1$, $p = 0.69$, partial $\eta^2 = 0.002$) or an Induction by Presentation interaction ($F(1, 70) = 1.06$, $p = 0.31$, partial $\eta^2 = 0.02$).

General Discussion

The ESI has been shown to enhance performance on a range of tasks that rely on episodic retrieval, including autobiographical remembering, imagining novel future scenarios and alternatives to them, means-end social problem solving, and divergent creative thinking (for a review, see Schacter & Madore, 2016). An open question is whether the enhancements following an ESI reflect the influence of reproductive or constructive episodic retrieval processes. Here, we used the DRM paradigm to examine in five experiments whether these robust benefits of the ESI extend to reducing susceptibility to false recall, indicating an impact of the ESI on reproductive episodic retrieval, or whether these benefits are accompanied by a cost in the form of increased susceptibility to false memory, suggesting an influence on constructive episodic retrieval. In Experiment 1, the ESI was administered before DRM word lists were encoded and had no effect on rates of false recall relative to an impressions control induction. In Experiment 2, and replicated in Experiment 3, the ESI was administered after list presentation and just before recall. Under these conditions, ESI selectively increased rates of false but not true recall. In Experiment 4, we demonstrated that the changes in false recall observed in Experiment 2 and 3 resulted from an increase from baseline produced by the ESI rather than a decrease from baseline produced by the impressions control induction. In Experiment 5, we increased the distinctiveness/memory strength of DRM word lists via increasing the number of presentations of study words during encoding, and showed that the effect of the ESI to boost false recall, observed once again after a single presentation, was eliminated after three presentations. These findings suggest that after three study list repetitions, item-specific information associated with studied items may have become more available, with such information likely used to reject illusory recall of critical lures, thereby counteracting the effects of the ESI.

The fact that we observed effects of the ESI only when it was administered just prior to the recall test, and not when it was administered prior to encoding, is consistent with our proposal that the ESI operates to bias retrieval orientation and event construction processes (see Madore et al., 2014, 2016b, 2018; Schacter & Madore, 2016). According to this proposal, the main impact of the ESI is to bias retrieval orientation to generate additional episodic details during subsequent tasks that involve event construction, such as encouraging people to focus their retrieval attempts on details that comprise an imagined future episode, including people, places, or objects. With respect to the current results, the ESI biased retrieval orientation towards the generation of illusory episodic details in the DRM (i.e., those associated with critical lures), that is, toward constructive rather than reproductive retrieval processes. This link between episodic specificity and an increased bias towards false memory is consistent with the recent findings of Dewhurst et al. (2018). In this study, individuals who exhibited a specific autobiographical memory retrieval style, as assessed by a sentence completion procedure (Raes et al., 2007), showed higher levels of false recognition on the DRM than individuals with a less specific retrieval style. Dewhurst et al.

(2018) failed to find a reliable correlation between memory specificity and true recognition, akin to the present null effect of the ESI on rates of true recall. These authors argued that individuals with specific retrieval styles rely more on episodic details than individuals with less specific retrieval styles when judging whether an item is old or new, and are therefore biased to false alarm to critical lures when their recollections of those items include episodic details. The ESI may bias individuals in a similar manner. The findings of Dewhurst et al. (2018), together with the present results, indicate that having a specific retrieval style, or an experimentally-induced specific retrieval orientation as a result of an ESI, can produce negative consequences.

The present findings are consistent with context/content borrowing accounts of false memory (Lampinen et al., 2005; O'Neil & Diana, 2017). In line with these theories, we think that the ESI enhanced the retrieval of episodic details incorrectly linked to critical lure items, thereby increasing the incidence of false memories in the DRM. The ESI apparently boosted the willingness of participants to rely on illusory episodic details associated with critical lures. Accordingly, participants did not employ a distinctiveness heuristic to reduce their false recall. Only when the distinctiveness/memory strength of DRM studied items was sufficiently high (due to the increased presentation of studied items in Experiment 5) could participants successfully reject lure items as studied. We suggest that after increased presentation of studied items during encoding, the level of detail associated with studied items outweighed that associated with critical lures even after ESI, thus reducing false recall. These observations highlight that the kinds of episodic details associated with studying list items worked in opposition to the kind of "borrowed" episodic details that support false recall and whose salience was heightened by ESI.

Our results are also consistent with a source monitoring account of false memories in the DRM (Johnson, Hashtroudi, & Lindsay, 1993; Johnson, 2006). According to the source monitoring framework, characteristics of our mental experiences are used to attribute the origin or 'source' of memories (i.e., memories from different sources have different characteristics). For example, a retrieved item is more likely to be attributed to a prior event if the experience of retrieval is accompanied by large amounts of perceptual detail. In the context of the DRM, errors in source monitoring occur because critical lures and studied items share similar amounts of episodic details and cannot be discriminated. The present findings fit within the source monitoring framework because the ESI increased the level of episodic detail associated with critical lures, thereby boosting the incidence of source monitoring errors where critical lures were falsely attributed to prior appearance in the study list.

As noted earlier, the ESI is adapted from the CI (Fisher & Geiselman, 1992). The current findings add to evidence that the CI and procedures similar to it such as the ESI can boost the retrieval of inaccurate details (Memon et al., 2010a; Köhnken et al., 1999). Of particular relevance, the current study adds to the relatively limited work examining the downstream impact of the CI on the reporting of inaccurate information (e.g., LaPaglia et al., 2014). Consistent with the present results, LaPaglia et al. (2014) found that a CI, when administered after the presentation of misleading information, increased inaccurate memories for an original event. It is important to note that although the ESI is modeled after the CI, as stated earlier, it does differ from the CI in important ways. For example, the ESI procedure does not include rapport-building, context reinstatement, reverse order recall, and the change perspective components of the CI. These differences may explain why we failed to identify an effect of the ESI to modulate rates of true memory. That is, based on the CI evidence alone, one would predict that the ESI would boost both accurate and inaccurate memory (Memon et al., 2010a; Köhnken et al., 1999). Relevant to this point, previous work has shown that the context reinstatement component of the CI provides a significant contribution to boosting accurate information (e.g., Davis, McMahon, & Greenwood, 2005). Future studies should manipulate the ESI procedure to further assess what factors boost true memory.

A number of studies have now indicated that the ESI compared with various control inductions enhances performance on a variety of subsequent tasks such as remembering and imagining, alternative event generation, means-end problem solving, and divergent thinking (for a review, see Schacter & Madore, 2016). Here, for the first time, we demonstrate that the ESI is also linked to memory errors, at least on the DRM task. These findings have implications for what common component processes the ESI may be targeting that could be responsible for both the costs and benefits observed across these tasks. With respect to remembering, imagining, alternative event generation, problem-solving, and divergent thinking, as noted earlier, we have argued that these tasks all rely on the construction of detailed mental events that are created in part from elements of episodic memories (e.g., when generating a novel creative use or imagining a future scenario, we relationally process and recombine retrieved episodic information in a novel way; see Schacter & Madore, 2016). Because the ESI instructs participants to generate and relationally process specific elements of a prior episode, such as people, places, and objects, it facilitates performance on subsequent tasks that also focus on specific details and their relations. Here, the ESI biased retrieval towards the generation of illusory episodic details with no effect on the generation of veridical episodic details. It is generally believed that DRM false memories arise from associative/relational processes in memory (for a review, see Gallo, 2010). The ESI may therefore be enhancing such associative/relational processes. This explanation is in line with our proposal that the ESI impacts event construction, which involves the relational binding of event details (see, Schacter & Madore, 2016), and can help to understand how the ESI can lead to benefits on such adaptive tasks as imagination, alternative event generation, problem solving, and divergent thinking, while also leading to costs such as an increase in false memory in the DRM. Taken together, the current findings further our understanding of the constructive use of episodic retrieval and how it impacts other cognitive phenomena that also involve generative event processing (see also, Madore et al., 2018).

An important distinction between the present study and our prior work using the ESI is that in our prior work, we employed tasks that did not require the retrieval of accurate episodic details, such as autobiographical remembering and imagining. Here, the ESI boosted the retrieval of specifically illusory details and had no effect on the retrieval of accurate information. The current findings suggest that our previously observed boosts in episodic detail during autobiographical remembering following the ESI (e.g., Madore et al., 2014) could be driven by an increase in inaccurate episodic details. Thus, whereas it makes sense to describe the effects of ESI on imagination, alternative event generation, problem solving, and divergent thinking tasks as “benefits”, because performance on these tasks increases after ESI and questions regarding retrieval of accurate or inaccurate episodic detail are irrelevant to those increases, the present results call into question whether the effects of ESI on autobiographical memory should be conceived as “benefits” if in fact ESI does not boost accurate recall on such tasks. Future studies should address this possibility by combining the ESI with autobiographical remembering tasks and measuring the accuracy of those memories.

Our results align with recent data that also support an event construction account of the ESI. Madore et al. (2018) tested the hypothesis that the ESI reflects primarily constructive retrieval processes rather than reproductive retrieval processes by employing novel procedures in which participants received a *memory specificity induction* that involved remembering an actual autobiographical event, an *imagination specificity induction* that involved imagining a novel future autobiographical event, or a *control induction* (math problems) prior to memory and imagination tasks, as well as a picture description control task. If the ESI primarily reflects an influence on constructive retrieval processes, the downstream effects of the ESI should be observed after retrieval of an actual autobiographical event (i.e., the memory specificity induction) *and* after constructing an imagined future event (i.e., the imagination specificity induction). In contrast, if the ESI primarily reflects the influence of reproductive retrieval processes, then downstream effects of ESI should be observed only after retrieval of an actual autobiographical event. In line with an event construction account of the ESI, the two specificity inductions produced equivalent and signifcant increases in the number of episodic details generated during the memory and imagination tasks relative to the control induction (with no effects on the generation of semantic details or on the generation of details in the picture description control task). Together with the present data, these findings provide strong support for a constructive retrieval account.

Relevant to the discussion of what component processes are shared across false memory and divergent thinking is the study of Dewhurst, Thorley, Hammond, and Ormerod (2011). Dewhurst et al. (2011) examined whether susceptibility to DRM-based false recognition is correlated with performance in convergent and divergent thinking tasks (i.e., the remote associates task and alternate uses task, respectively). In this study, susceptibility to false recognition was significantly predicted by performance on a measure of convergent thinking but not by performance on the divergent thinking task. These findings may appear to be inconsistent with our current and prior ESI findings showing that the ESI boosts false recall as well as performance in a divergent thinking but not a convergent thinking task (Madore et al., 2015; see also Madore et al., 2016a, 2017). We note that the Dewhurst et al. (2011) study differs from our ESI work in two critical ways. First, the current study employed a recall version of the DRM procedure and Dewhurst et al. (2011) employed a recognition version. Second, Madore et al. (2015, 2016a, 2017) scored the divergent thinking task both as a function of the *quantity* of uses generated (e.g., the number of categories of appropriate uses) as well as the *quality* of uses generated (e.g., ratings of creativity). The ESI effect was present for the quantity and not the quality measure. In contrast, in the Dewhurst et al. (2011) study, the divergent thinking responses were scored only on the basis of the quality of uses generated. These differences in methodology and analysis could explain the disparity across studies. Regardless, these studies indicate that the component processes that underlie both false memory and divergent thinking are yet to be fully specified and highlight the need for future studies that explore the link across these cognitive phenomena.

It will be important for future studies to employ the ESI in conjunction with 'think-out-loud protocols' during the DRM to enhance our understanding of the basis of ESI effects on false memories (see Lampinen et al., 2005). These protocols have shown that participants verbally produce the same episodic information associated with studied DRM list words during retrieval. For example, when studying the word *sit*, a participant may verbally generate, "sometimes sitting down is good". A false memory for the critical lure *chair* is accompanied by the statement, "I remember chair, because I can remember sitting down". Based on the present findings, we predict that the ESI would enhance generation of such content-related information during the retrieval of critical lures during the DRM. In addition, these protocols could be used to further examine effects of the ESI on true memory. Consistent with the present findings, the more specific retrieval orientation induced by the ESI may not lead to a greater production of content-related information during the retrieval of studied items, but instead might be expressed in greater confidence for content-related information for critical lures as well as studied items.

One limitation of the present study is the lack of a significant main effect of Presentation on false recall in Experiment 5. Based on prior evidence (Benjamin, 2001; Kensinger & Schacter, 1999; McDermott, 1996; Schacter et al., 1998), we predicted that false recall would be significantly reduced following three versus one presentation of the DRM word lists during encoding. However, only two prior studies have examined the effects of study presentation on DRM false recall (as opposed to recognition; McDermott, 1996; Kensinger & Schacter, 1999). Both of these studies employed five study presentations, in contrast to three study presentations in the current study. The reduced number of presentations employed here could account for the null main effect of Presentation on false recall. Regardless of the null finding, we highlight that although the reduction in false recall following three versus one presentation was stronger after the ESI (i.e., 0.18 versus 0.32), it trended in the same direction following the control induction (i.e., 0.17 versus 0.22). Accordingly, we believe that the failure to see a significant overall reduction in rates of false recall following three versus one presentation is more apparent than real.

A second limitation of the present study is that we examined the effects of the ESI on false memory solely in the DRM paradigm, and therefore our results are limited in that respect. Notably, while some have argued that DRM-based false memories are significantly linked to other forms of memory errors (e.g., autobiographical false memories; Gallo, 2010; Otgaar, Verschuere, Meijer, & van Oorsouw, 2012), others have demonstrated that DRM-based false memories have little or no relationship to other forms of memory errors (e.g., misinformation effect false memories; Ost, Blank, Davies, Jones, Lambert, & Slamnon, 2013; Zhu, Chen, Loftus, Lin, & Dong, 2013; Bernstein, Scoboria, Desjarlais, & Soucie, 2018). In addition, DRM-based false memories are limited in that they are largely driven by semantic processing (Gallo, 2010). While the present study takes a first step in examining the impact of the ESI on one of the most reliable and widely adopted procedures for generating false memories (i.e., the DRM), it will be important for future research to investigate whether or not the present ESI effects extend to other measures of false memory. In addition, given the potential real-world applications of the ESI (e.g., in boosting problem solving and creative thinking), it will also be particularly important to examine whether the ESI extends to more ecologically valid forms of false memory (e.g., schema-driven false memories; Dewhurst, Anderson, Grace, & Howe, 2018).

A final limitation worth noting is that all prior ESI studies including the present one have examined the effects of the ESI on tasks that require generative processing (e.g., true and false recall in the DRM, generating remembered past or imagined future autobiographical episodes, or producing novel but appropriate uses of common objects; for a review, see Schacter & Madore, 2016). It will be important for future studies to assess whether the effects of the ESI extend to tasks that do not have a generative component (e.g., a recognition version of the DRM). Such studies would help to elucidate whether the effect of the ESI can be observed across generative and non-generative tasks that tap episodic retrieval or only those that tap generative episodic retrieval.

The present findings clearly demonstrate that the ESI enhances false recall in the DRM, indicating that the ESI biases people to rely on constructive rather than reproductive retrieval processes. These findings add to the evidence that adaptive episodic memory processes can also lead to memory errors (e.g., Schacter et al., 2011). For example, according to the constructive episodic simulation hypothesis (Schacter & Addis, 2007, in press), episodic memory involves flexible retrieval processes that support the simulation of novel future events through the recombination of retrieved episodic elements. The adaptive function of simulation comes at a cost however, because the same flexible retrieval processes that support simulation leave episodic memory prone to error (for further discussion, see Schacter, 2012, in press; and for recent evidence, see Carpenter & Schacter, 2017, 2018). In the current study, we provide the first evidence that the ESI, which has been linked to such adaptive functions as episodic simulation, contributes to memory errors.

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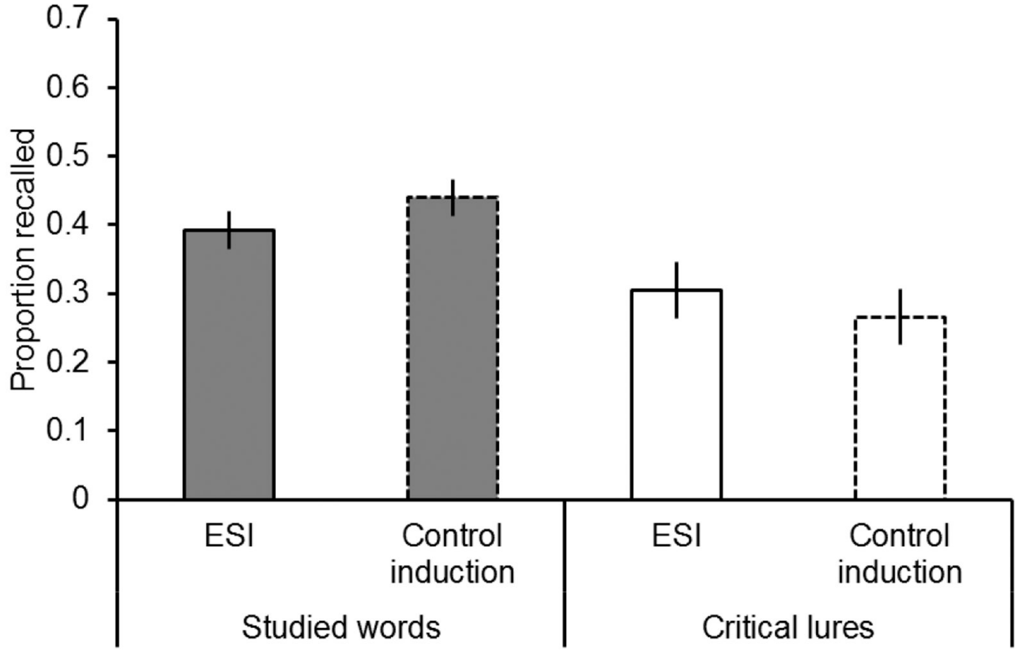

Figure 1.

Results from Experiment 1. Mean proportion of studied words and critical lures recalled as a function of induction (episodic specificity induction (ESI) and control induction). Error bars denote ± 1 standard error of the mean and asterisks indicate significant results (*p < 0.05; see main text for details).

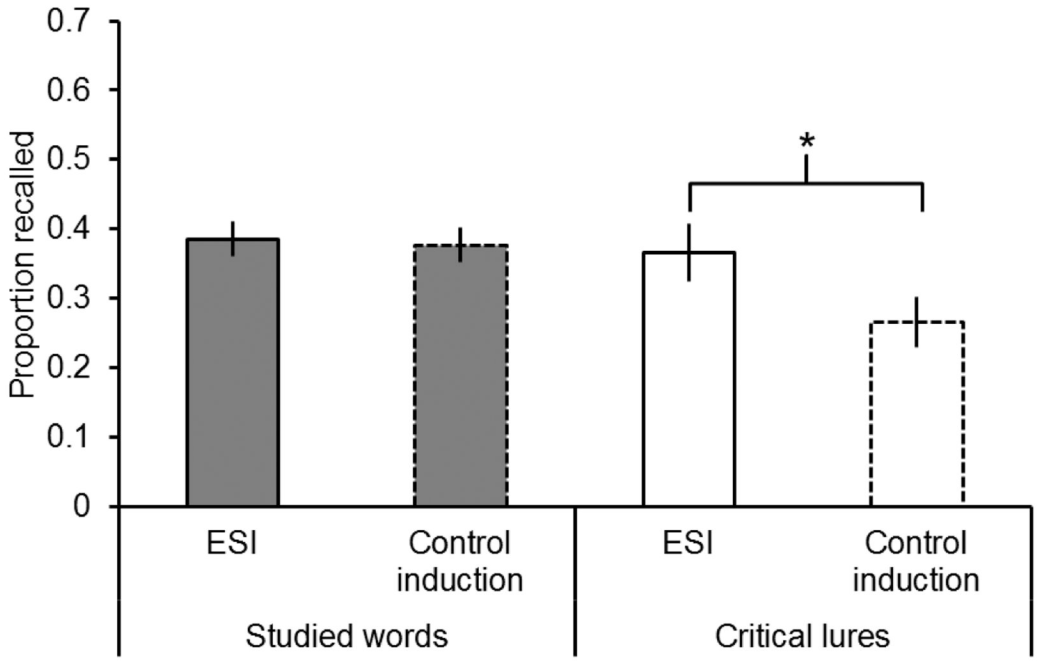

Figure 2.
Results from Experiment 2. Mean proportion of studied words and critical lures recalled as a function of induction (episodic specificity induction (ESI) and control induction). Error bars denote ± 1 standard error of the mean and asterisks indicate significant results (*p < 0.05; see main text for details).

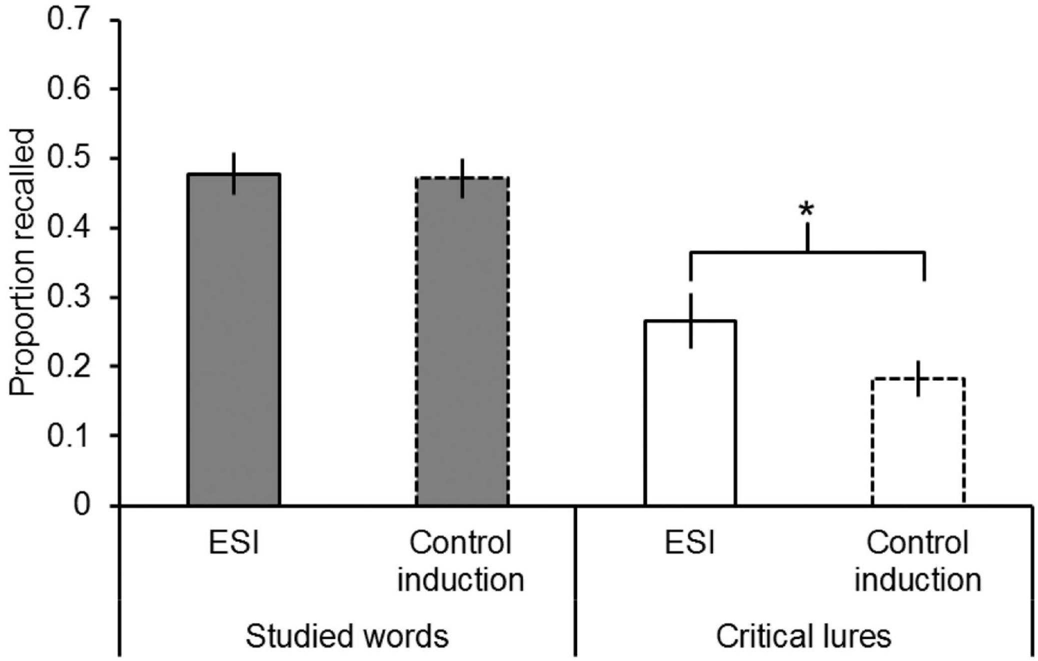

Figure 3.
Results from Experiment 3. Mean proportion of studied words and critical lures recalled as a function of induction (episodic specificity induction (ESI) and control induction). Error bars denote ± 1 standard error of the mean and asterisks indicate significant results (*$p < 0.05$; see main text for details).

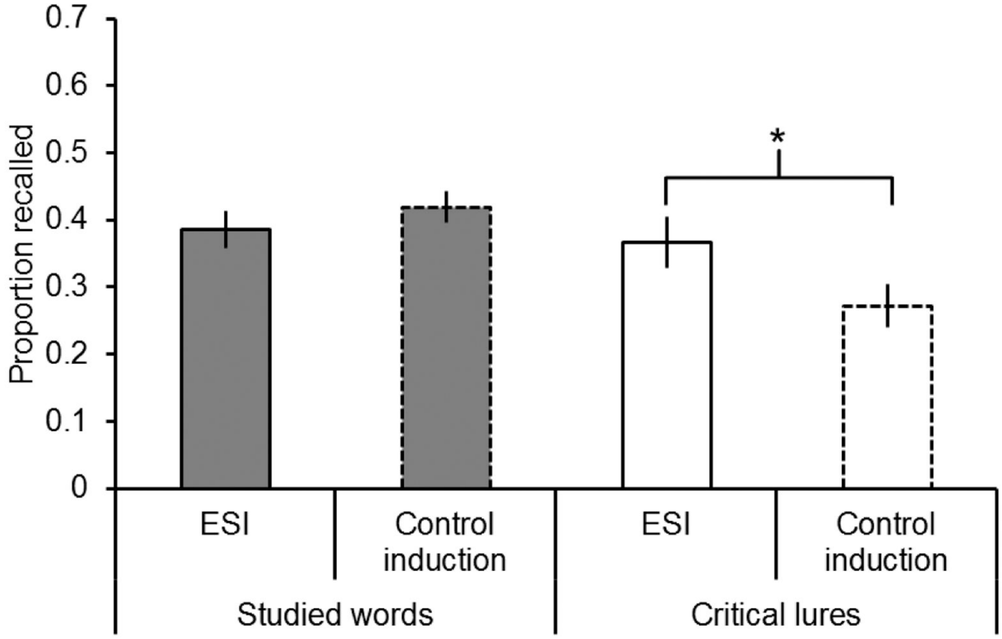

Figure 4.
Results from Experiment 4. Mean proportion of studied words and critical lures recalled as a function of induction (episodic specificity induction (ESI) and control induction). Error bars denote ± 1 standard error of the mean and asterisks indicate significant results (*$p < 0.05$; see main text for details).

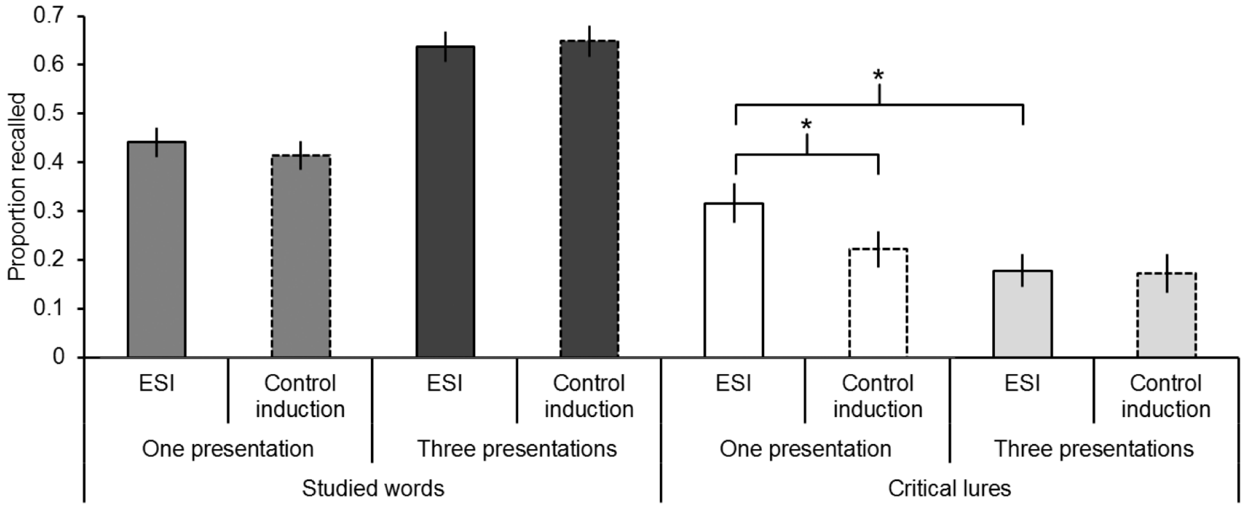

Figure 5.

Results from Experiment 5. Mean recall of studied words and critical lures as a function of presentation group (one presentation and three presentations) and induction (episodic specificity induction (ESI) and control induction). Error bars denote ± 1 standard error of the mean and asterisks indicate significant results (*$p < 0.05$; see main text for details).

Table 1

	ESI			Control induction		
	Studied words	**Critical lures**	**Related intrusions**	**Studied words**	**Critical lures**	**Related intrusions**
Experiment 1	0.39 (0.03)	0.31 (0.04)	0.06 (0.02)	0.44 (0.03)	0.27 (0.04)	0.08 (0.02)
Experiment 2	0.39 (0.03)	0.37 (0.04)	0.08 (0.02)	0.38 (0.03)	0.27 (0.04)	0.05 (0.01)
Experiment 3	0.48 (0.03)	0.27 (0.04)	0.09 (0.02)	0.47 (0.03)	0.18 (0.03)	0.07 (0.02)
Experiment 4	0.39 (0.03)	0.37 (0.04)	0.11 (0.02)	0.42 (0.02)	0.27 (0.03)	0.11 (0.02)
Experiment 5 (One presentation)	0.44 (0.03)	0.32 (0.04)	0.08 (0.02)	0.41 (0.03)	0.22 (0.04)	0.08 (0.02)
Experiment 5 (Three presentations)	0.63 (0.03)	0.18 (0.03)	0.05 (0.02)	0.65 (0.03)	0.17 (0.04)	0.03 (0.007)

[1.]Mean proportion (± 1 standard error of the mean) of studied words, critical lures, and related intrusions recalled as a function of induction (episodic specificity induction (ESI) and control induction) for each experiment.

[2.]We also examined whether generation of related intrusions per 10-word list differed as a function of induction. These rates significantly differed in only Experiment 5 in the three presentation group ($t(35) = 2.16$, $p = 0.04$).