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Two Mechanisms of Constructive Recollection: Perceptual Recombination and Conceptual Fluency

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Recollection is constructive and prone to distortion, but the mechanisms through which recollections can become embellished with rich yet illusory details are still debated. According to the conceptual fluency hypothesis, abstract semantic or conceptual activation increases the familiarity of a nonstudied event, causing one to falsely attribute imagined features to actual perception. In contrast, according to the perceptual recombination hypothesis, details from actually perceived events are partially recollected and become erroneously bound to a nonstudied event, again causing a detailed yet false recollection. Here, we report the first experiments aimed at disentangling these 2 mechanisms. Participants imagined pictures of common objects, and then they saw an actual picture of some of the imagined objects. We next presented misinformation associated with these studied items, designed to increase conceptual fluency (i.e., semantically related words) or perceptual recombination (i.e., perceptually similar picture fragments). Finally, we tested recollection for the originally seen pictures using verbal labels as retrieval cues. Consistent with conceptual fluency, processing-related words increased false recollection of pictures that were never seen, and consistent with perceptual recombination, processing picture fragments further increased false recollection. We also found that conceptual fluency was more short-lived than perceptual recombination, further dissociating these 2 mechanisms. These experiments provide strong evidence that conceptual fluency and perceptual recombination independently contribute to the constructive aspects of recollection.

Keywords: false memory, false recollection, familiarity, imagination inflation, source monitoring

Episodic memory—or our ability to consciously recollect contextual details about past events—involves reconstructive processes that are susceptible to distortion. This reconstructive aspect of memory has been well documented in the false-memory literature (for review, see Brainerd & Reyna, 2005), and also has been highlighted in the literature on memory reconsolidation and malleability (Alberini, Milekic, & Tronel, 2006; Dudai, 2004; McGaugh, 2000). An important point to emerge from this research is that memory errors and distortions are driven by a variety of processes, ranging from a relatively decontextualized sense of familiarity or inferences, on the one hand, to the subjective experience of a vivid and detailed (yet erroneous) recollection, on the other. Indeed, many researchers have given highly detailed false memories a special name in order to differentiate them from other kinds of memory errors, including "rich false memories" (Loftus & Bernstein, 2005), "vivid false memories" (Lampinen, Meier, Arnal, & Leding, 2005), "phantom recollections" (Brainerd, Wright, Reyna, & Mojardin, 2001), "illusory recollections" (Gallo, 2006), and "false recollections" (Arndt, 2012).

Although the occurrence of false recollection is well established, surprisingly little work has been aimed at understanding the reconstructive mechanisms that give rise to the erroneous details associated with false recollections. Here, we report a series of experiments designed to test between two alternative mechanisms, which we refer to as *conceptual fluency* and *perceptual recombination*. As reviewed next, it is well established that conceptual processes can drive memory errors (e.g., associative activation, gist-based information, semantic inferences; see Roediger, 1996), and also that people can confuse perceptual features or contextual information associated with different items in memory (e.g., source memory errors, feature conjunction errors; see Johnson, Hashtroudi & Lindsay, 1993). However, the extent that these different kinds of information contribute to the creation of detailed false recollections, as opposed to recall or recognition errors based on familiarity or source memory inferences, is poorly understood. Can these hypothetical mechanisms be experimentally disentangled? Is one mechanism sufficient to explain the creation of false recollections, or are both needed? Before describing the current research, we first briefly review research that is most relevant to each of the two hypothetical mechanisms in question, as well as some of the limitations of that research that we aimed to address with the new experiments that we report here.

Conceptual Fluency

It has been well demonstrated that semantic or conceptual processing can increase processing fluency—or the ease with which information can be understood—and that conceptual fluency can influence episodic memory judgments. For example, subliminally presenting a conceptually related word just prior to a recognition memory decision increases the likelihood that the test

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word will be judged as studied (Rajaram & Geraci, 2000). Although dual-process models have interpreted these fluency effects in terms of familiarity as opposed to recollection (e.g., Rajaram, 1993; see Yonelinas, 2002), it has been argued that fluency can give rise to the subjective experience of recollecting studied information in some contexts (Kurilla & Westerman, 2008; Taylor & Henson, 2012; Wang, Li, Gao, Xu, & Guo, 2015; Whittlesea, 2002).

Within the false-memory literature, it has been proposed that conceptual fluency can drive the creation of detailed false recollections in addition to a more general sense of familiarity. Gallo and Roediger (2003) described one way that conceptual fluency might drive false recollection, partly inspired by an earlier discussion of fluency attributions in Jacoby, Kelley, and Dywan (1989). Their argument was an attempt to explain false recollection in the Deese-Roediger-McDermott (DRM) task (Deese, 1959; Roediger & McDermott, 1995; for review, see Gallo, 2010), or the finding that people often report detailed recollections of a nonstudied word (e.g., sleep) after studying a list of semantically related words (e.g., bed, rest, awake). To explain the origin of these erroneously recollected details, Gallo and Roediger (2003) suggested that, when taking a memory test, participants might use their imagination in an effort to try to recollect whether (or not) the word had been presented in the study phase. Although this kind of mental recapitulation process might help to trigger memories for actually studied items (see Jacoby, Shimizu, Daniels, & Rhodes, 2005), it also might cause participants to create a false memory for strongly associated words. In essence, the conceptual fluency of these words would cause mentally imagined features to be mistaken for ones that had previously been experienced during the study phase, thereby causing the creation of a perceptually detailed false recollection.

Although Gallo and Roediger (2003) did not provide direct evidence for this conceptual fluency mechanism, and in fact offered multiple explanations for false recollection in the DRM task, two other lines of research support the hypothesis. The first line of evidence comes from source memory tasks. Henkel and Franklin (1998) found that the processing of conceptually related items (e.g., pants) increased the likelihood of erroneously claiming to have seen a picture of imagined items (e.g., shirt) on a source memory task (see also Lyle & Johnson, 2006). To the extent that errors on this source memory task reflected false recollections, these findings support the conceptual fluency hypothesis. The second line of evidence comes from misinformation tasks, in which participants often claim to recollect specific features of events that were only suggested in a misleading narrative (Karpel, Hoyer, & Toglia, 2001; Zaragoza & Mitchell, 1996). Because the misinformation itself does not present detailed perceptual information, these effects suggest that increasing the conceptual fluency of the suggested event affects memory judgments (e.g., Garry & Wade, 2005). A study by Zaragoza, Mitchell, Payment, and Drivdahl (2011) provided some of the strongest evidence for this interpretation. Participants watched a burglary video and then were exposed to misleading questions about an event that was not witnessed (e.g., a thief stole a ring). These questions either encouraged conceptual elaboration (e.g., "Was the fact that the thief stole a ring central to the plot?") or perceptually detailed imagery (e.g., "What color was the velvet box containing the ring?"). Although both kinds of elaboration increased high-confidence (yet false) claims of seeing the ring in the video compared with a control, the effect was greatest with conceptually misleading questions. Zaragoza et al. suggested that this condition likely caused spontaneous imagery of the misinformation as well as conceptual elaboration (or fluency), resulting in a stronger misattribution effect.

These lines of evidence converge upon the idea that conceptual fluency can drive false recollection, but it is important to note that many of these studies were not designed to test a conceptual fluency mechanism, and other interpretations are possible. First, past research has not consistently used recollection tests, whereby participants are required to respond based on recollection and are warned against using familiarity or other information. In the absence of warnings and controls for familiarity-based responding, it is not always clear that memory errors reflect false recollection. For example, errors on source memory tasks can reflect inferences based on familiarity or other information (e.g., "I studied a picture of pants, so I probably also studied a picture of a shirt"). Similarly, errors on misinformation tasks might be created by inferences in the absence of a conceptual fluency mechanism. Second, in those instances in which conceptual fluency was manipulated with procedures that involved mental imagery (implicitly or explicitly), it is unclear whether conceptual fluency contributed to memory errors above and beyond the influence of the imagined perceptual features. As discussed next, the processing of perceptually related features may be sufficient for false recollection, so that more definitive evidence for a conceptual fluency mechanism would require a clear separation between the mental imagery and conceptual fluency manipulations.

Perceptual Recombination

In contrast to the conceptual fluency hypothesis, whereby the details associated with false recollection are derived from imagination, the perceptual recombination hypothesis argues that these details are derived from events that were actually experienced in an associated context. According to this mechanism, the perceptual features from studied events can become detached or fragmented in memory, and these partial features can be recollected in response to a related event that was not actually seen (e.g., it was not presented during study, or it was imagined but not actually seen). If these fragmented perceptual features become associated with the nonstudied event, then they may cause a false recollection of having actually seen the event. This kind of mechanism has been proposed several times in the literature to explain false recollection effects, variously described as "content borrowing" (Lampinen, Neuschatz, & Payne, 1999), "feature borrowing" (Gallo & Roediger, 2003), "feature importing" (Lyle & Johnson, 2006), and "miscombined binding" (Dodson, Bawa, & Krueger, 2007b; Dodson, Bawa, & Slotnick, 2007a), although recombination and conceptual fluency effects are often conflated in the literature (for an example from the DRM task, see Lampinen et al., 2005).

Much of the work relevant to the feature recombination mechanism has come from source memory tasks, including the aforementioned task by Henkel and Franklin (1998). They had participants study line pictures (magnifying glass) that were perceptually similar to imagined items (lollipop). A key finding was that increasing the number of perceptually similar studied pictures also increased false claims of having perceived a picture of the imagined item. Subsequent work showed that these memory errors were associated with high confidence (Henkel, Franklin, & Johnson, 2000) as well as the recollection of specific features that were originally linked to the perceived items (e.g., location or color; Lyle, Bloise, & Johnson, 2006; Lyle & Johnson, 2006, 2007). The subjective specificity of these memory errors suggests that feature recombination had occurred between imagined and perceived items, as opposed to a familiarity-based process, but it is important to recognize that another interpretation is possible. Because these studies used relatively simple and perceptually similar line drawings, the memory errors might have reflected the correct recollection of a studied picture (magnifying glass) in response to the incorrect test label (lollipop). In these cases, memory errors would be caused by confusing test labels across the stimuli (i.e., a misidentification effect, Geraci & Franklin, 2004; Vannucci, Mazzoni, Marchetti, & Lavezzini, 2012), as opposed to a false recollection because of perceptual recombination.

Research with recognition memory tasks is also relevant to the feature recombination hypothesis, but has its own limitations. For example, in the memory conjunction task (e.g., Reinitz, Lammers, & Cochran, 1992), participants study compound words (e.g., jailbird, blackmail) and later falsely recognize nonstudied words made from the component parts (e.g., blackbird). These kinds of errors are generally attributed to failed binding or associative processes in memory, which is a key component of the feature recombination hypothesis (cf. Chalfonte & Johnson, 1996). However, recombination effects in recognition memory (and related associative recognition studies, e.g., Hockley & Consoli, 1999) are usually attributed to familiarity-based responding as opposed to perceptually detailed false recollections. In a related vein, it is known that false recognition can be based on perceptual similarities between study and test pictures (Koutstaal et al., 2003; Koutstaal & Schacter, 1997; Pidgeon & Morcom, 2014; Stark, Yassa, Lacy, & Stark, 2013), but because pictures are presented at test in these recognition memory studies, it is difficult to differentiate between familiarity of the test item and false recollection effects. Cued recollection tasks can provide a more straightforward way to study false recollection than do recognition memory tasks.

Current Experiments

The goal of the current experiments was to more definitively investigate the relative contributions of conceptual fluency and perceptual recombination to the constructive aspects of recollection. To this end, we developed a three-stage misinformation task that allowed us to experimentally control the relative contribution of conceptual and perceptual information while also controlling for familiarity and other processes that can affect accuracy on a cued recollection test. In the first phase (target encoding), participants viewed object labels (e.g., "puppy") and formed a mental image of the object. After each study item they then were shown an actual picture of the object (targets) or not (lures). Our picture stimuli were colored photos with realistic perceptual features. In the second phase (misinformation encoding), we presented information that was related to some of the studied items in order to manipulate conceptual fluency or perceptual recombination. The nature of this misinformation is described in the context of each experiment. To avoid unwanted rehearsal effects, there was no mention of a final memory test during these first two phases, and instead, participants incidentally encoded the material using cover tasks. The third phase gave a surprise cued recollection test, in which participants were presented with encoding labels and asked to recollect whether or not a picture of the object had been presented in the original phase.

An important aspect of our design was that some misinformation was related to targets, whereas other misinformation was related to lures. This allowed us to instruct participants, at test, that recollecting misinformation would not help them to decide whether or not the test item was presented as a picture. Instead, they were to focus on recollecting pictures from the original study phase. Similar to the logic of a criterial recollection test (see Gallo, 2013), this design aspect minimized the likelihood of a recall-to-reject strategy or other inferences from the misinformation phase that can complicate interpretation of memory errors. Another important aspect of our design is that each picture had a verbal label that was unlikely to be confused with other studied pictures. The use of these labels as retrieval cues ensured that responses on the picture recollection task would reflect the recollection of the specified picture (i.e., target picture recollections or false recollections of pictures for lures), as opposed to confusions between the labels of different studied pictures.

Finally, after the picture recollection test, we administered a speeded yes–no recognition memory test for the labels that had been used as recollection test cues. Unlike our picture recollection test, this speeded recognition test was intended to be sensitive to differences in familiarity or fluency. Thus, if two conditions of interest differed on the picture recollection test but not on the speeded recognition test, it would suggest that the difference was because of a recollection process independent from familiarity or fluency effects (e.g., false recollection driven by feature recombination). In contrast, if two conditions of interest differed on both tests, it would suggest that a fluency process had affected the recollection test (e.g., false recollection driven by conceptual fluency).

The goal of Experiments 1 and 2 was to use this task to independently test the conceptual fluency and perceptual recombination hypotheses, respectively. To anticipate, we found evidence for each of these processes, although the effect was more robust for perceptual recombination than for conceptual fluency. The goal of Experiments 3 and 4 was to replicate these initial results under delayed conditions designed to elicit more robust false recollection effects, and also to determine the extent that the timing of the misinformation might differentially affect each of the two mechanisms. As will be described further, there was reason to suspect that the conceptual fluency manipulation would be more transient or short-lived than the feature recombination manipulation.

Experiment 1: Conceptual Fluency

Method

The goal of Experiment 1 was to test the extent that conceptual fluency could create false recollection for nonstudied pictures. To do this, participants first studied a list of labels to objects, some of which were presented with pictures of the actual objects (targets) and others that were not (lures). Next, in the misinformation phase, we presented semantically related words to half of the targets and half of the lures, whereas the other targets and lures had no related words (baseline items). These items were presented in a rapid fashion using a cover task intended to minimize mental imagery (see Procedure). Participants then took a picture recollection task using the studied labels as retrieval cues.

Participants. Thirty-two individuals (nine males) aged 18 to 26 years old (M = 20.13, SD = 1.88) were recruited from the University of Chicago and surrounding area. All participants had normal or corrected-to-normal vision, and English was their first language. The institutional review board at the University of Chicago approved all experimental procedures in this and the other studies. Participants were compensated for their time with $10 per hour or class credit.

Stimuli. The set of stimuli consisted of 40 different conceptual categories each containing four exemplars. The 40 categories were separated into four lists (one per experimental condition) and counterbalanced across subjects. Each category contained one parent item (e.g., "puppy"), which could be presented during the encoding phase as a label with its corresponding picture (target) or just a label (lure). Pictures were 250 × 250 pixels of objects on a white background. The other three items within a category were objects both conceptually related and perceptually similar to the parent item (e.g., "kitten," "ferret," "hamster"). These words were presented during the misinformation phase using word identification judgments as a cover task (see Procedure). This task used both unscrambled and scrambled versions of these words, such that the middle two letters were switched (e.g., "lmie" for "lime"). When the middle letters were the same (e.g., "kitten"), the first middle letter and its immediate antecedent were switched (e.g., "ktiten"). When a word contained an odd number of letters (e.g., "whiskey"), the middle letter and its immediate antecedent were switched (e.g., "whsikey").

Procedure. The experiment consisted of three main phases (encoding, misinformation, cued recollection) and a final manipulation check (see Figure 1). Prior to each phase, participants were read the instructions by an experimenter, and they also read the instructions themselves on the computer screen. During encoding, participants were presented with the 40 unrelated parent labels in a black font on a gray background (e.g., puppy). Each object label was presented for 750 ms and was then followed by a black empty square for 2,000 ms. During this time, participants were instructed to form a mental image of a picture of the object within the square and rate whether or not they were successful at imagining a detailed picture using "v" or "b" on the keyboard ("yes" and "no," respectively). For half of the trials (targets), a picture of the object appeared within the square for 750 ms postmental imagery. As an incidental learning cover task, participants were told that these were examples of the types of mental images that they were to form and to use them to calibrate their imagery ratings. The remaining trials (lures) only contained the object label and mental imagery box but were not followed by a picture of the object. The next trial began after a pseudorandom intertrial interval (intertribal

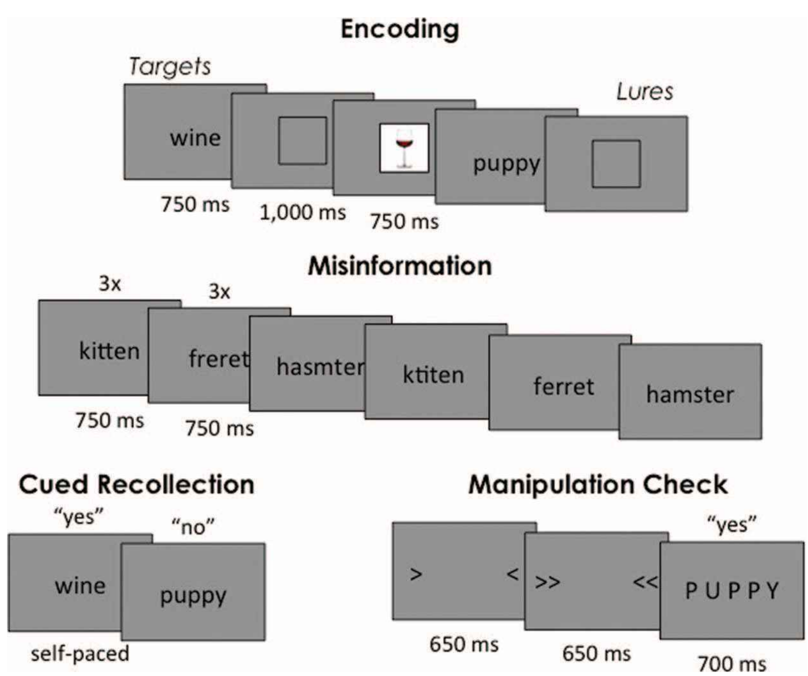

Figure 1. Paradigm for Experiments 1 and 3. Encoding consisted of object labels presented with their corresponding pictures (targets) or alone (lures). Misinformation was semantically related words presented both intact and scrambled. Although not pictured, misinformation was for half of the targets and half of the lures. Cued recollection consisted of object labels from encoding, and participants were asked to recall whether or not a picture had been presented of the object. The manipulation check was a speeded recognition test of encoding labels and foils. Two sets of arrows were presented rapidly prior to each word in order to establish a rhythm. See the online article for the color version of this figure.

interval [ITI]) that, on average, was 2,500 ms, with no ITI less than 500 ms or greater than 5,000 ms.

During the misinformation phase, participants were rapidly presented with scrambled and nonscrambled labels that were semantically related to half of the targets and half of the lures from encoding. For each of these targets and lures, there were three related labels (e.g., "kitten," "ferret," "hamster"). Each label was shown three times unscrambled and three times scrambled. Stimuli from this phase were always randomly intermixed across categories. Labels were presented for 750 ms, with a 250-ms ITI. This task was rapid to minimize imagery and, therefore, perceptual influences. As an incidental learning cover task, participants were to indicate if they could identify what word the scrambled or nonscrambled label represented by pressing buttons labeled "yes" or "no."

In the cued recollection phase, participants completed a surprise, self-paced recollection test for the pictures from encoding. Labels from encoding were presented one at a time, and participants were to decide if they had seen a corresponding picture by pressing "yes" or "no." After this decision, they were to rate their confidence ("low," "medium," or "high"). Participants were explicitly warned that the second phase was meant to make the memory task more difficult and to ignore it. Furthermore, they were instructed that a recall-to-reject strategy would be ineffective (i.e., recollecting the presentation of related misinformation to reject a test item), as related items were presented for both targets and lures. Instead, they were told to focus their decision only on whether or not they could recollect an intact picture of the test item.

After the cued recollection phase, a manipulation check was carried out to determine familiarity differences across conditions. Participants were rapidly presented with 80 labels (20 targets and 20 lures from the earlier recollection test, and 40 new unrelated lures) in a speeded recognition test, using the response tempo procedure (e.g., Balota, Burgess, Cortese, & Adams, 2002). Test labels were presented in all capital letters with spaces between each letter (e.g., "L E M O N") in order to minimize familiarity of the word form from the prior cued recollection test. Before each label, a set of arrows was presented on either side of where the word would appear for 650 ms, followed by another set of arrows closing in on the word location for another 650 ms. These arrows were to prepare participants for the speed of the label duration and to establish a rhythm for their response so that recollection may be minimized. After the second set of arrows, a label was presented for 700 ms, during which participants had to respond if they had previously seen it in the first or third phase by pressing "yes" and "no." If participants responded after 700 ms, then the text "TOO SLOW" appeared on the screen for 2,000 ms. Data from all responses were included in analyses in order to avoid item selection biases. After each trial, a press of the spacebar was required to proceed to the next trial.

Analyses. The conditions were targets with conceptual misinformation, targets without conceptual misinformation, lures with conceptual misinformation, and lures without conceptual information. All target and lure data were analyzed separately. All statistics used two-tailed *t* tests and were considered significant at $p < .05$ throughout this article.

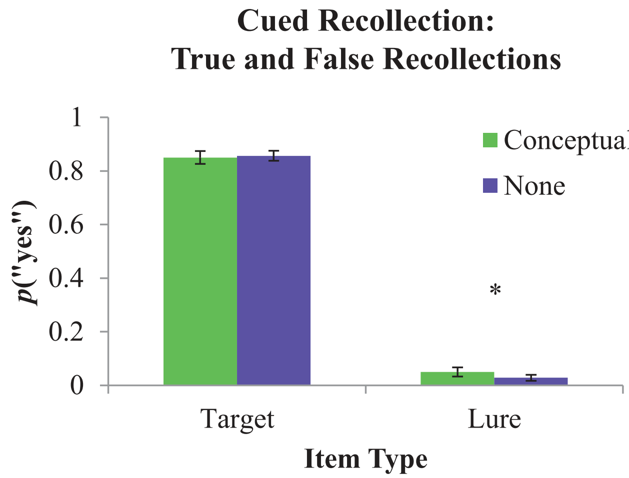

Figure 2. Picture recollection hit and false alarm rates after the conceptual fluency manipulation in Experiment 1. * $p < .05$. See the online article for the color version of this figure.

Results and Discussion

As shown in Figure 2, picture recollection accuracy was very high, as participants correctly accepted many of the targets (M = .85) and made very few false alarms to lures (M = .04). Nevertheless, there was a small but significant increase in false alarms from processing conceptually related labels (M = .05) compared with the no-misinformation baseline (M = .03), $t(31) = 2.521$, $p = .017$, $d = .271$, standard error of the mean (SEM) = .009. This effect was specific for lures, as there was no significant difference between targets with related labels (M = .85) and targets without (M = .86), $t(31) < 1$. Average confidence for false alarms was 1.92, indicating that these errors reflected medium confidence on the 3-point scale. As expected, average confidence for targets was greater at 2.90. We also analyzed false alarms made with only high or medium confidence as a more stringent measure of false recollection. Unfortunately, these errors were too rare to allow for strong conclusions, although there was a trend-level difference between false alarms for lures with misinformation (M = .03) compared with those without (M = .02), $t(31) = 1.68$, $p = .103$, $d = .178$, $SEM = .007$. Therefore, conceptual fluency appears to be sufficient to elicit false picture recollections, though this effect was very small when memory was tested shortly after encoding.

We also tested whether our conceptual processing manipulation evoked greater familiarity for the encoding labels by analyzing the speeded recognition data. Note that this is likely to be a conservative estimate of familiarity differences during the cued recollection test, because on the speeded recognition test, participants had just viewed the labels in the cued recollection phase, thereby inflating familiarity across all conditions. On average, participants were very good at keeping the response tempo (mean latency across all items = 578.10 ms). As expected, lures in the conceptual misinformation condition tended to be recognized more often than lures with no misinformation (Ms = .81 and .77, respectively), but this effect failed to reach conventional significance, $t(31) = 1.346$, $p = .188$ $d = .296$, $SEM = .032$. No difference was observed between targets with conceptual misinformation (M = .85) and those without (M = .84), $t(31)$ = .154, p = .879. Thus, in this experiment, we found a small but significant effect of the conceptual fluency manipulation on false picture recollection, but negligible effects of this fluency manipulation on a speeded recognition test.

Experiment 2: Perceptual Recombination

Method

The goal of Experiment 2 was to test the extent that perceptual recombination could create false recollection for nonstudied pictures. To do this, scrambled pictures of objects that were perceptually similar to half of the targets and lures were presented in the misinformation phase. These scrambled pictures were intended to provide perceptual features that could subsequently fuel a perceptual recombination process. More specifically, similar to the feature recombination thought to occur in attention tasks (Treisman, 1998; Treisman & Schmidt, 1982), we assumed that some of the features from related pictures (e.g., the roundness of an orange, or the yellowness of a squash) could be partially retrieved and mistakenly associated with the previously formed mental image (e.g., a puppy), either during an offline consolidation process or during a faulty recollection attempt at test, resulting in a more perceptually detailed false memory. Of course, presenting these pictures of related items also might increase conceptual fluency. Thus, as a baseline in this experiment, we repeatedly presented words that were semantically related to the other targets and lures, in order to increase the conceptual fluency of these items to the same level (or greater) as the items associated with scrambled pictures. According to the perceptual recombination hypothesis, presenting perceptually related fragments should increase false recollection above this conceptual fluency baseline.

The pictures in our misinformation phase were scrambled because we wanted to ensure that false picture judgments on the cued recollection task would reflect false recollections of nonstudied pictures, as opposed to correctly recollecting a related picture from the misinformation phase and misidentifying it as corresponding to the test label (i.e., a mislabeling error as opposed to a false recollection). To avoid this possibility, we chose items with distinct labels, and, moreover, participants were asked at test to recollect intact pictures from the original study phase, while ignoring the scrambled pictures that they saw during the misinformation phase. Thus, even if participants correctly recollected parts of the scrambled misinformation picture, this alone would not lead them to think that this scrambled picture corresponded to an intact target picture. Additional reconstructive processes would be required to create the false recollection of an intact picture.

Subjects. A group of 32 individuals (13 males) aged 19 to 31 years old (M = 22.88, SD = 4.01) were recruited from the same population as in Experiment 1, using the same procedures.

Stimuli. All stimuli were the same as those in Experiment 1 except that in addition to the semantically related words presented during the misinformation phase, misinformation could also be presented in the form of perceptually similar scrambled pictures. Pictures were scrambled by separating them into quadrants and replacing each quadrant with its neighbor in a counter clockwise fashion. This was done so that the scrambled pictures were still perceptible but could not be misidentified for an intact picture (see Figure 3 for examples).

Procedure. Only the misinformation phase differed from Experiment 1 (see Figure 4). During the misinformation phase, three perceptually related scrambled pictures were presented for half of the targets and half of the lures. For the other half of the targets and lures, semantically related unscrambled and scrambled labels were presented. As explained above, related words were presented as a baseline to counteract the conceptual fluency that might have resulted from presenting scrambled pictures. In order to match (or overshoot) conceptual fluency in the baseline condition, each scrambled picture was only presented once, whereas each unscrambled label was presented three times, as familiarity has been shown to be greater for words presented three times compared with a picture presented once (Gallo, Weiss, & Schacter, 2004). In order to match the total time spent between encoding and cued recollection relative to Experiment 1, scrambled labels were only presented twice. The task was for participants to indicate if they could identify the picture or word in each trial. The duration of each stimulus and ITI were the same as in Experiment 1.

Results and Discussion

Results from the recollection test are presented in Figure 5. Processing perceptually related scrambled pictures evoked significantly more false recollections of pictures (M = .19) than the processing of conceptually related words (M = .11), $t(31)$ = 2.871, p = .007, d = .333, SEM = 0.027, even though related items in our conceptual processing baseline occurred with greater frequency during the misinformation task (i.e., 5 times greater, including scrambled words that were still perceptible). Similar to Experiment 1, this effect was not observed for targets (Ms = .73 and .77 for perceptual and conceptual conditions, respectively), $t(31)$ = .886, p = .382. Average confidence was 2.80 for targets

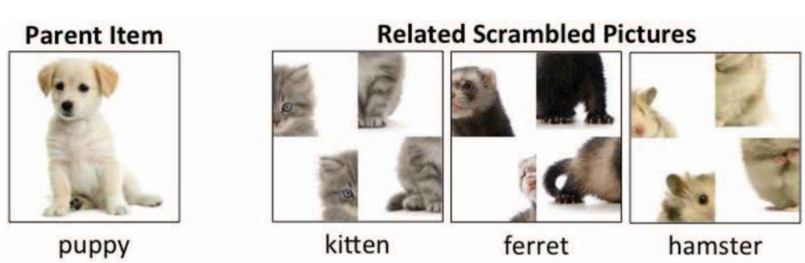

Figure 3. Examples of related scrambled pictures and their parent item. See the online article for the color version of this figure.

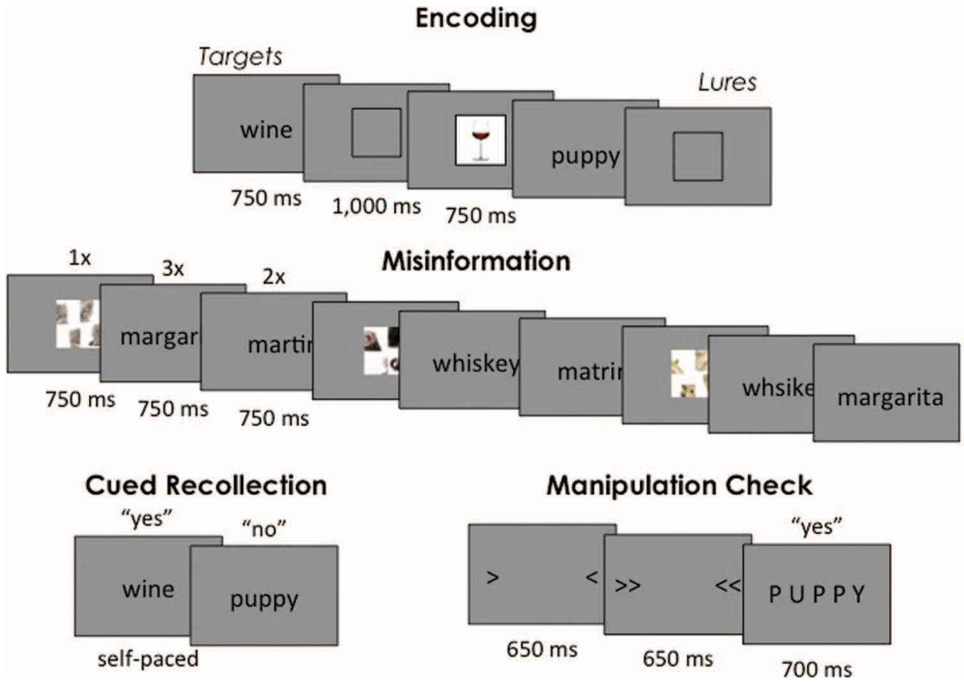

Figure 4. Paradigm for Experiments 2 and 4. Encoding, cued recollection, and the manipulation check were identical to Experiments 1 and 3. Misinformation consisted of perceptually similar scrambled pictures for half the targets and lures and the conceptual misinformation manipulation from Experiments 1 and 3 for the other half of targets and lures. Note, in Experiments 2 and 4, scrambled words presented one less time (twice as opposed to thrice, as in Experiments 1 and 3) so that the same amount of time passed between the encoding and cued recollection phases. See the online article for the color version of this figure.

and 2.00 for false alarms, again indicating medium confidence errors. False alarms were again quite low when only high and medium confidence responses were included. Nevertheless, there was a near significant difference between false alarms for lures with perceptual misinformation (M = .14) compared with those with conceptual misinformation (M = .08), $t(31) = 1.85$, $p = .074$,

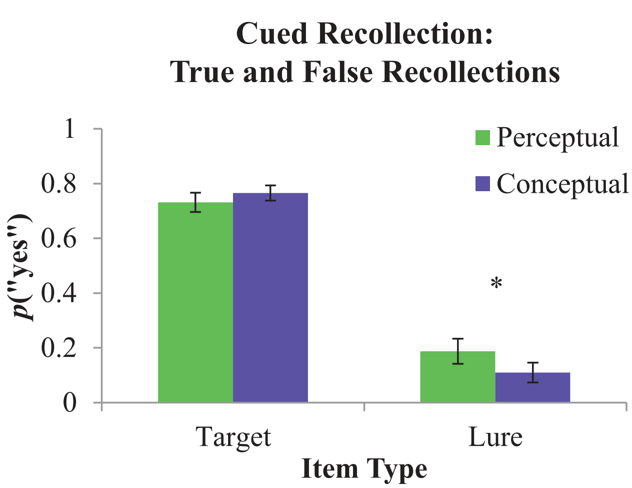

Figure 5. Picture recollection hit and false alarm rates after the perceptual recombination manipulation in Experiment 2. * $p < .05$. See the online article for the color version of this figure.

$d = .279$, $SEM = .030$. These data provide strong evidence that related percepts stored in memory can be recombined to produce the false recollection of a nonstudied picture.

On the speeded recognition test, participants again were capable of meeting the response deadline (mean latency across all items = 578.10 ms). Speeded recognition data confirmed that our conceptual baseline made the recollection test lures at least as familiar as those in the perceptual recombination condition, as hits did not differ between these conditions (Ms = .79 and .80, for lures from the perceptual and conceptual conditions, respectively), $t(31) = .3123$, $p = .757$. With respect to targets from the recollection test, the recognition of targets from the conceptual processing condition (M = .87) was greater than those from the perceptual processing condition (M = .81), $t(31) = 2.204$, $p = .035$, $d = .457$, $SEM = .031$. This effect suggests that we "overshot" fluency in the conceptual condition by presenting each related word multiple times in addition to presentation of the actual target picture shortly before the speeded recognition test, further indicating that the effects of perceptual features on false recollection were likely because of perceptual recombination and not a fluency or familiarity mechanism.

Experiment 3: Delayed Conceptual Fluency

Method

The goal of this experiment was to introduce a study to test delay, in order to increase false alarms relative to the low levels observed in Experiment 1, as well as to test the timing of the conceptual fluency mechanism. This experiment was similar to Experiment 1, except we introduced a 24-hr delay either before or after the misinformation phase. We hypothesized that conceptual fluency should decay over time so that the misinformation effect would be strongest when misinformation was presented postdelay or just before the recollection test. This prediction was motivated by the decline in decontextualized feelings of familiarity that have been observed over time (cf. Yonelinas, 2002), as well as the decrease in conceptual relatedness effects on false alarms that are observed over a retention interval in the DRM task (cf. Gallo, 2006). In contrast, presenting conceptually related information just prior to the test should maximize conceptual activation, analogous to test-based manipulations of fluency in other tasks (e.g., Jacoby & Whitehouse, 1989; Rajaram & Geraci, 2000; Whittlesea, 1993), yielding a more robust effect.

Subjects. A group of 60 individuals (22 males) was recruited on Day 1, using the same population and procedures as Experiment 1, but four failed to complete the second part of the experiment on Day 2, leaving 56 individuals (21 males) aged 18 to 31 years old ($M = 22.25$, $SD = 3.38$).

Procedure. The experiment was identical to Experiment 1 except a 24-hr delay was introduced either before or after misinformation (see Figure 6). One group (28 participants) completed the misinformation phase on Day 1 immediately after encoding, and another group (28 participants) completed the misinformation phase on Day 2 immediately before the cued recollection phase. Therefore, encoding was always completed on Day 1, and cued recollection was always completed on Day 2, but the timing of the misinformation phase was varied in a between-groups fashion. The second day of experiment always began at the same time as the first day.

Results and Discussion

The cued recollection data for lures (see Figure 7) was submitted to a 2 (misinformation day: Day 1, Day 2) × 2 (misinformation condition: conceptual, no misinformation) mixed model ANOVA with misinformation day as a between-subjects factor and misinformation condition as a within-subjects factor. There was a main effect of misinformation condition, $F(1, 54) = 4.009$, $p = .050$, $\eta^2_G = .005$, and a significant interaction between misinformation day and misinformation condition, $F(1, 54) = 7.127$, $p = .010$, $\eta^2_G = .009$. This interaction was driven by a significant difference between false alarm rates with conceptually related items ($M = .25$) and those without on Day 2 ($M = .18$), $t(27) = 3.292$, $p = .003$, $d = .317$, $SEM = .023$, with no effect on Day 1 (Ms = .20 and .21 for conceptual and no-misinformation conditions, respectively), $t(27) = .474$, $p = .640$. Average confidence for all targets was 2.74, and for all lures was 2.03, suggesting that false alarms were made with medium confidence. When only high and medium confidence false alarms were included, there remained a significant difference between lures with conceptual misinformation ($M = .21$) on Day 2 compared with those without ($M = .15$), $t(27) = 2.92$, $p = .007$, $d = .264$, $SEM = .021$. These findings replicate the conceptual fluency effect on false picture recollection observed in Experiment 1, demonstrating an effect when conceptual fluency was manipulated just prior to test, and they also show that this effect does not persist after a 24-hr delay between the conceptual misinformation and the recollection test.

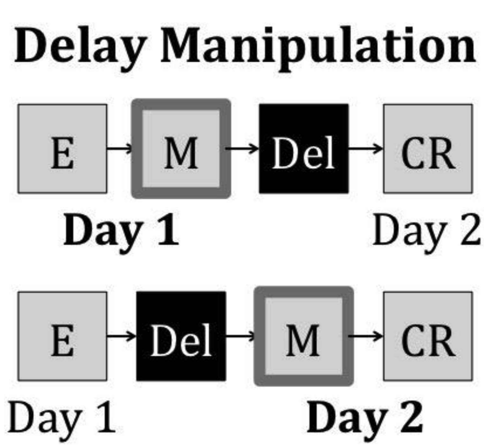

Figure 6. Delay manipulation for Experiments 3 and 4. Encoding always took place on Day 1, and cued recollection and the manipulation check always took place 24 hr later on Day 2. Misinformation could take place on Day 1 immediately after encoding, or on Day 2 just prior to cued recollection. E = encoding; M = misinformation; Del = delay; R = cued recollection.

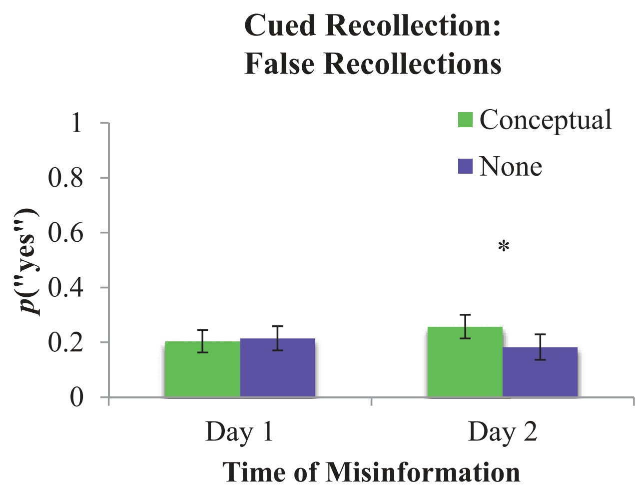

Figure 7. Picture recollection false alarm rates after the conceptual fluency and delay manipulation in Experiment 3. * $p < .05$. See the online article for the color version of this figure.

In contrast to the lures, neither main effects nor the interaction were significant for the target data (Day 1, Ms = .74 and .71 for conceptual and baseline conditions, respectively; Day 2, Ms = .77 and .76, for conceptual and baseline conditions; all Fs < 1, ps > 0.100). Therefore, no other analyses were carried out on these data. Similar to Experiment 1, the conceptual fluency manipulation affected the lures more than the targets.

On the speeded recognition test, participants again were able to meet the response deadline (mean latency across all items = 559.36 ms). The recognition data for lures was submitted to a 2 (misinformation day: Day 1, Day 2) × 2 (misinformation condition: conceptual, no misinformation) mixed model ANOVA with misinformation day as a between-subjects factor and misinformation condition as a within-subjects factor. There was a significant main effect of day, $F(1, 54) = 4.690$, $p = .035$, $\eta_G^2 = .061$, a nearly significant main effect of misinformation condition, $F(1, 54) = 3.659$, $p = .061$, $\eta_G^2 = .017$, and a significant interaction between misinformation day and misinformation condition, $F(1, 54) = 4.931$, $p = .031$, $\eta_G^2 = .022$. A priori contrasts yielded no significant difference between misinformation conditions on Day 1 (*M*s = .81 and .81 for conceptual and baseline conditions, respectively), $t(27) < 1$, but a significant difference between misinformation conditions on Day 2, $t(27) = 2.946$, $p = .007$, $d = 0.495$, $SEM = 0.035$, such that speeded recognition hits were greater for lures with conceptual misinformation ($M = 0.773$) compared with those without ($M = 0.671$). These data confirm that our conceptual fluency manipulation increased familiarity for lures when manipulated just prior to the test, but this effect did not persist after the 24-hr delay. Neither main effects nor the interaction were significant for the target data (Day 1, *M*s = .79 and .78 for conceptual and baseline conditions, respectively; Day 2, *M*s = .82 and .78 for conceptual and baseline conditions; all *F*s < 1.250, *p*s > 0.100).

Experiment 4: Delayed Perceptual Recombination

Method

Experiment 3 revealed that the effect of conceptual fluency on false picture recollection was replicated when manipulated just prior to test, but did not persist after a 24-hr delay. The purpose of Experiment 4 was to test the same temporal dynamics of perceptual recombination. Similar to conceptual fluency, it is possible that memory for the perceptual features would fade over the delay, which would push for a stronger recombination effect with misinformation presented just prior to test. However, unlike conceptual fluency, we hypothesized that the effects of perceptual recombination might be more contextually specific, which would push confusions between features of intact and scrambled pictures to be greater when the picture fragments were presented prior to the delay (i.e., the same context as the targeted picture information). This prediction assumes that presenting the target and misleading information in the same study session will increase contextual similarities (cf. Goff & Roediger, 1998), and also will reduce differences in the expected memorability of these two kinds of information (cf. Bink, Marsh, & Hicks, 1999; Hashtroudi, Johnson, & Chrosniak, 1990). As a result of these potentially opposing factors, we expected that the perceptual recombination mechanism might be differently affected by time than conceptual fluency, although we did not predict beforehand which factor would more strongly contribute.

Subjects. A group of 60 individuals (19 males) with the same population and procedure as Experiment 1 was recruited on Day 1, but two failed to complete the second part of the experiment on Day 2, and two others were excluded because of below-chance memory performance and failure to understand instructions, leaving 56 individuals (19 males) aged 18 to 31 years old ($M = 21.71$, $SD = 2.90$). Because of a computer failure, data from the familiarity manipulation check could not be obtained from two participants.

Procedure. The experiment was identical to Experiment 2, except a 24-hr delay was introduced either before (28 participants) or after (28 participants) the misinformation phase in a between-groups fashion similar to Experiment 3.

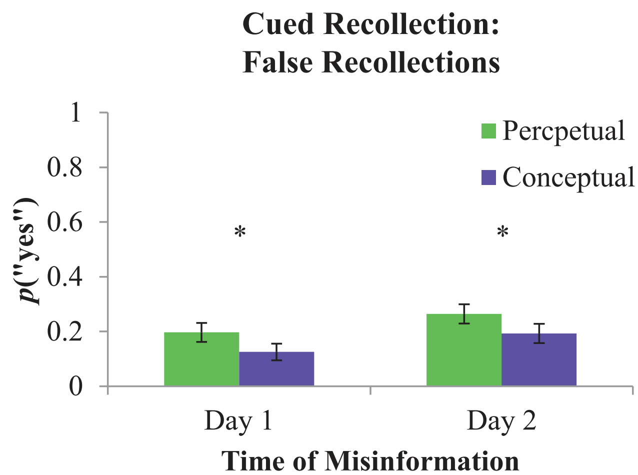

Figure 8. Picture recollection false alarm rates after the perceptual recombination manipulation in Experiment 4. * $p < .05$. See the online article for the color version of this figure.

Analysis. Because of a failure to collect two participants' manipulation check data in the Day 1 group, Type III sum of squares was used for unbalanced groups.

Results and Discussion

The cued recollection data are presented in Figure 8. For lures, we conducted a 2 (misinformation day: Day 1, Day 2) × 2 (misinformation condition: perceptual, conceptual) mixed model ANOVA with misinformation day as the between-subjects factor and misinformation condition as the within-subjects factor. There was a significant main effect of misinformation condition, $F(1, 54) = 18.950$, $p < .001$, $\eta_G^2 = .040$, with no effect of delay and no interaction (all *F*s <1, *p*s > .100). Contrasts between the perceptual and conceptual conditions on Day 1 (*M*s = .20 and .13, respectively), $t(27) = 3.041$, $p = .005$, $d = .415$, $SEM = .023$, and Day 2 (*M*s = .26 and .19, respectively), $t(27) = 3.116$, $p = .004$, $d = .387$, $SEM = .023$, resulted in significant differences, such that greater false recollections were found in the perceptual condition. Again, hits were made with medium to high confidence (average confidence = 2.73) and false alarms were made with medium confidence (average confidence = 2.06). When only high and medium confidence false alarms were compared between perceptual and conceptual conditions, significant effects were still observed for the Day 1 group (*M*s = .16 and .09 for perceptual and conceptual conditions, respectively), $t(27) = 3.12$, $p = .004$, $d = .475$, $SEM = .023$, and the Day 2 group (*M*s = .20 and .15 for perceptual and conceptual conditions, respectively), $t(27) = 2.20$, $p = .036$, $d = .263$, $SEM = .023$. Therefore, in contrast to our results from the conceptual fluency experiment, we found a robust perceptual recombination effect on both sides of the 24-hr delay. Neither main effects nor the interaction were significant for the target data (all *F*s < 1, *p*s > 0.100).

On the speeded recognition test, participants again were well within the response deadline window (mean latency across all items = 559.33 ms). Recognition data for lures and targets were separately submitted to a 2 (misinformation day: Day 1, Day 2) ×

2 (misinformation condition: perceptual, conceptual) mixed model ANOVA with misinformation day as the between-subjects factor and misinformation condition as the within-subjects factor. Neither the main effects nor the interaction for either model were significant (Day 1, *M*s = .86 and .85 for perceptual and conceptual conditions, respectively; Day 2, *M*s = .87 and .85, for perceptual and conceptual conditions; all $F\text{s} < 1.000$, $p\text{s} > 0.100$), confirming that this experiment was successful in matching familiarity across the perceptual and conceptual conditions.

General Discussion

This study is the first to show that conceptual fluency and perceptual recombination can independently contribute to the constructive aspects of recollection. Our results are consistent with prior studies pointing toward conceptual fluency (Henkel & Franklin, 1998; Zaragoza et al., 2011) and perceptual recombination mechanisms (Dodson et al., 2007a, 2007b; Lampinen et al., 1999; Lyle & Johnson, 2006) of false recollection. We also showed that these mechanisms contributed to false recollection in the same picture recollection task, and although we found a more robust effect of perceptual recombination than conceptual fluency in our single-session experiments, the overall effect sizes associated with the two mechanisms were relatively similar across our experiments. These patterns suggest that both mechanisms can play a significant role in the creation of detailed false recollections.

In addition to isolating each of these two hypothetical mechanisms, a novel finding of this study was the differential temporal characteristics of conceptual fluency and perceptual recombination on false recollections. This dissociation bolsters the conclusion that these represent two different mechanisms of constructive recollection, and it also sheds light on the nature of each mechanism. With respect to conceptual fluency, the effects appear to decline after a delay analogous to the effects of time on false alarms to related lures in the DRM task (for review, see Gallo, 2006). Unlike the DRM task, however, there were no observable effects of our conceptual fluency manipulation on false recollections when it was delivered prior to the delay. One reason could be that our task aimed to create false recollections of perceptually detailed object pictures, which, in general, are harder to create than false memories of previously studied words as in the DRM task (cf. Israel & Schacter, 1997). Another factor could be that fluency is manipulated to a greater degree in the DRM task by presenting more related words than in the current paradigm.

In contrast to conceptual fluency, our manipulation of perceptual recombination was resilient to the delay period. In fact, there did not appear to be a numerical decline from our perceptual misinformation condition after a 24-hr delay. This alludes to two potential factors at play. When perceptual misinformation is delivered just prior to retrieval, the recent perceptual activation may drive false memory formation because of the availability of these percepts in memory. This availability would facilitate the ease of conjuring up a (falsely) recollected picture when prompted to do so. However, when perceptual misinformation is delivered just after encoding, these two phases now share a temporal context and may be more confusable for this reason. Furthermore, offline postencoding processes (e.g., consolidation) may, in this case, result in the strengthening of nonveridical memories rather than veridical ones (cf. Darsaud et al., 2011). Future work will be needed to determine the extent that these different factors might contribute.

Implications for Dual-Process Theories

There are obvious parallels between the mechanisms highlighted here and recollection and familiarity in dual-process models. Traditionally, false alarms on recognition memory tests are thought to arise from familiarity or familiarity-related processes, and recollection is thought to suppress false alarms (via monitoring processes such as recall-to-reject or a distinctiveness heuristic). However, in addition to these well-established effects, our current results indicate that partial recollections of veridical information may sometimes support false recollections via perceptual recombination. In addition, we found that conceptual fluency can contribute to false recollections when an object is mentally imaged. Importantly, we used the term *conceptual fluency* throughout this article to differentiate it from the idea of familiarity in dual-process models, but it should be pointed out that the two concepts are often considered closely related. Indeed, we used a speeded recognition memory test, typically thought to tap into a familiarity-based process, as a way to indirectly measure the effects of our experimental manipulations on conceptual fluency. It is possible that our manipulation of conceptual fluency had affected false recollection via a familiarity-based mechanism, in which case the idea that familiarity and recollection are independent would need to be revisited.

In a related vein, one might ask whether a global matching kind of process could explain our perceptual misinformation results without appealing to a feature recombination process. According to the global matching idea, increasing the number of perceptually related pictures in memory could increase the likelihood that other items from the category would be attributed to a picture, either because of a general feeling of familiarity for any image from the category (real or imagined), or because of a category-specific inference that pictures were likely studied. We see this interpretation as unlikely, because our task design and instructions made it very clear to participants that they should only respond "yes" on the picture recollection test when they believed that they could recollect an intact picture of the object from the original study phase, and that the presentation of related scrambled pictures was independent from a test item's status as a target or lure. Moreover, many of the false alarms were made with medium or high confidence in our task, whereas errors based familiarity or inferences alone should be made with lower confidence. Although we cannot definitively rule out these other processes, it seems more likely to us that our perceptual recombination manipulation increased false recollection judgments above the fluency baseline by fueling a feature recombination process.

Implications for False Memory Theories

An important aspect of our methodology that differentiates it from prior false memory research is that the external percepts driving false recollections were only presented in a fragmented fashion, and none of the studied pictures were similar to or resembled the items that were subsequently falsely recollected. In prior work (e.g., Lampinen et al., 2005; Lyle & Johnson, 2006), participants could have used exact replicas of the misleading information to corroborate their false memories. That is, the content or features that the false memories took on could be roughly the same as those that had been encountered during the study phase, but misattributed to the wrong event or context. In the current paradigm, the pictures that drove false recollections were scrambled, whereas the pictures to be recollected were intact. Furthermore, many times, both color and form were quite different between the perceptual misinformation and the falsely recollected object (e.g., hairbrush, razor, and cotton swab for the false recollection of toothbrush). Thus, in addition to showing that conceptual information can drive false recollection of a perceptually detailed picture, the current task also provided strong evidence that specific perceptual features can be detached from studied events and recombined into a false recollection.

In the current experiments we disentangled conceptual and perceptual mechanisms of constructive recollection using a picture memory task, raising the question as to how these effects might generalize to other kinds of memory distortion. As described in the introduction, relatively few studies have attempted to disentangle perceptual and conceptual mechanisms for false memories for witnessed events (e.g., misinformation tasks; Zaragoza et al., 2011) or autobiographical events (Garry & Wade, 2005). In fact, although we have disentangled these mechanisms here, they are by no means mutually exclusive, and it is possible that both mechanisms likely played a role in other contexts, in which the to-be-remembered events are likely to include a combination of perceptual and conceptual elements. Given that both conceptual and perceptual mechanisms can contribute to the creation of detailed false recollections, future research into the nature of episodic memory should take both factors into account.

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