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When Misinformation Improves Memory: The Effects of Recollecting Change

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Abstract
In two experiments, we explored the effects of noticing and remembering change in the misinformation paradigm. People watched slide shows, read narratives containing misinformation about the events depicted in the slide shows, and took a recognition test on which they reported whether any details had changed between the slides and the narratives. As expected, we found a strong misinformation effect overall. In some cases, however, misinformation led to improved recognition, which is opposite the usual finding. Critically, misinformation led to improved recognition of the original event when subjects detected and remembered a change between the original event and the postevent information. Our research agrees with other findings from retroactive-interference paradigms and can be interpreted within the recursive-remindings framework, according to which detecting and remembering change can enhance retention. We conclude that the misinformation effect occurs mostly for witnessed details that are not particularly memorable. In the case of more memorable details, providing misinformation can actually facilitate later recollection of the original events.

Keywords
misinformation, false memory, change detection, change recollection, remindings, open data, open materials

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In the misinformation paradigm (e.g., Loftus, 1975; Loftus, Miller, & Burns, 1978), people witness a crime or accident and are later reexposed to some information from the event. In this *postevent information*, certain details are changed: A stop sign might become a yield sign, or a screwdriver might become a hammer. Later, when asked about the original event, people exposed to such misinformation often remember the changed details as having been part of the original event—in other words, people remember certain details of the original event inaccurately.

The misinformation effect is robust. In numerous experiments, researchers have implanted false memories of broken glass, tools, and more (for a review, see Loftus, 2005). Most textbook accounts imply that the misinformation effect is nearly ubiquitous, occurring in all people nearly all the time and for all events for which misinformation is provided. Some past results and the findings we report here, however, show that this is not so.

Tousignant, Hall, and Loftus (1986), for example, showed that subjects who read postevent information more slowly were less likely to endorse a misinformation lure on a recognition test. They argued that the slower reading times meant subjects were noticing inconsistencies between the original event and the narrative, and that detecting such changes reduced the misinformation effect. Tousignant et al. did not measure change detection directly, but reading times and postexperiment interviews of the subjects corroborated the *discrepancy-detection principle*, which predicts that noticing discrepancies substantially reduces misinformation effects.

In a striking experiment, Loftus (1979) showed just how important noticing change can be for preventing misinformation effects. Subjects viewed a wallet-snatching incident and then read a narrative that included several pieces of misinformation. Critically, the fifth piece of misinformation was a blatant change that every subject was

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expected to notice; indeed 21 of the 23 subjects who viewed the blatant change rejected that misinformation on the final test. Furthermore, those subjects subsequently rejected other smaller pieces of misinformation: Noticing the blatant change improved recognition overall.

These results by Tousignant et al. (1986) and Loftus (1979) suggest that the misinformation effect arises when change is not detected during the postevent narrative. Many misinformation experiments have used the same standard materials (e.g., Loftus, 1991; McCloskey & Zaragoza, 1985), in which the changes are subtle—for example, the brand name on a coffee can changes from Folgers to Maxwell House. Perhaps misinformation effects occur only when people have poor memory for the original event or the change is about an unimportant detail (McCloskey & Zaragoza, 1985). However, the change cannot be too subtle, or it would be difficult to know whether subjects were recalling the original event or the misinformation. Takarangi, Parker, and Garry (2006) wrote about the challenge of creating effective misinformation materials:

> Our final version is the result of several iterations. . . . We analyzed subjects' responses in each iteration, and adjusted the movie in line with our overall aim: to maximize the effect produced by each critical item. Accordingly, we increased or decreased the time various items appeared on screen, removed items that did not show a misinformation effect, etc. (pp. 585–586)

The challenge in creating effective misinformation materials may explain why the literature is based on only a few sets of materials. However, this custom may have resulted in a misrepresentation of the ubiquity of the misinformation effect. How general is it? Are there items in most of these sets that do not produce the effect? What happens to memory for the original detail when one notices a change while reading the narrative and recalls doing so during the test?

In the current project, we had two aims. The first was to provide an explanation for why detecting change matters and to test whether remembering a change at the final test (change recollection) can improve memory for the original event. Recent work in the recursive-remindings framework (Benjamin & Ross, 2010; Hintzman, 2011) suggests that noticing and later remembering change can reduce interference and sometimes enhance memory (Jacoby, Wahlheim, & Kelley, 2015; Putnam, Wahlheim, & Jacoby, 2014; Wahlheim & Jacoby, 2013). This framework (discussed in more detail in the General Discussion) provides an explanation for why detecting and recollecting change can reduce or even reverse the misinformation effect.

The second aim was to examine whether some details would be more susceptible to misinformation effects than others. As noted earlier, the misinformation effect does not occur when the change is obvious. Thus, we predicted that easy-to-remember details would show smaller misinformation effects than hard-to-remember details and that misinformation about easy-to-remember details might even enhance memory for the original information.

We used a standard misinformation design and directly measured change detection and change recollection. Subjects watched slide shows, read narrative texts describing the slide shows (sometimes reporting when they noticed a discrepancy), and then completed a recognition test for the original events. Critically, after each recognition decision, subjects indicated if there was a discrepancy between the slide show and the narrative, either by making a source-memory judgment (Experiment 1) or by directly reporting change (Experiment 2). Although other misinformation studies have used source-memory tasks (e.g., Lindsay, 1990; Lindsay & Johnson, 1989; Zhu, Chen, Loftus, Lin, & Dong, 2010), those tasks typically either replaced the recognition test or came after the recognition test. Including the source judgment in the recognition-test phase and providing a response option for reporting remembering change meant that the source-memory task could be used to measure change recollection (Putnam et al., 2014).

We made three predictions. First, we expected that recognition memory performance would be lower when misinformation was presented than when no misinformation was presented (a misinformation effect). Second, we predicted that detecting and recollecting change would lead to more accurate recognition for the original detail. Finally, we predicted that more memorable details (as measured by the proportion of correct recognition in the neutral condition) would show smaller misinformation effects and that memorable details might even show memory facilitation. A pilot experiment (reported in the Supplemental Material available online) provided preliminary support for our predictions.

Experiment 1

Experiment 1 included a change-detection task and a source-memory task that measured change recollection. While reading the narrative, subjects in the *change-detection* group pushed a button when they noticed the narrative conflicting with the photos from the slide show, whereas subjects in the control group did not. We expected that the subjects in the change-detection group would show enhanced recognition performance both because warning people about misinformation during study can reduce false memories (Butler, Zaromb, Lyle, &

Roediger, 2009; Greene, Flynn, & Loftus, 1982; Tousignant et al., 1986) and because asking people to think back to previous events encourages them to notice changes, which in turn can lead to superior memory performance (Jacoby, Wahlheim, & Yonelinas, 2013; Putnam et al., 2014). More important, we expected that subjects' recognition accuracy for an original detail would be higher when they remembered a discrepancy between the slide show and the narrative than when they did not initially detect and then remember the discrepancy.

Method

Subjects. Seventy-two undergraduates from Washington University participated in groups of 1 to 6 people in exchange for $10 or course credit. Twelve subjects were replaced with 12 new subjects after a computer programming error was discovered. Before beginning data collection, we decided on a sample size that would match the sample size in similar work conducted in our lab (Roediger & Geraci, 2007). Washington University's institutional review board approved the study.

Materials and counterbalancing. The materials consisted of six sets of misinformation stimuli (adapted from Okado & Stark, 2005) and a source-memory test (adapted from Zhu et al., 2010), all presented via computer.

Slide shows. Each slide show consisted of 50 photographs portraying an event. There were two versions of each slide show that were identical except for 12 slides in which one critical detail was changed. For example, in one event, a man breaking into a car finds $1 bills, and in the alternative version, he finds $20 bills. Half of the subjects saw one version, whereas the other half saw the alternative version.

Narrative. Each narrative described the event in the corresponding slide show in 50 sentences; each sentence corresponded to one photo. The sentences that referred to the critical items did so in a manner that was consistent (*repetition items*), ambiguous (*neutral items*), or inconsistent (*misinformation items*) with the original slide show. For example, if the car thief found $1 bills in the slide show, the narrative read, "He examined the bills, and saw they were all $1.00 bills" (repetition), "He examined the bills, and saw they were all U.S. currency" (neutral), or "He examined the bills, and saw they were all $20.00 bills" (misinformation). There were four repetition items, four neutral items, and four misinformation items in each narrative. The conditions to which items were assigned were counterbalanced across subjects, so that each item appeared in the three conditions equally often.

Recognition test. There was an 18-question multiple-choice test for each slide show, with 12 critical questions and 6 filler questions. Subjects were asked to respond on the basis of what they remembered from the original slide shows. Each question had three response options: the correct answer from the original event; the misinformation lure; and a new lure, the *foil*. For example, the responses for the question "What type of bills did the young man find in the change compartment?" were "$1.00," "$5.00," and "$20.00." In our example, the "$1.00" response would be the correct option, the "$20.00" response would be the misinformation lure, and the "$5.00" response would be the foil.

Source-memory test. Immediately after each recognition decision, subjects were asked, "Where did you remember seeing your response to this question?" The response options were "Saw in pictures only," "Saw in text only," "Saw in both (they were the same)," "Saw in both (they were different)," and "Neither (I'm guessing)." Subjects responded by clicking on their selection or by pressing a corresponding letter key on the keyboard.

Design. The experiment had a 3 (item type: repetition, neutral, misinformation) × 2 (instructions: detection, control) mixed-model design. Item type was manipulated within subjects, whereas instructions were manipulated between subjects.

Procedure. Subjects were told that they would watch slide shows and that they should remember the events for an upcoming memory test. The computer presented the pictures for 3 s each, with a 250-ms interstimulus interval. After seeing all 50 pictures from an event, subjects saw a message saying that the slide show had ended and pressed the space bar to start the next one (the six slide shows were presented in a random order). After watching all six sequences, subjects worked on a distractor task for 5 min.

During the narrative phase, subjects were told that they would read descriptions of the events they had just observed and should try to remember what had happened in the narratives. The narratives appeared onscreen one sentence at a time. Subjects in the control group pressed the space bar to advance to the next screen. Subjects in the change-detection group were instructed that there might be differences between the slide shows and the narratives, and that in addition to remembering the narratives, they should note when the narratives were inconsistent with the photos. They were told to press the "z" key when they noticed that the presented sentence was inconsistent with what had occurred in the photos and to press the "m" key when they did not notice anything inconsistent. Pressing either key advanced the screen to the next sentence. Subjects in both groups were not able to respond for the first 500 ms, to ensure that they did not click through the screens haphazardly, but reading and responding were otherwise self-paced. After a response, there was a 250-ms interstimulus interval, and then the next sentence appeared. After reading all six narratives, subjects worked on a distractor task for 5 min.

At the start of the test phase, subjects read instructions explaining that the test had recognition questions and source-memory questions. They were told to answer the recognition questions on the basis of what they remembered from the slide shows rather than what they read in the narratives. They then read instructions for the source-memory task:

> After responding to each memory question you will be asked whether anything changed between the pictures and the text. Report whether you remember the response to each question as occurring in just the slides, just the text, both the pictures and the text (same thing in both places), both the pictures and the text (with some inconsistencies) or neither the pictures or the text (guessing).

Memory for the events was tested in the same order in which they were studied. Before each set of questions was presented, subjects were told which event the questions would be about and were reminded to answer according to what they remembered from the photos. The questions appeared in random order. The three response options (correct answer, misinformation lure, foil) were labeled with "A," "B," and "C," and presented below the questions (the options were randomly assigned to letters). Immediately after answering a recognition question, subjects answered the source-memory question for that detail and then moved on to the next recognition question. The test had no time limit.

Results

Because of a programming error, the results for one item were removed from all analyses (including this item did not change the results). We collapsed the data across the change-detection and control groups in all analyses reported here because the results in these two conditions were similar (see the Supplemental Material for details).

Recognition test. On the recognition test, subjects could select the detail from the original event (a *hit*), the detail from the narrative (a *false alarm*), or the foil (technically, selecting a foil would also be considered a false alarm, but for simplicity we use the term *false alarm* to refer only to selecting the detail from the narrative on the final test). Figure 1 displays the hit and false alarm rates as a function of item type and shows a standard misinformation effect.[1] Recall that the manipulation of item type occurred during the narrative (the repetition items repeated the photo details, the neutral items were ambiguous about the photo details, and the misinformation items contradicted the photo details).

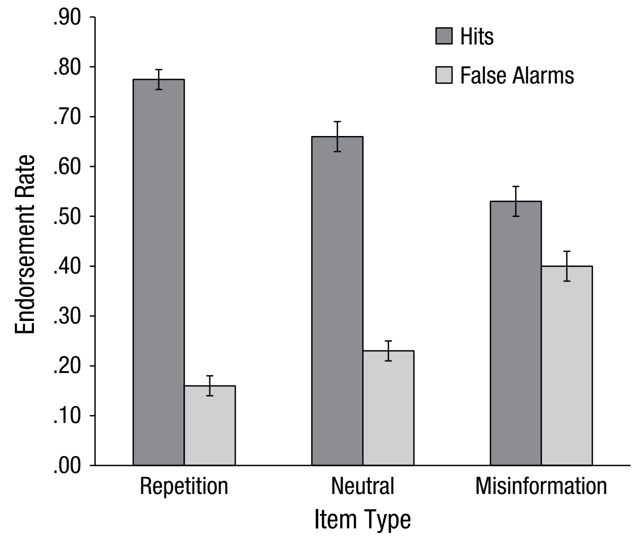

Fig. 1. Hit and false alarm rates on the final recognition test in Experiment 1 as a function of item type. Error bars represent 95% confidence intervals. See Table S2 in the Supplemental Material for results split by group.

Item type affected the hit rate, $F(2, 142) = 95.99$, $p < .001$, $\omega^2 = .38$. Follow-up t tests showed that the hit rate was highest for the repetition items and lowest for the misinformation items, with the neutral items in between, all $t(71)\text{s} \geq 6.75$, $p\text{s} < .001$, $d\text{s} \geq 1.00$. Item type also influenced the false alarm rate, $F(2, 142) = 98.16$, $p < .001$, $\omega^2 = .45$, which was highest for the misinformation items and lowest for the repetition items, with the neutral items in between, all $t(71)\text{s} \geq 4.49$, $p\text{s} < .001$, $d\text{s} \geq 0.74$. Thus, presenting misinformation lowered recognition memory performance.

One concern with the recognition results is that including the "text" response option on the source-memory test could have artificially inflated the false alarm rate if subjects chose the misinformation lures knowing they could select "text" on the source test, even though they were instructed to respond on the basis of what they remembered from the photos. Figure S3 in the Supplemental Material displays recognition performance after removal of the items for which the "text" response was chosen, and the pattern is identical to that in Figure 1. Thus, a misinformation effect was evident even after we removed the trials on which subjects might not have precisely followed instructions.

Memory performance conditionalized on change detection. During the narrative phase, subjects in the change-detection group were much more likely to correctly report changes when asked about the misinformation items (M = .44, 95% confidence interval, or CI = [.39, .48]) than to erroneously report changes when asked about the repetition items (M = .17, 95% CI = [.13, .20]) or the neutral items (M = .12, 95% CI = [.10, .15]), both $t(35)$s > 10.98, ps < .001, ds > 2.21. Accurately detecting change led to enhanced performance on the misinformation items in the final recognition test. The top row of Table 1 shows the hit rates for the neutral items and for the misinformation items both when change was and was not detected. Critically, when change was not detected, the misinformation items had a lower hit rate than the neutral items, $t(35) = 7.28$, $p < .001$, $d = 1.69$, but when change was detected, the misinformation items and neutral items had similar hit rates, $t(35) = 0.91$, $p > .250$, $d = 0.21$. Thus, detecting change between the photos and the narratives eliminated the misinformation effect.

Memory performance conditionalized on source-memory judgment. The top panel of Figure 2 shows hit rate on the recognition test for the misinformation items as a function of response on the source-memory test. For comparison, the average hit rate for the neutral items is also shown. (The response rates for the various options on the source-memory test are in Table S1 in the Supplemental Material.) Source-memory response affected the hit rate for the misinformation items, $F(4, 176) = 42.03$, $p < .001$, $\omega^2 = .42$. The hit rates for the misinformation items were lower than the average hit rate for the neutral items when subjects remembered the misinformation items from the text, $t(59) = 16.71$, $p < .001$, $d = 3.32$; when they remembered the misinformation items from both the text and the pictures (they remembered the narrative as matching the pictures), $t(71) = 9.89$, $p < .001$, $d = 1.84$; and when they were guessing about the source of the misinformation items, $t(57) = 6.49$, $p < .001$, $d = 1.26$. In contrast, when subjects selected the "pictures only" response, the hit rate for the misinformation items was similar to that for the neutral items overall, $t(69) = 0.36$, $p > .250$, $d = 0.05$. Furthermore, when subjects indicated that the narrative contradicted the photos, the hit rate for the misinformation items was higher than that for the neutral items overall, $t(63) = 4.88$, $p < .001$, $d = 0.80$.

Similarly, the source-memory response affected the false alarm rate for the misinformation items, $F(4, 176) = 38.42$, $p < .001$, $\omega^2 = .41$. The bottom panel of Figure 2 shows that the pattern for the false alarm rate was consistent with that for the hit rate. The false alarm rate for the misinformation items was higher than the average false alarm rate for the neutral items when subjects remembered the misinformation items from the text, $t(59) = 16.02$, $p < .001$, $d = 3.05$; when subjects remembered the misinformation items from both the text and the pictures (they remembered the narrative as matching the pictures), $t(71) = 11.11$, $p < .001$, $d = 2.01$; and when they were guessing about the source of the misinformation items, $t(57) = 4.12$, $p < .001$, $d = 0.81$. But when subjects selected the "pictures only" response, the false alarm rate for the misinformation items was similar to the average false alarm rate for the neutral items, $t(69) = 1.21$, $p > .250$, $d = 0.17$. Finally, when subjects indicated that the narrative contradicted the photos, the false alarm rate for the misinformation items was lower than the average false alarm rate for the neutral items, $t(63) = 3.27$, $p = .002$, $d = 0.62$. Thus, detecting and recollecting the changes for misinformation items led to retroactive facilitation: When subjects remembered having noticed a change, correct recognition was greater for the misinformation items than for the neutral items.

Table 1. Recognition Performance in Experiments 1 and 2: Hit Rates for the Misinformation Items, When Change Was and Was Not Detected, and Overall Hit Rates for the Neutral Items

	Item type		
Experiment	Neutral	Misinformation, no change detected	Misinformation, change detected
Experiment 1	.66 [.62, .70]	.43 [.37, .48]	.69 [.63, .75]
Experiment 2	.62 [.58, .66]	.44 [.39, .48]	.71 [.63, .78]

Note: These data include only subjects in the change-detection groups. The numbers in brackets are 95% confidence intervals.

Discussion

Experiment 1 produced a misinformation effect, replicating hundreds of prior studies. Detecting and recollecting change, however, reduced that misinformation effect. When subjects remembered a response from only the slides, the effect was eliminated; when they remembered that an item had changed, the effect was reversed: Recognition for the original event was better than recognition for the neutral items. This outcome supported our hypothesis that detecting and recollecting change can enhance memory for a target and is consistent with previous work showing the benefits of noticing and remembering change (e.g., Jacoby et al., 2015).

The similarity in overall performance between subjects in the change-detection and control groups surprised us. We had thought that subjects in the detection group would show better source monitoring and, in turn, better recognition. Instead, the two groups performed equally well. One explanation for this finding is that our study

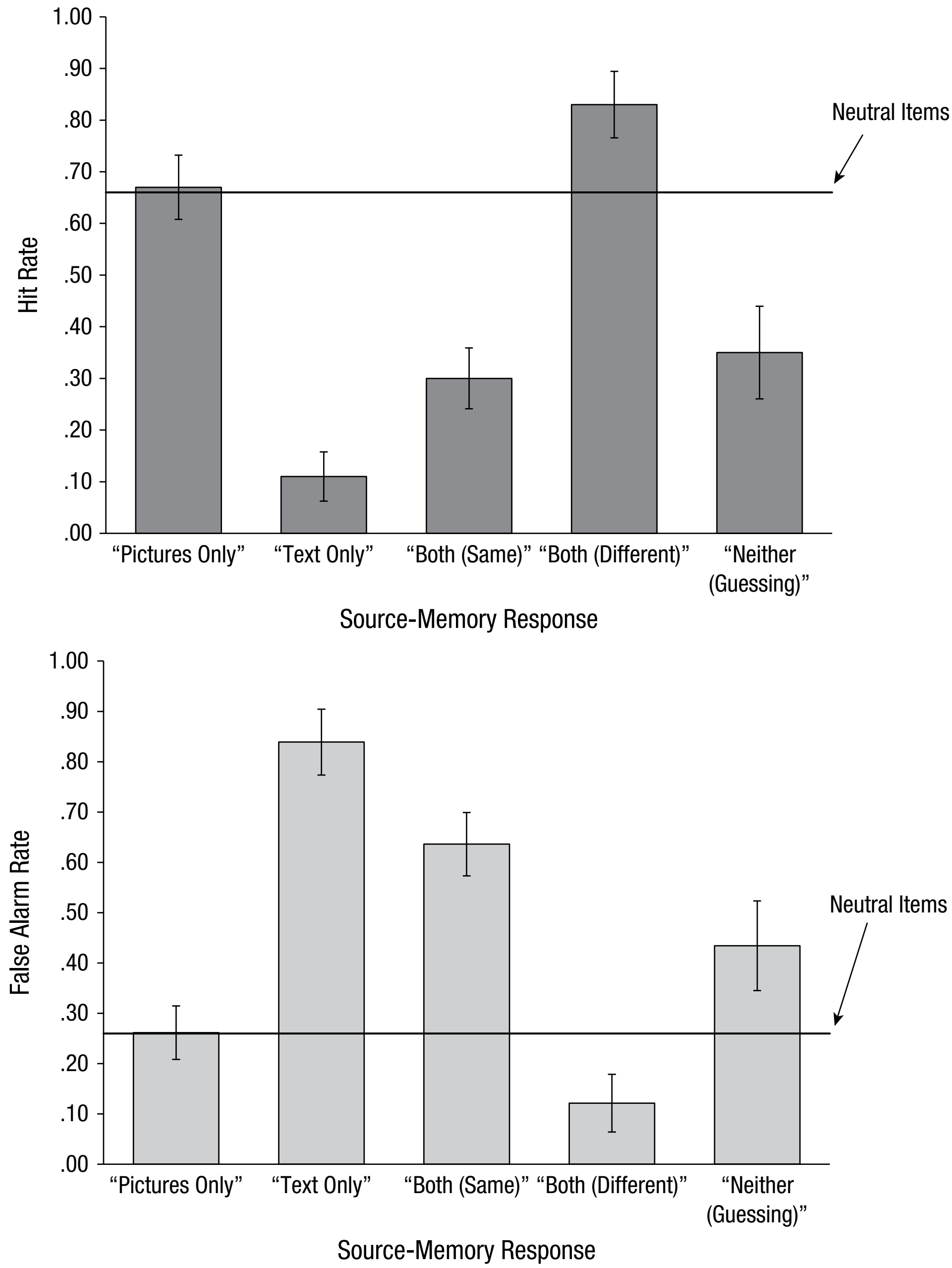

Fig. 2. Hit (top panel) and false alarm (bottom panel) rates for the misinformation items in Experiment 1 as a function of response on the source-memory test. For comparison, the average hit and false alarm rates for the neutral items are also shown. Chance responding would be .33. Error bars represent 95% confidence intervals.

used a large number of misinformation items (4 per event, for a total of 24 items), whereas most studies showing that warning subjects about misinformation reduces misinformation effects have used far fewer (Greene et al., 1982, used 4 critical items, but only one event). Control subjects likely noticed inconsistencies even though they were not instructed to do so.

Experiment 2

In Experiment 2, we replicated Experiment 1 with a more direct measure of change recollection (see Wahlheim & Jacoby, 2013). Instead of completing the source-memory task, subjects reported directly whether the details in the photos were changed in the narratives.

Method

Seventy-two subjects from the same pool as in Experiment 1 were randomly assigned to the control group or the change-detection group (36 subjects in each). Experiment 2 was identical to Experiment 1 except that the source-memory task was replaced with a direct change-recollection task. Before starting the final recognition test, subjects were told that they should respond only with what they remembered from the photos and that the details in the narratives had sometimes differed from the details in the photos. They were also told that after making each recognition decision, they would be asked, "Did the narrative present a different version of the story from the photos about this particular detail?" and that they should respond with "yes" or "no." Subjects saw an example of a correct response and asked the experimenter any questions before beginning the final test.

Results

As in Experiment 1, the change-detection and control groups performed similarly on the final test, so the data were collapsed across the two groups in the analyses reported here.

Recognition test. Figure 3 presents the hit and false alarm rates on the recognition test as a function of item type and shows that we again replicated the misinformation effect.[2] Item type affected the hit rate, $F(2, 142) = 37.39$, $p < .001$, $\omega^2 = .50$. The repetition items had the highest hit rate, and the misinformation items had the lowest, with the neutral items in between, all $t(71)$s ≥ 3.26, ps < .002, ds ≥ 0.40. Item type also influenced the false alarm rate, $F(2, 142) = 33.06$, $p < .001$, $\omega^2 = .20$, which was highest for the misinformation items and lowest for the repetition items, with the neutral items in between, all $t(71)$s ≥ 3.93, ps < .001, ds ≥ 0.27.

Memory performance conditionalized on change detection. As in Experiment 1, subjects in the change-detection group were much more likely to correctly report changes when asked about the misinformation items (M = .40, 95% CI = [.35, .45]) than to erroneously report changes when asked about the repetition items (M = .17, 95% CI = [.14, .20]) or the neutral items (M = .14, 95% CI = [.11, .17]), both $t(35)$s ≥ 10.26, ps < .001, ds ≥ 1.39. Accurately detecting change led to enhanced performance on the misinformation items in the final recognition test. The bottom row of Table 1 shows the hit rates for the neutral items and for the misinformation items both when change was and was not detected. Critically, when change was not detected, the misinformation items had a lower hit rate than the neutral items, $t(35) = 6.22$, $p < .001$, $d = 1.28$, but when change was detected, the misinformation items had a higher hit rate than the neutral items, $t(35) = 2.25$, $p = .031$, $d = 0.50$. Noticing that a detail changed led to retroactive facilitation instead of a misinformation effect.

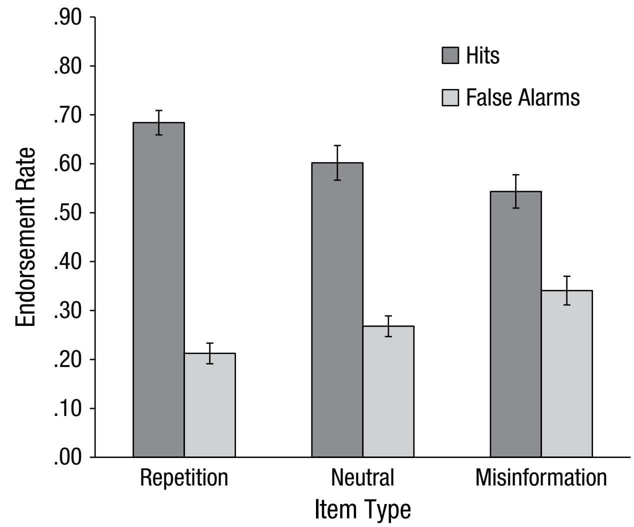

Fig. 3. Hit and false alarm rates on the final recognition test in Experiment 2 as a function of item type. Error bars represent 95% confidence intervals. See Table S3 in the Supplemental Material for results split by group.

Memory performance conditionalized on change recollection. The top panel of Figure 4 shows the hit rates on the recognition test for the misinformation items when a change was recollected and when a change was not recollected, as well as the overall hit rate for the neutral items (Table S4 in the Supplemental Material shows the overall change-recollection rates by item type). As expected, failing to recollect change led to retroactive interference; the hit rate for the misinformation items for which change was not recollected was worse than the hit rate for the neutral items, $t(71) = 9.72$, $p < .001$, $d = 1.67$. In contrast, recollecting change led to retroactive facilitation; the hit rate for the misinformation items for which change was recollected was higher than the hit rate for the neutral items, $t(71) = 6.35$, $p < .001$, $d = 0.77$. Examining the false alarm rates (bottom panel of Fig. 4) revealed a complementary pattern: The false alarm rate for the misinformation items when change was recollected was lower than the false alarm rate for the neutral items, $t(71) = 5.96$, $p < .001$, $d = 0.75$, whereas the false alarm rate for the misinformation items when change was not recollected was higher than the false alarm rate for the neutral items, $t(71) = 10.56$, $p < .001$, $d = 1.64$.

Does recollecting change make a unique contribution to reducing interference? If an item is memorable, then subjects are likely to notice when it changes. Although one of our central points is that memorable

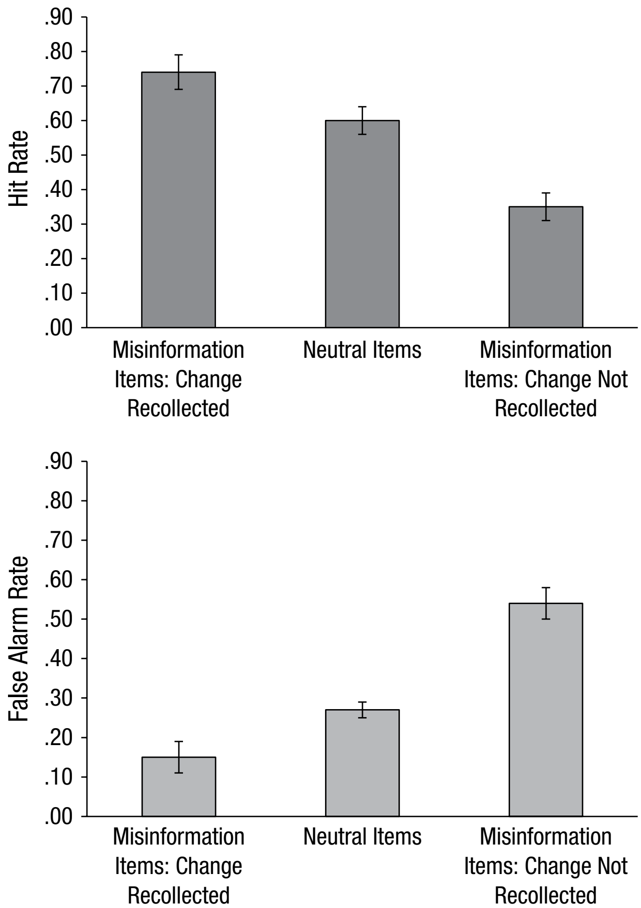

Fig. 4. Results from Experiment 2. The top panel displays the hit rates for the misinformation items when change was and was not recollected, as well as the overall hit rate for the neutral items. The bottom panel displays the false alarm rates for the misinformation items when change was and was not recollected, as well as the overall false alarm rate for the neutral items. Error bars represent 95% confidence intervals.

items are likely to be resistant to misinformation, our conditionalized analyses made it difficult to discern how much change recollection itself uniquely contributed (i.e., over and above item effects) to reducing the misinformation effect. As in previous research (Putnam et al., 2014), we used hierarchical linear regression to test whether change recollection made a unique contribution to successful recognition.

We built two models (see Table 2), one by items and one by subjects, that predicted the hit rate for the misinformation items. Both models started with the hit rates for the neutral items (Step 1), which captured item differences and individual differences in general memory. Next, we added the effects of change recollection (captured by d', with a "changed" response to a misinformation item considered a hit and a "changed" response to a neutral item considered a false alarm; Step 2). Finally, we added the interaction of the hit rate for the neutral items with change recollection (Step 3). For the item analysis, estimates for item memorability, d', and the interaction were calculated for each of the 72 items and entered into the regression model. The left column in Table 2 shows that item differences predicted hit rate for the misinformation items, but that change recollection also made a unique contribution. Similarly, for the subject-level analysis, estimates for general memory, d', and the interaction were calculated for each of the 72 individual subjects collapsing across the 72 items and entered into the regression model. The right column in Table 2 shows that there were individual differences in subjects' memory abilities that predicted successful recognition for the misinformation items and that change recollection made a unique contribution to the model. These models suggest that although memory performance for the misinformation items was driven in part by subject and item effects, change recollection did make a unique contribution.

Memorability and the misinformation effect

We hypothesized that more memorable details (measured by performance in the neutral condition) would be less susceptible to the misinformation effect. We combined the results of our pilot experiment, Experiment 1, and Experiment 2 for a more powerful analysis, and we correlated the hit rate when details were in the neutral condition with the false alarm rate when they were in the misinformation condition. As Figure 5 shows, there was a negative correlation, $r = -.55$, $p < .001$, 95% CI = [−.69, −.36], indicating that the more memorable a detail was, the less likely it was to show a misinformation effect. Put another way, the misinformation effect generally occurred for details that were poorly remembered from the original event.

Discussion

Experiment 2 replicated Experiment 1 in showing a misinformation effect and demonstrating that recollecting change leads to facilitation: When subjects detected and recollected change for the misinformation items, those items were remembered better than the neutral items. Critically, change recollection uniquely contributed to this facilitation, above any item or subject effects. Finally, details that were less memorable were more likely to show a misinformation effect.

General Discussion

Both experiments showed strong misinformation effects: Introducing misinformation during the narrative phase

Table 2. Results of the Regression Models Predicting the Hit Rate for Misinformation Items in Experiment 2

Step and predictor	Unit of analysis: Items	Subjects
Step 1		
Item differences or general memory differences	.23*	.24*
Step 2		
Change recollection (d')	.23*	.12*
Step 3		
Interaction	.02	.00

Note: The table displays the values of ΔR^2 on each step of the two models, one computed at the item level (collapsed across subjects) and the other at the subject level (collapsed across items). In Step 1, the predictor was item differences in the hit rate in the neutral condition (item-level model) or individual differences in the hit rate for the neutral items (subject-level model). *Change recollection* refers to item and individual differences in discriminability of change recollection for the misinformation items; d' was calculated by treating the change-recollection rate for the misinformation items as the hit rate and the change-recollection rate for the neutral items as the false alarm rate.
*$p \leq .001$.

lowered performance on the recognition test compared with conditions in which no misinformation was presented. However, we also showed that when subjects remembered discrepancies between the photos and the narratives in the misinformation condition, their recognition for the original details was *better* than their recognition for the neutral items. This outcome—improved memory when misinformation was introduced—seems paradoxical, but it is consistent with the discrepancy-detection hypothesis (Tousignant et al., 1986) and with the recursive-remindings framework, which suggests that noticing and later remembering a change can enhance memory (e.g., Jacoby et al., 2015). Indeed, one previous study that showed facilitative effects of misinformation, albeit not in the standard paradigm that we used, indicated that facilitation might occur if subjects covertly retrieve the original event while reading the postevent information (Chandler, Gargano, & Holt, 2001). However, that work did not use explicit measures of change detection or recollection.

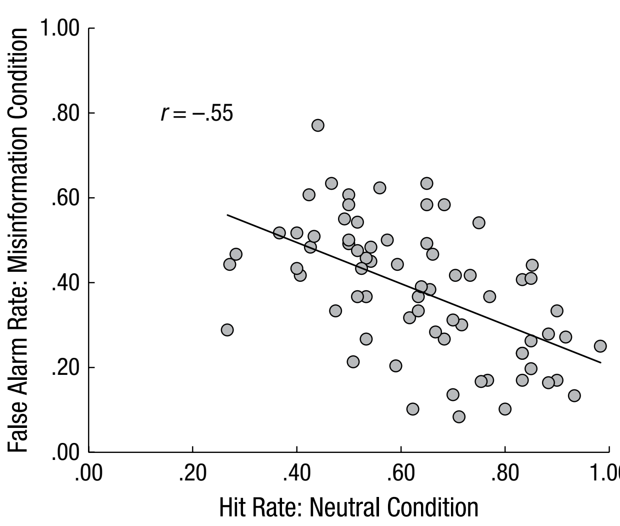

Fig. 5. Scatterplot (with best-fitting regression line) showing the relationship between the hit rate for details when they were in the neutral condition and the false alarm rate for the same details when they were in the misinformation condition. Each point represents a detail. The hit and false alarm rates were calculated combining the data from the pilot experiment, Experiment 1, and Experiment 2.

Why does remembering change enhance performance? Jacoby et al. (2015) provided a detailed overview, grounded in the recursive-remindings framework (e.g., Hintzman, 2011), of why detecting and recollecting change can enhance memory. Briefly, this framework suggests that people are often spontaneously reminded of earlier events. Looking back to an earlier event is a form of covert retrieval practice (Putnam & Roediger, 2013) or spaced repetition, both of which can enhance memory. Detecting a change between the original event and the narrative in the misinformation paradigm can be considered a reminding, which will enhance recollection of the original event. In the current experiments, recollecting change at the test likely also helped because source-monitoring errors contribute to misinformation effects (e.g., Lindsay & Johnson, 1989). Subjects who clearly recollect change may avoid such errors because they have additional information that can inform their recognition decision. In short, misinformation effects can be reduced or reversed by detecting inconsistencies (through spaced retrieval practice) and by recollecting change (through enhanced source monitoring). Of course, one caveat is that subjects in our experiments were sometimes instructed to note discrepancies and always asked to base their recognition responses on the original events—people outside the lab will usually be much less vigilant in their remembering.

Additionally, our experiments showed that the memorability of individual details is critical in determining whether a misinformation effect occurs. We used standard misinformation materials and showed that the misinformation effect does not occur with all items. If a picture is too memorable, changing it later will be obvious, and the misinformation effect will be eliminated or even reversed. The misinformation will provoke a covert retrieval of the original detail, which the subject will realize is the correct version. Our contribution is to show that this process does not require a blatant change (Loftus, 1979), but can occur with standard misinformation materials that are widely used (Okado & Stark, 2005). Of course, other factors, such as increasing the time between the original event and the postevent information, could lead to false memories for highly memorable items simply because those items will be less well remembered after a long delay (Loftus et al., 1978).

Concluding Comments

Two experiments showed the standard misinformation effect using canonical materials but, critically, revealed that misinformation sometimes enhances recognition above baseline levels. This second finding is unusual and shows that misinformation may either harm or help memory, depending on whether it prompts change detection. The misinformation effect generally occurs for details that are hard to remember in the first place (Fig. 5). This finding has theoretical importance in highlighting how detecting and later remembering discrepancies influences interference effects and in showing the role that item memorability plays in the misinformation effect. This finding also has practical importance in showing that the mere fact that a person (or witness) has been exposed to misinformation may not mean that false memories have been implanted. In the case of memorable details, the misinformation may cue a covert retrieval of the initial event and enhance memory for it.

Action Editor

Colleen M. Kelley served as action editor for this article.

Author Contributions

A. L. Putnam and V. W. Sungkhasettee oversaw data collection; A. L. Putnam performed the data analysis. A. L. Putnam drafted the manuscript, and H. L. Roediger, III, and V. W. Sungkhasettee provided revisions and comments. All the authors designed the study, interpreted the results, and approved the final version of the manuscript before submission.

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Supplemental Material

Additional supporting information can be found at http://pss.sagepub.com/content/by/supplemental-data

Open Practices

All data and materials have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/n9xep/ and https://osf.io/ntwek/, respectively. The complete Open Practices Disclosure for this article can be found at http://pss.sagepub.com/content/by/supplemental-data. This article has received badges for Open Data and Open Materials. More information about the Open Practices badges can be found at https://osf.io/tvyxz/wiki/1.%20View%20the%20Badges/ and http://pss.sagepub.com/content/25/1/3.full.

Notes

1. The endorsement rates for the foils were quite low: .07 for repetition items, .11 for neutral items, and .07 for misinformation items.

2. The endorsement rates for the foils were quite low: .10 for repetition items, .12 for neutral items, and .11 for misinformation items.

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