UNIVERSITY OF CALIFORNIA,
IRVINE

Failure to detect discrepancies drives retrieval-enhanced suggestibility

THESIS

submitted in partial satisfaction of the requirements
for the degree of

MASTER OF ARTS

in Social Ecology

by

Brendon Jerome Butler

Thesis Committee:
Distinguished Professor Elizabeth F. Loftus, Chair
Professor Linda J. Levine
Professor Elizabeth A. Martin

2017

DEDICATION

I dedicate this thesis to my family and friends for their unwavering support

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to thank Dialsmith® for allowing me to use their Perception Analyzer Online®.

ABSTRACT OF THE THESIS

Failure to detect discrepancies drives retrieval-enhanced suggestibility

By

Brendon Jerome Butler

Master of Arts in Social Ecology

University of California, Irvine, 2017

Distinguished Professor Elizabeth F. Loftus, Chair

Retrieval-enhanced suggestibility (RES) refers to the finding that immediately recalling the details of a witnessed event can *increase* susceptibility to later misinformation. In three experiments, we sought to gain a deeper understanding of the role that retrieval plays in susceptibility to misinformation. Consistent with past research, initial testing did increase susceptibility to misinformation—but only for those who failed to detect discrepancies between the original event and the post-event misinformation. In all three experiments, subjects who retrospectively detected discrepancies in the post-event narratives were more resistant to misinformation than those who did not. In Experiments 2 and 3, retrospective detectors who took an initial test were more likely to endorse misinformation than those in the single test condition. These results indicate the complexity of the relationship between retrieval practice, discrepancy detection, and misinformation endorsement.

Keywords: discrepancy detection; misinformation; retrieval-enhanced suggestibility

INTRODUCTION

We are constantly bombarded with information throughout our daily lives. Much of this information is accurate, but some of it is not. Failing to notice when we are receiving this misinformation, and incorporating into our memories, can lead to myriad adverse consequences. Moreover, research has shown that attempting to retrieve the original event from our memories can make us *more* susceptible to post-event misinformation. Out in the real world, this phenomenon could have some adverse consequences. For example, a student who takes a practice test before heading off to a study group may become more susceptible to incorrect explanations given to the group by one of her peers. Similarly, an eyewitness may be more likely to believe another eyewitness' incorrect account of a crime if she had just been asked to give her own version of how the crime occurred. The present work aims to uncover: (a) How retrieval practice influences susceptibility to misinformation; (b) Which types of retrieval practice increase or decrease the likelihood of noticing when information you're receiving is faulty; and (c) How does detecting these discrepancies affect your acceptance or rejection of misleading information.

CHAPTER 1: RETRIEVAL-ENHANCED SUGGESTIBILITY AND DISCREPANCY DETECTION

A recent phenomenon called retrieval-enhanced suggestibility has been the focus of many studies in the past seven years. Retrieval-enhanced suggestibility, or RES, refers to this finding: immediately recalling the details of a witnessed event can increase an individual's susceptibility to later misinformation. Researchers have suggested that the increased susceptibility is a result of increased attention; the initial test questions drive subjects to pay more attention to the later misinformation, which in turn increases their likelihood of learning the misinformation (Gordon, Thomas, and Bulevich, 2015).

Ordinarily we think that testing people is good for memory. However, retrieval-enhanced suggestibility can be thought of as a reverse testing effect; initial testing can actually impede final test performance if a person is exposed to misinformation in between the two tests. In the initial study (Chan, Thomas, and Bulevich, 2009), subjects watched a video of a television show that depicted criminal activity. Immediately after watching the video, half of the subjects were tested on details from the video, while the other half completed an alternate task. All subjects were later exposed to misinformation in the form of a post-event narrative that summarized some of the details in the crime video, followed by a final test on the details of the video. Chan and colleagues found that the subjects who took the initial test were more susceptible to misinformation and performed worse on the final test than those who did not take the initial test. This finding is now referred to as retrieval-enhanced suggestibility (RES).

RES is especially intriguing considering that we know that testing generally leads to better memory, not worse. Moreover, testing is also known to protect against retroactive interference, which is when newly-learned information interferes with memories for previously learned material (Wohldmann, Healy, and Bourne, 2008). Pastötter, Schicker, Niedernhuber, and Bäuml (2011) proposed that initial testing improves the encoding process of the learned material. As a result of the enhanced encoding, an individual's memory is more resistant to potential interference from subsequent information. When considering the RES paradigm and the testing effect literature, it would make sense to think that the initial test would protect against the consequences of retroactive interference like other studies have shown, not exacerbate them.

Some researchers believe that the RES effect is due to initial test questions serving as cues that guide attention to the misinformation (Gordon, Thomas, and Bulevich, 2015). For example, if on the initial test a witness is asked, "What color was the robber's hat?", the witness effectively gets a cue that the hat color is salient. As a result, when the witness encounters post-event information later on, she will pay more attention to information concerning the hat color. The result of that increased attention is increased learning of the misinformation. Researchers studying RES have measured increased attention by recording how long participants take to read the misinformation narrative, and what is typically found is that subjects who took an initial test do spend more time reading sentences that contain misinformation. This increased reading time indicates that they are in fact attending to the misinformation more (than witnesses who were not initially tested), and the increased attention leads to increased learning.

Of particular interest to the current study are the other consequences of initial testing, such as increased discrepancy detection. If a witness is paying more attention to the misinformation, would she also be more likely to notice that something is wrong with it?

Discrepancy Detection

Being able to detect discrepancies between something you've seen and something you're being told plays an important an important role in the acceptance (and subsequent learning) or rejection of information. For example, one relevant study found that reading misinformation-containing post-event narratives more slowly was associated with increased scrutiny, which in turn lead to a greater likelihood of detecting discrepancies and resisting the misinformation (Tousignant, Hall, & Loftus, 1986).

The Present Study

Previous research indicates that subjects who spend more time reading sentences that contain misinformation are paying more attention to it, which increases the likelihood that discrepancies are detected and misinformation resisted. In contrast, researchers examining the RES effect have shown that people are more susceptible to the misinformation *because* they are paying more attention to it. One aim of the present study was to resolve the discrepancy between these two competing ideas.

The present study was performed using the typical RES paradigm. In the first experiment[1], all subjects watched two slideshows both of which depicted a crime taking place. Immediately after viewing the slideshows, subjects in the repeated test condition took a cued recall test that pertained to details from the two slideshows, while subjects in the single test condition performed an alternate task. After a retention interval, all subjects read the same post-event narratives that contained misinformation. Finally, all subjects took a final recognition test for their memory of the details from the slideshows. In order to determine which subjects detected discrepancies between details in the slideshows and details in the narratives, we designed a funneled source memory task that was initiated after each question on the final test. By analyzing subjects' responses on the source memory task, we were able to identify who noticed discrepancies between the two sources of information.

CHAPTER 2: EXPERIMENTAL WORK

Experiment 1

The general experimental procedure for all three experiments can be seen in Figure 2.1. We predicted that subjects in the repeated test condition would be more likely to detect discrepancies between the slideshows and the narratives. If initial testing does indeed direct attention toward misinformation in the post-event narrative, that directed attention should lead to increased scrutinization of the information, more frequent discrepancy detection, and increased resistance to misinformation. Further, we predicted that when subjects detected discrepancies, they would be less likely to endorse misinformation on the final test, regardless of testing condition.

Method

Subjects. A total of 98 undergraduate students from the University of California, Irvine participated in this study in exchange for course credit. Of these, 16 subjects were excluded from the data analysis due to incomplete data resulting from computer problems.

Design and materials. This experiment had a 2 x 2 mixed design, with condition (*single test vs. repeated test*) being manipulated between subjects, and item type (*consistent vs. misinformation*) manipulated within subjects. Subjects were randomly assigned to one of the two conditions: *single test* (*n* = 42) or *repeated test* (*n* = 40).

The materials used in this experiment are modified versions of those used in previous misinformation studies (e.g. Okado & Stark, 2005). The "witnessed events" consisted of two sets of slideshows, each of which depicted a crime taking place. In the first slideshow, a man is shown stealing a woman's wallet, and in the second, a man is shown burglarizing a car. Each slideshow consisted of 50 slides that were shown at a rate of 3.5 seconds per slide..

The post-event information was presented as a written narrative. Each narrative was 50 sentences long, with each sentence summarizing one of the 50 slides from the corresponding slideshow. The sentences were presented on the screen one at a time and subjects pressed a button after reading one to advance to the next. Three of the sentences in each narrative (six total) were altered to include misinformation. For example, if the slideshow depicted a man using a *credit card* to open a car door, the altered sentence read, "The man used a *clothes hanger* to open the car door."

There were two versions of the recall test, both relating to 18 details from the slideshows (nine questions per slideshow). The first version was free recall, where subjects were able to type in their responses to the questions. The second version of the test was multiple choice cued-recall. On the cued recall test, 12 of the 18 questions pertained to details from the slideshows that were unchanged in post-event narrative. On these questions, subjects could choose between three options: the correct response (consistent item) or one of two neutral lures. For the six questions that pertained to details that were later altered in the post-event narrative, subjects could choose between the consistent item (correct response), the misinformation item, or a neutral lure.

A funneled source memory task was used to determine whether subjects detected change between the details in the slideshows and the narratives (Appendix A). After each question, subjects were asked how they knew the answer they selected. They could respond by selecting: (a) I saw it in the slideshow (b) I read it in the narrative (c) It was in both (d) I don't know. Subjects were then asked additional questions based on their initial source memory response (except those that selected "I don't know", who were not further-questioned on the source of their memory). Our funneled source memory task is much improved on previous source memory measures, which typically give subjects the opportunity to indicate where they heard/saw/read something, but does not allow them to indicate the source (and differences between the sources) of information with granularity.

Procedure. Subjects were told that they would be watching a series of slideshows and that their memory for the slideshows would be tested later. Immediately after viewing the slideshows, subjects in the repeated test condition completed the free recall test, while those in the single test condition completed a series of health/life surveys as an alternate task. After either the immediate test or the health/life survey, all subjects filled out a demographics questionnaire and watched a distractor video to fill the retention interval. Subjects were then presented with post-event information, which consisted of narratives that summarized the two slideshows. Once subjects finished reading the post-event narratives, they took the final, cued-recall test and source memory task.

Results

Misinformation endorsement contingent on condition. Initial testing led to an RES effect — those in the repeated testing condition were significantly more likely to endorse a misinformation item than those in the single test condition ($M_{\text{single}} = 0.52$, $M_{\text{repeated}} = 0.41$), $t(80) = 2.16$, $p = .03$, $d = .48$. Also consistent with past RES literature, there was no difference between groups in the endorsement of consistent items, $t(80) = 1.57$, $p = 0.11$.

Misinformation endorsement contingent on retrospective detection status. Of particular importance to the present study was investigating how detecting change affects suggestibility. Subjects' response(s) to the source memory task were used to determine detection status; those who noticed a discrepancy between the slideshows and the narratives were considered "detectors" and those who did not were considered "non detectors." As there were six pieces of misinformation in the narratives, each subject could endorse up to six misinformation items, and could detect a discrepancy for each of the six items. Because each subject produced multiple data points (repeated measures), we used a mixed effects logistic regression with dichotomous outcome variables, misinformation endorsement and detection.

Detection rates for all three experiments can be found in Table 2.1. Overall, subjects detected discrepancies 29.6% of the time. In addition to being more likely to endorse misinformation on the final test, those in the repeated test condition ($M = 0.36$) were also more likely to detect discrepancies than those who took just one test ($M_{\text{repeated}} = 0.36$, $M_{\text{single}} = 0.24$), $t(240) = 2.93$, p < .01, $d = 0.26$. Collapsed across conditions, non detectors ($M = 0.56$) were significantly more likely to endorse misinformation on the final test than detectors ($M = 0.23$), $z = 7.05$, $p < .001$, 95% CI [0.24, 0.42]. As can be seen in Figure 2.2, there was no difference between conditions in misinformation endorsement rates for detectors, $M_{\text{diff}} = 0.02$, $z = 0.33$, $p = .74$. However, non detectors in the repeated test condition were significantly more likely to endorse misinformation than non detectors in the single test condition ($M_{\text{repeated}} = 0.67$, $M_{\text{single}} = 0.46$), $z = 3.52$, $p < .001$, 95% CI [0.09, 0.32].

Discussion

Failing to retrospectively detect discrepancies predicted how likely a subject was to endorse misinformation. Consistent with our hypothesis, this finding was most noticeable for those in the repeated test condition.

One possible concern with the findings is that subjects were asked retrospectively whether they detected discrepancies between the events and misinformation. Imperfect subject memory could mislead us into thinking detection occurred when it did not (or vice versa). Ideally, a method that measured detection concurrently, and did not depend so heavily on memory, would provide more useful information about detection. Thus, in Experiment 2, we introduced a method to measure detection concurrently.

Experiment 2

The primary aim of Experiment 2 was to improve upon Experiment 1 with measure of detection that was less memory-dependent. An additional aim of the second experiment was to determine whether there was a difference in how often subjects detected discrepancies concurrently versus retroactively, and if these differences affected misinformation endorsement. Rates of concurrent and retrospective detection have varied considerably across studies in both misinformation and choice blindness paradigms (e.g. Cochran, Greenspan, Bogart, & Loftus, 2016; Johansson, Hall, Sikström, & Olsson, 2005; Johansson, Hall, Sikström, Tärning, & Lind, 2006). We expected our robust measures of detection to give us a more-accurate prediction of how subjects detected discrepancies when presented with misinformation.

Method

Subjects. A total of 121 undergraduate students from the University of California, Irvine participated in this study in exchange for course credit.

Design, materials, and procedure. The design of the experiment was unchanged from Experiment 1; 2 x 2 mixed design, with condition (*single test vs. repeated test*) being manipulated between subjects, and item type (*consistent vs. misinformation*) manipulated within subjects. Subjects were randomly assigned to one of the two conditions: *single test* (n = 64) or *repeated test* (n = 57). The materials used in Experiment 2 were the same as those used in Experiment 1. The procedure for Experiment 2 was exactly the same as Experiment 1, with the addition of a concurrent detection task, which was similar to concurrent detection tasks used in previous studies (e.g. Wahlheim & Jacoby, 2013; Putnam, Sungkhasettee, & Roediger, 2016). As in Experiment 1, the post-event narrative was presented to subjects one sentence at a time. However, instead of simply pressing a button to advance to the next sentence, subjects were instructed to press a button on the screen indicating whether the sentence they just read was consistent or inconsistent with what they saw in the slideshows. Subjects that pressed the button labeled "Inconsistent" were labeled detectors, and those that pressed the button labeled "Consistent" were labeled non detectors.

Results

Misinformation endorsement contingent on condition. Comparing the performance of those who took a single test and those who had taken an initial test (thus repeated test), there were no differences in the endorsement of misinformation on the final test ($M_{\text{single}} = 0.51$, $M_{\text{repeated}} = 0.54$, $p = 0.58$). In other words, we did not observe an RES effect. In hindsight, this might not be particularly surprising given that the concurrent detection task could serve as a warning, signaling to subjects that there were issues with the post-event narrative. Past research has shown how warnings reduce an individual's susceptibility to misinformation, both in traditional misinformation (Greene, Flynn, & Loftus, 1982;) and retrieval-enhanced suggestibility (Thomas, Bulevich, & Chan, 2010) paradigms. Additionally, the concurrent detection task is likely to have caused subjects to read the sentence more slowly (or even re-read sentences), which also can lead to greater resistance to misinformation (Tousignant et al., 1986).

Misinformation endorsement contingent on concurrent detection status. There were no differences in concurrent detection rate between the two conditions, ($M_{\text{single}} = 0.45$, $M_{\text{repeated}} = 0.47$), $t(119) = 0.57$, $p = .54$. Consistent with the discrepancy detection principle, subjects (in both conditions) that detected a discrepancy between the misinformation and the post-event narrative were less likely to endorse misinformation on the final test, $z = 12.78$, $p < .001$, 95% CI [0.36, 0.50].

Misinformation endorsement contingent on retrospective detection status. Subjects retrospectively detected discrepancies 21% of the time, which was a noticeable decrease from Experiment 1. Further, there were no differences in detection rate between test conditions, ($M_{\text{single}} = 0.22$, $M_{\text{repeated}} = 0.20$), $t(122) = 0.56$, $p = .52$.

When collapsed across conditions, non detectors were more likely to endorse misinformation than detectors, ($M_{\text{non detectors}} = 0.53$, $M_{\text{detectors}} = 0.15$), $z = 5.27$, $p < .001$, 95% CI [0.24, 0.52]. Unlike in Experiment 1, non detectors in the repeated test condition were not more likely to endorse misinformation than non detectors in the single test condition, ($M_{\text{repeated}} = 0.54$, $M_{\text{single}} = 0.52$), $z = 0.53$, $p = .59$, 95% CI [-0.06, 0.12]. In fact, a completely different finding emerged — detectors in the repeated test condition were *more likely* to endorse misinformation than detectors in the single test condition, ($M_{\text{repeated}} = 0.29$, $M_{\text{single}} < 0.01$), $z = 2.14$, $p = .03$, 95% CI [0.02, 0.57].

Misinformation endorsement contingent on concurrent and retrospective detection status. Some subjects detected discrepancies both concurrently *and* retroactively; we call these subjects “super detectors”. About six percent of subjects in each condition were classified as super detectors. Consistent with the discrepancy detection hypothesis, super detectors were more resistant to misinformation than non detectors, ($M_{\text{super}} = 0.12$, $M_{\text{non detectors}} = 0.55$), $z = 7.76$, $p < .001$, 95% CI [0.32, 0.53]. These results can be seen in Figure 2.3.

Discussion

Two main findings emerged in Experiment 2. First, and as expected, the presence of the concurrent detection task appears to have made subjects more resistant to misinformation, when compared to their performance in a study that did not ask for concurrent detection. This was most notable for retrospective non detectors in the repeated test condition. The second, unexpected finding was that retrospective detectors in the repeated test condition were significantly more likely to endorse misinformation than those in the single test condition.

Experiment 3

The unexpected results in Experiment 2 hinted that the presence of the concurrent detection task was affecting how subjects were engaging with the misinformation during the post-event narratives. We speculated that concurrent detection task used in Experiment 2 was causing subjects to pay much more attention to each sentence than they ordinarily would. We hypothesized that because the post-event narrative was presented one sentence at a time, and subjects had to make discrepancy decisions for each one, they were hyper-vigilant, resulting in more resistance to misinformation. In order to verify the robustness of the results we uncovered in the second experiment, we repeated the experiment with an improved concurrent detection task that didn't force subjects to make a discrepancy decision for each sentence, but still allowed them to indicate when they noticed a discrepancy.

As a replacement to the previous concurrent detection task, we partnered with the market research company Dialsmith® and used their Perception Analyzer Online® as a detection tool. The Perception Analyzer Online is a state-of-the-art solution for moment-moment evaluation of recorded media (Dialsmith). As it's used in market research, respondents are able to continuously rate — in real time — how positively or negatively feel about the media they are currently viewing. For our purposes, we used the Perception Analyzer Online to track how subjects evaluated the consistency/inconsistency of the post-event narrative.

Method

Subjects. A total of 124 undergraduate students from the University of California, Irvine participated in this study in exchange for course credit.

Design, materials, and procedure. The design of the experiment was the same as in Experiments 1 and 2; a 2 x 2 mixed design, with condition (*single test vs. repeated test*) being manipulated between subjects, and item type (*consistent vs. misinformation*) manipulated within subjects. Subjects were randomly assigned to one of the two conditions: *single test* (n = 62) or *repeated test* (n = 62). The materials used in Experiment 3 were the same as those used in Experiments 1 and 2.

The procedure for Experiment 3 was the same as Experiment 2, with the exception of the post-event information and concurrent detection task. Instead of reading sentences one at a time, subjects listened to an audio recording of the post-event narrative.

As subjects listened to the audio narrative, they rated the consistency of the information they were hearing by continuously moving an on-screen slider from 0 (inconsistent) to 100 (consistent). Subjects that moved towards zero after hearing a sentence containing misinformation were classified as detectors, and those that remained the same or moved closer to consistent were classified as non detectors. We view this concurrent detection method as an improvement over the methods used in Experiment 2 and other studies for several reasons: First, subjects were not forced to read the post-event narrative sentence-by-sentence and make a binary consistent/inconsistent decision for each individual sentence; by using the Perception Analyzer Online, subjects are able to rate consistency on a continuous scale. Second, using this new concurrent detection method allows subjects to listen to the post-event narrative as opposed to reading it sentence-by-sentence, which mirrors a more realistic scenario where a person might hear post-event information on the news or from a fellow witness.

Results

Misinformation endorsement contingent on condition. As in Experiment 2, there were no differences in concurrent detection rate between the single and repeated testing conditions, (M_{single} = 0.49, $M_{repeated}$ = 0.55), t(122) = 0.93, p = .12.

Misinformation endorsement contingent on concurrent detection status. Misinformation endorsement rates and a visual representation of the real-time concurrent detection can be seen in Figures 4 and 5 respectively. There were no differences in concurrent detection rate between the two conditions, (M_{single} = 0.22, $M_{repeated}$ = 0.20), t(122) = 0.63, p = .53. Surprisingly, when collapsed across conditions, there were no differences in the endorsement of misinformation, z = 0.58, p = 0.55.

Misinformation endorsement contingent on retrospective detection status. Overall, subjects retrospectively detected discrepancies only 8% of the time, which was a noticeable decrease from Experiments 1 & 2. Further, there were no differences in detection rate between the single and repeated test conditions, (M_{single} = 0.08, $M_{repeated}$ = 0.08), t(122) = 0.65, p = .51.

When collapsed across conditions, non detectors were much more likely to endorse misinformation than detectors ($M_{non\ detectors}$ = 0.55, $M_{detectors}$ = 0.18), z = 6.48, p < .001, 95% CI [0.25, 0.48]. Although not statistically significant, the same pattern from Experiment 2 emerged; detectors in the repeated test condition were more likely to endorse misinformation than detectors in the single test condition ($M_{repeated}$ = 0.27), M_{single} = 0.08), z = 1.81, p = .07, 95% CI [-0.01, 0.40].

Misinformation endorsement contingent on concurrent and retrospective detection status. Two percent of subjects in the single test condition and six percent of subjects in the repeated test condition were classified as super detectors. As expected and collapsed across conditions, super detectors were less likely to endorse misinformation than non detectors, (M_{super} = 0.27, $M_{\text{non detectors}}$ = 0.53), z = 3.31 p = .001, 95% CI [0.10, 0.41].

Discussion

Even as they used a less-intrusive concurrent detection method, subjects were still affected by having to make discrepancy judgments as they listened to the post-event narrative. As a result, the peculiar finding from Experiment 2 remained; subjects who took an initial test and detected discrepancies retroactively were *more* likely to endorse misinformation than if those who took an initial test and failed to detect discrepancies.

CHAPTER 3: GENERAL DISCUSSION AND CONCLUSIONS

General Discussion

Our findings provide a deeper understanding of how people detect (or fail to detect) discrepancies between a witnessed event and misleading post-event information. By using several different detection methods, including the use of the Perception Analyzer Online as a concurrent detection task, we took a deeper look at discrepancy detection. We found that overall, subjects usually failed to detect discrepancies between something they saw and information they are later told. Unless subjects were explicitly told to make consistency judgments on a sentence-by-sentence basis, they rarely noticed the discrepancies. This can be seen most clearly in the detection rates in Experiment 3. Further, if the subject failed to detect a discrepancy in real time (concurrent detection), their retrospective detection rate plummeted to less than four percent.

Consistent with the discrepancy detection principle, detectors in both conditions were less likely to endorse misinformation than non detectors[1]. Similarly, recent work has found that noticing change in the post-event narrative can be viewed as a reminding, which will improve memory of the original event (Putnam et al., in press). Interestingly, the results we reported here indicate that this is not always the case — some subjects who detected discrepancies still endorsed misinformation on the final test, especially those in the repeated test condition.

This finding brings to light a complex interplay between repeated retrieval attempts, discrepancy detection, and misinformation endorsement. When there was no concurrent detection task, (Experiment 1), retrospective detectors in both conditions endorsed misinformation at similar rates. However, in Experiments 2 and 3 — which had concurrent

[1] The only exception being concurrent detectors in Experiment 3.

detection tasks — retrospective and super detectors in the repeated test condition were *more* likely to endorse misinformation than those in the single test condition.

While seemingly counterintuitive, the results found in Experiments 2 and 3 share some similarities with prior work on change detection and proactive facilitation. Wahlheim and Jacoby (2012) had subjects study word lists in an A—B, A—D paradigm. In the first phase of the experiment, subjects were instructed to read List 1 pairs (A—B) as quickly as possible. During the second phase, subjects were required to study and learn List 2 pairs (A—D), as well as indicate when they noticed that the word on the right (D) was different than the one presented earlier (B). The authors found a facilitative effect of memory — memory for List 2 (A—D) was improved when subjects noticed that a change had occurred. Additionally, repeated presentations of the first event (List 1) increased the likelihood of detecting change, which further improved the memory for the second event (List 2).

The findings reported by Wahlheim and Jacoby provide theoretical backdrop for which we can explain some of the puzzling findings in Experiments 2 and 3. In the present study, the first and second events (Lists 1 and 2 in Wahlheim and Jacoby, 2012) are the set of slideshows and the post-event narrative, respectively. Further, the repeated presentations of the first event are present in the RES paradigm, as the initial test serves as an additional presentation of the event or a recursive reminding. At the final test, those that notice a discrepancy are more likely to endorse misinformation. We believe that this is the result of proactive facilitation, where memory for the misinformation response is strengthened. This strengthened memory is then incorrectly provided as the correct one, thus resulting in subjects endorsing misinformation.

Our work also shows a clear distinction in the outcomes between covert and overt retrieval practice. The concurrent detection tasks we used are forms of covert retrieval that caused the subject to be reminded of what occurred in the actual event. When looking at those that detected a discrepancy concurrently (covert retrieval), there were no differences in misinformation endorsement between conditions. However, when there was an overt retrieval attempt — the final test — subjects in the repeated test condition were more likely to endorse misinformation than their single-test counterparts.

Conclusions

The work presented here contribute to a more nuanced understanding of the relationship between retrieval, discrepancy detection, and misinformation endorsement. Contrary to prior findings, detecting discrepancies between new, faulty information and something you have seen previously does not always result in increased resistance to the misinformation, nor does it always lead to enhanced memory for the original event. Detecting a discrepancy after having an additional retrieval attempt (in the present study, the initial test) can lead to an increased endorsement misinformation when compared to those that did not have the additional retrieval opportunity. Gaining a more in-depth understanding of the role of retrieval practice, both covert and overt, is an important and daunting goal for future research. As mentioned in Significance Statement at the beginning of this paper, retrieval has a significant impact on various areas of life, ranging from education to the legal sector.

References

Cochran, K. J., Greenspan, R. L., Bogart, D. F., & Loftus, E. F. (2016). Memory blindness: Altered memory reports lead to distortion in eyewitness memory. *Memory & Cognition*, 717–726. http://doi.org/10.3758/s13421-016-0594-y

Chan, J. C. K., Thomas, A. K., & Bulevich, J. B. (2009). Recalling a Witnessed Event Increases Eyewitness Suggestibility. *Psychological Science*, 1–8.

Corballis, M. C. (2011). The recursive mind: The origin of human language, thought, and civilization. Princeton: Princeton University Press.

Dialsmith. www.dialsmith.com

Gordon, L. T., Thomas, A. K., & Bulevich, J. B. (2015). Looking for answers in all the wrong places: How testing facilitates learning of misinformation. *Journal of Memory and Language*, *83*, 140–151. http://doi.org/10.1016/j.jml.2015.03.007

Greene, E., Flynn, M. S., & Loftus, E. F. (1982). Inducing resistance to misleading information. *Journal of Verbal Learning and Verbal Behavior*, *21*(2), 207-219.

Hintzman, D. L. (2004). Judgment of frequency versus recognition confidence: Repetition and recursive reminding. *Memory & Cognition*, 32, 336–350. doi:10.3758/BF03196863

Johansson, P., Hall, L., Sikström, S., & Olsson, A. (2005). Failure to detect mismatches between intention and outcome in a simple decision task. *Science, 310, 116-119.*

Johansson, P., Hall, L., Sikström, S., Tärning, B., & Lind, A. (2006). How something can be said about telling more than we can know: On choice blindness and introspection.

Consciousness and Cognition, *15*(4), 673–692. http://doi.org/10.1016/j.concog.2006.09.004

Kornell, N., Klein, P. J., & Rawson, K. A. (2015). Retrieval attempts enhance learning, but retrieval success (versus failure) does not matter. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(1), 283.

Okado, Y., & Stark, C. E. L. (2005). Neural activity during encoding predicts false memories created by misinformation. Learning & Memory, 12(1), 3–11.

Pastötter, B., Schicker, S., Niedernhuber, J., & Bäuml, K.-H. T. (2011). Retrieval during learning facilitates subsequent memory encoding. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *37*(2), 287–297.

Putnam, A. L., Sungkhasettee, V. W., & Roediger, H. L. (2016). When Misinformation Improves Memory: The Effects of Recollecting Change. *Psychological Science*.

Thomas, A. K., Bulevich, J. B., & Chan, J. C. K. (2010). Testing promotes eyewitness accuracy with a warning: Implications for retrieval enhanced suggestibility. *Journal of Memory and Language*, *63*, 149–157. http://doi.org/10.1016/j.jml.2010.04.004

Tousignant, J. P., Hall, D., & Loftus, E. F. (1986). Discrepancy detection and vulnerability to misleading postevent information. *Memory & Cognition*, *14*(4), 329–338. http://doi.org/10.3758/BF03202511

Wahlheim, C. N., & Jacoby, L. L. (2013). Remembering change: The critical role of recursive remindings in proactive effects of memory. *Memory and Cognition*, *41*, 1–15. http://doi.org/10.3758/s13421-012-0246-9

Wohldmann, E. L., Healy, A. F., & Bourne Jr, L. E. (2008). A mental practice superiority effect: less retroactive interference and more transfer than physical practice. Journal of Experimental Psychology: Learning, Memory, and Cognition, 34(4), 823.

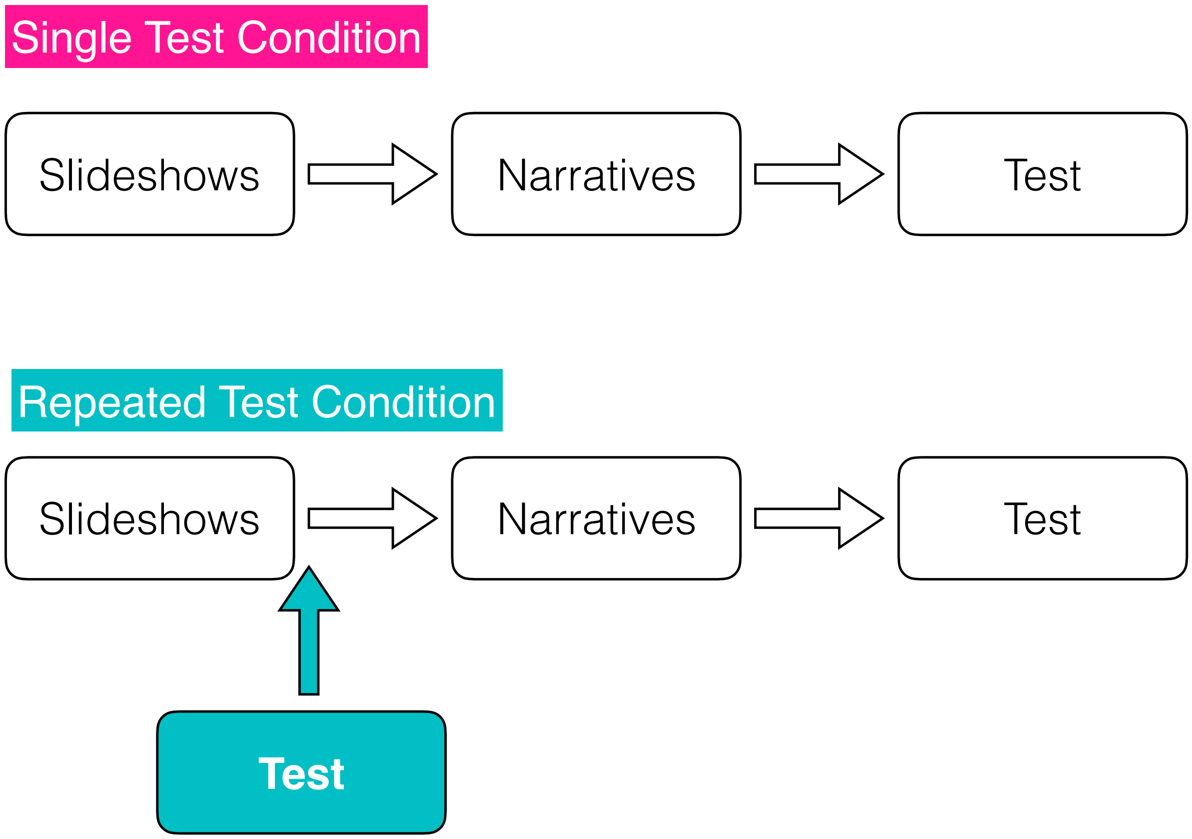

Figure 2.1. General experiment procedure.

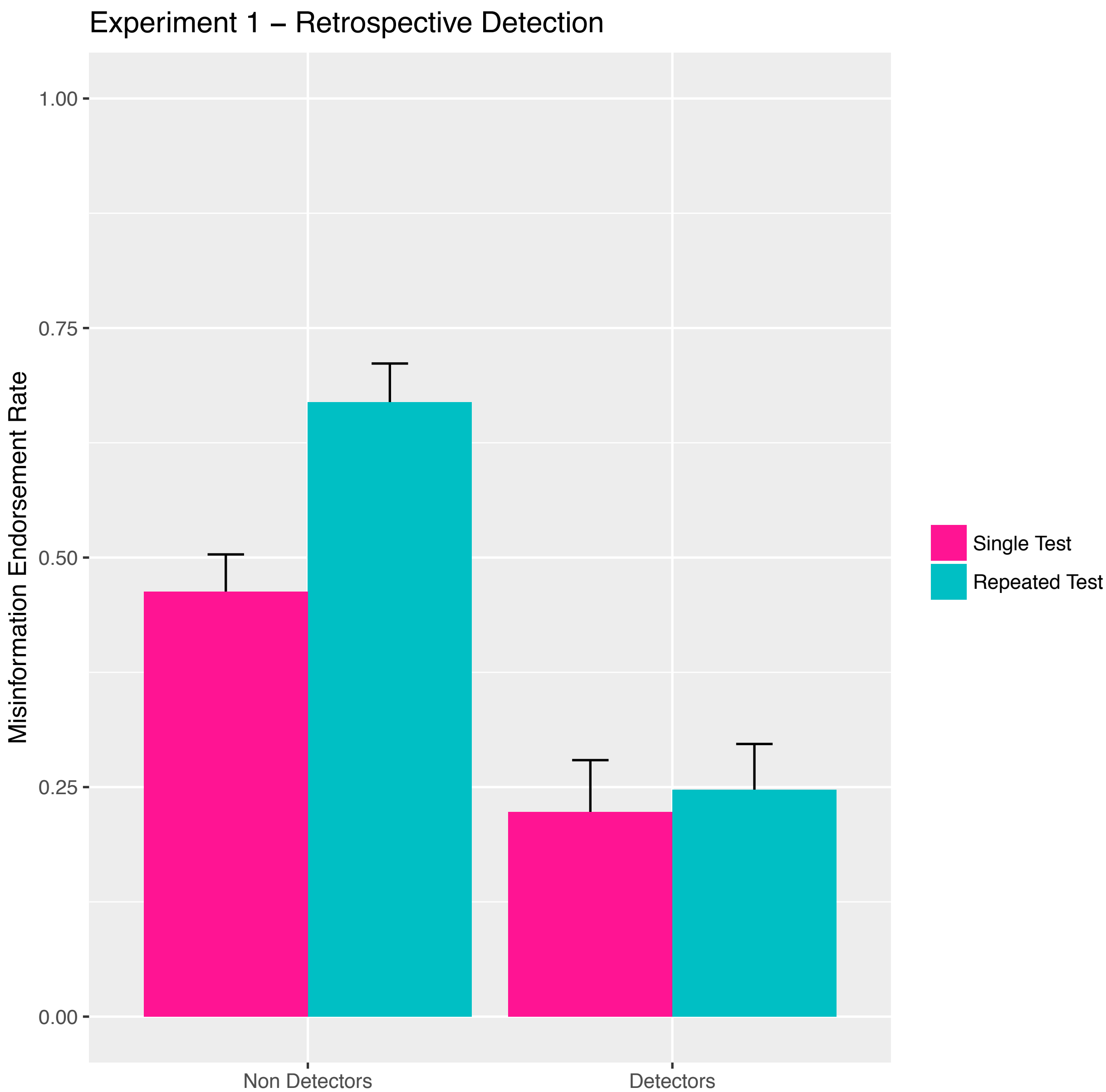

Figure 2.2. Experiment 1 misinformation endorsement rates for retrospective detectors and non detectors, broken down by condition. Error bars represent +1 SEM.

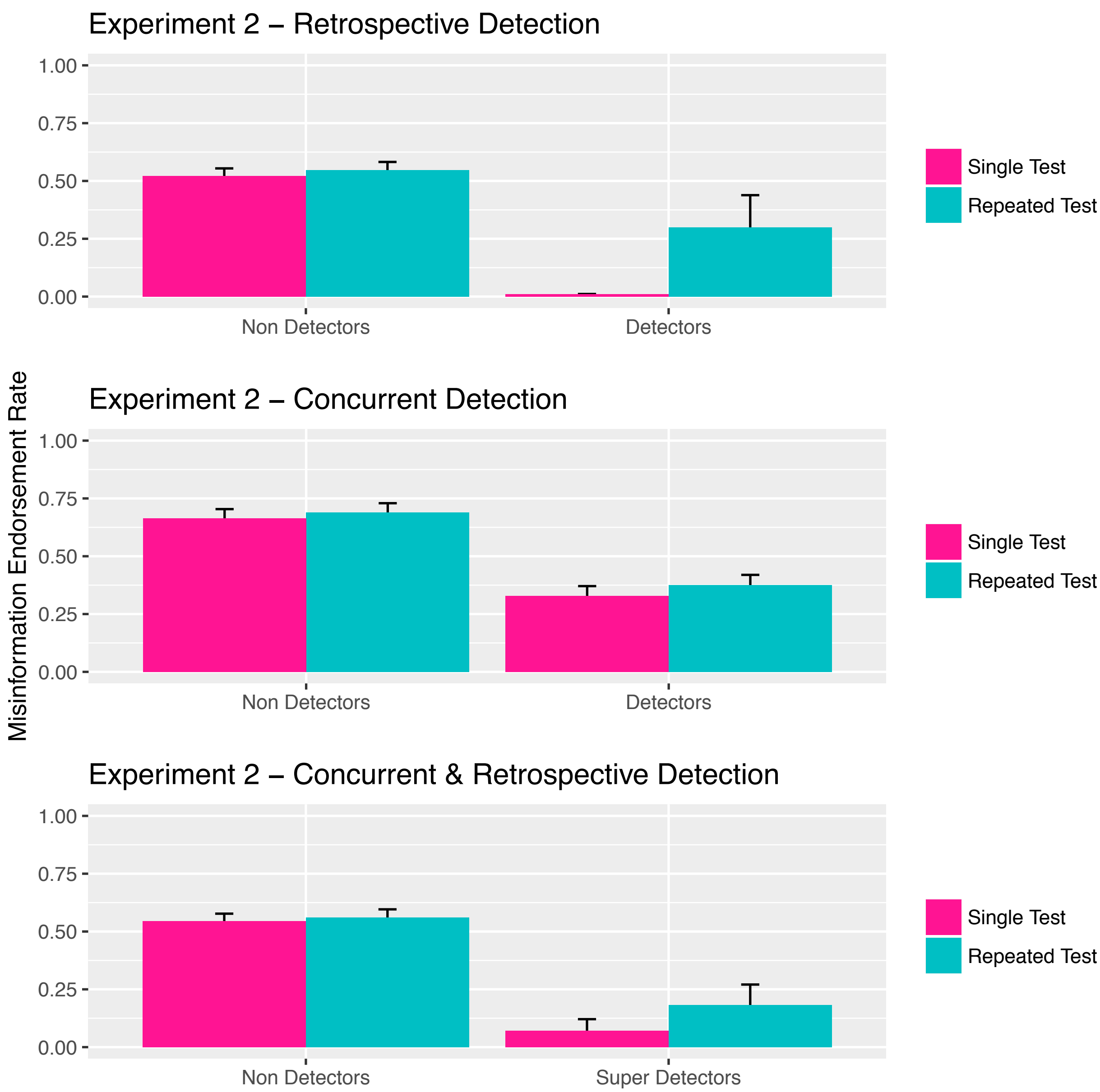

Figure 2.3. Experiment 2 misinformation endorsement rates for retrospective (top panel), concurrent (middle panel), and super (bottom panel) detectors and non detectors, broken down by condition. Error bars represent +1 SEM.

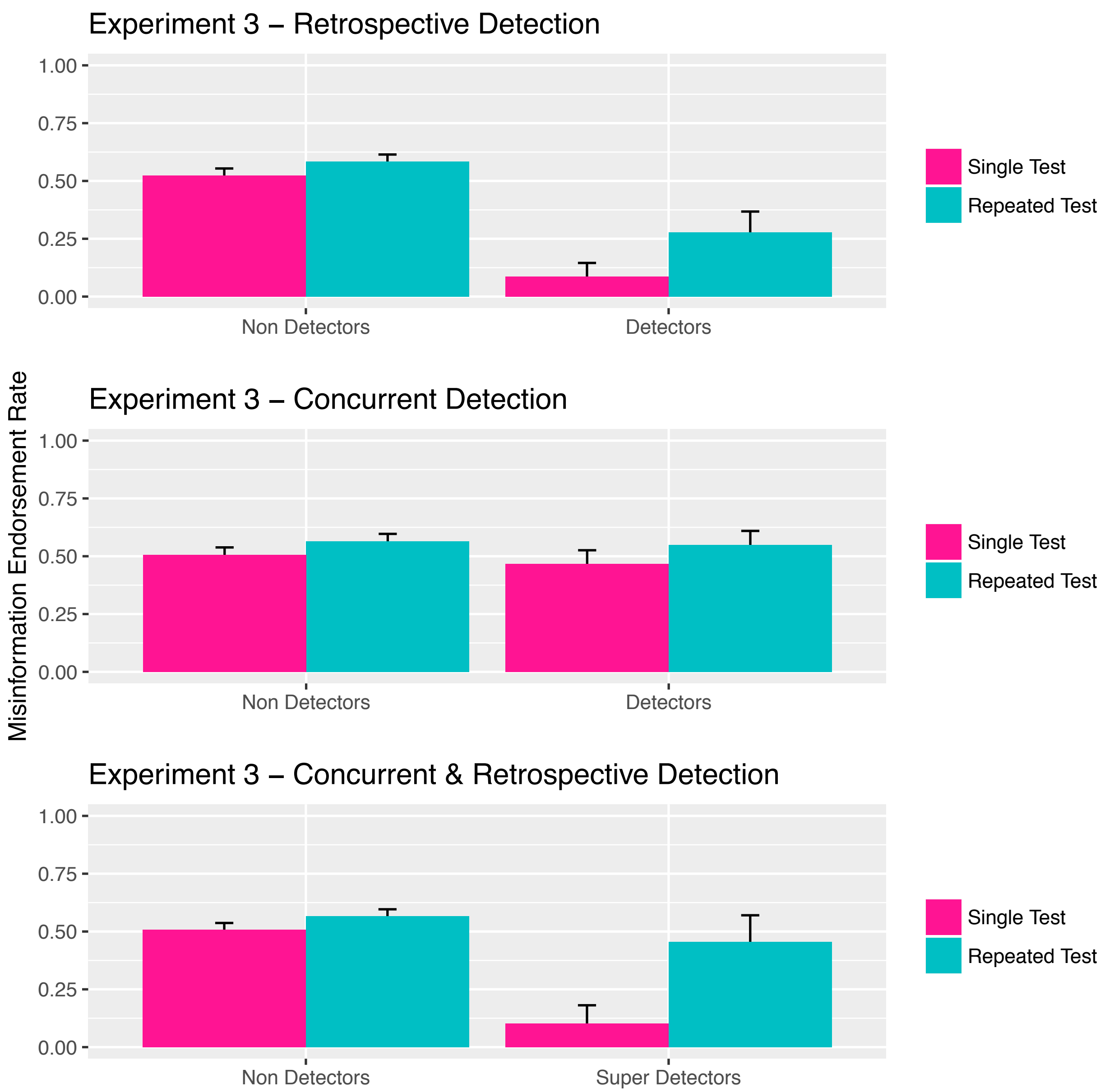

Figure 4. Experiment 3 misinformation endorsement rates for retrospective (top panel), concurrent (middle panel), and super (bottom panel) detectors and non detectors, broken down by condition. Error bars represent +1 SEM.

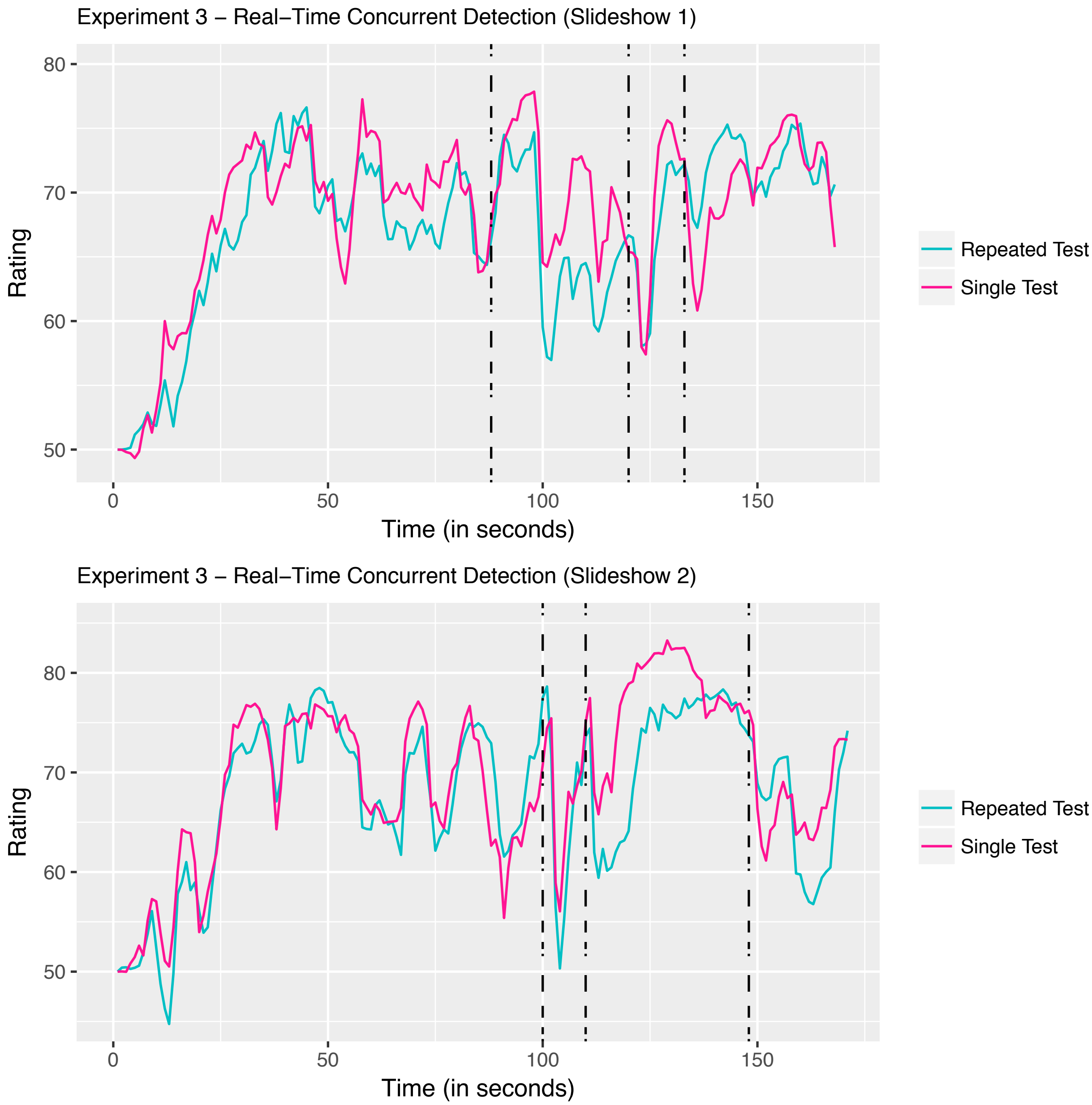

Figure 5. Real-time concurrent detection ratings for Experiment 3. Ratings could range from 0 (Inconsistent) to 100 (Consistent). Averages for all subjects are shown here. The dashed lines indicate when subjects heard misinformation in the audio post-event narrative.

Table 1 Detection rates for all three experiments.

	Detection Type			
	Concurrent	Retrospective	Both	No Detection
Experiment 1				
Retrieval Practice	—	0.35	—	0.65
Control	—	0.24	—	0.76
Experiment 2				
Retrieval Practice	0.47	0.20	0.06	0.40
Control	0.45	0.18	0.06	0.44
Experiment 3				
Retrieval Practice	0.20	0.08	0.05	0.81
Control	0.22	0.08	0.02	0.84

Appendix A: Slideshows, Misinformation Narratives, and Final Test Questions

Narrative 1

[Presented approximately 40 minutes after the photographic slideshows. *Italic type indicates misleading information*, whereas regular type is not misleading**.** This key was not visible to participants]

Narrations

Now we will show you a description of the slideshow you saw earlier about the woman called Jane.
Please read each sentence carefully as it appears, you will have a few seconds on each sentence before the next one appears.
This description will last about 5 minutes.
Please stay focused on reading and following the story for the whole time.

[Each of the following sentences were presented on screen for 5500ms]

1. Jane was walking down Main Street in Baltimore.
2. She was window shopping and continued walking.
3. Jane stopped to look at a video store after passing a hair salon.
4. She went inside.
5. Jane bought something inside, and left the video store.
6. On her way up the stairs from the store, she saw a friend.
7. Jane waved hello, and he smiled.
8. The two friends hugged.
9. They chatted for a little while.
10. Jane indicated that she had bought something from the video store.
11. She showed her friend the new DVD.
12. Her friend did not approve of her selection.
13. They continued to talk.
14. They then hugged goodbye.
15. They walked in opposite directions.
16. Jane continued down Main Street, passing by a woman on a cell phone.
17. A man was walking across the street towards Jane.
18. The man was headed directly towards the girl, who was oblivious to him.
19. The man bumped into Jane from behind.
20. This bump caused her bag to fall to the ground.
21. Her new DVD, sunglasses, mirror and other things fell out of the bag.
22. After he bumped into her, she felt sore and rubbed her arm.
23. The man apologized for running into her.
24. She was angry because all of her items were wet and on the ground.
25. Both of them stooped to the ground to pick up the items.

26. He placed her mirror back in the plastic bag, while she picked up her tape dispenser.
27. The girl stood up and turned around to make sure nothing else had fallen out.
28. *While her back was turned, the man reached with his right hand into her pocketbook.*
29. *He took her wallet and hid it in his pants pocket.*
30. He helped her with her plastic bag that had a yellow smiley face on it.
31. They put the plastic bag back inside her other bag.
32. Jane shook his hand to thank him for helping her out.
33. The man headed back towards the street, first watching a man who was getting something out of his car trunk.
34. The man crossed the street.
35. As Jane continued down the street, the woman talking on her cell phone was finishing her conversation.
36. Jane took out her cell phone.
37. Suddenly Jane realized that her wallet was missing.
38. She searched frantically in her bag for her wallet.
39. The woman who had been on the cell phone called out to Jane.
40. *The woman had a green backpack on.*
41. The woman explained what she had seen the man do and pointed towards the direction the man headed.
42. Jane looked across the street to see if he was there.
43. Unfortunately, the man had already disappeared.
44. Jane turned back to the woman with a disappointed look.
45. Jane shrugged her shoulders, realizing that she would not be able to catch up with him now.
46. Jane thanked the woman for trying to help her.
47. The two headed in opposite directions.
48. Jane turned a corner and disappeared.
49. The other side of the street still looked empty.
50. The man, who had been watching them, came out from his hiding place.

Narrative 2

Narrations

Now you will see a series of sentences describing the slideshow you saw earlier about the man and the car.

Please read each sentence carefully as it appears, you will have a few seconds on each sentence before the next one appears.
This narrative will last about 5 minutes.
Please stay focused on reading and following the story for the whole time.

[Each of the following sentences were presented on screen for 5500ms]

1. On a cloudy afternoon, a young man walked down a residential street.
2. He noticed a light purple car across the street.
3. He crossed the street and walked towards the car.
4. He looked into the car, which had a Johns Hopkins University sticker on the rear window.
5. He tried to open the driver-side door.
6. He looked around suspiciously to see if anyone noticed him by the car.
7. He used an object to open the car door.
8. The door opened.
9. The young man pulled the driver's seat back so he could get in.
10. He then opened the change compartment.
11. He saw several bills and a few pennies in the compartment.
12. He examined the bills.
13. He put the money into his pocket.
14. He then looked into the back seat of the car.
15. He saw a purse and picked it up.
16. He found a purse and rummaged through it with his right hand.
17. Finding nothing in it, he threw down the purse in frustration.
18. Angry, the young man wondered what to do next.
19. The young man pulled the trunk lever to open it.
20. He got out of the car.
21. He left the front door open as he headed towards the trunk.
22. He approached the trunk to see if the lever worked.
23. He saw that the trunk had opened.
24. He opened the trunk all the way.
25. The young man was pleased with what he saw in the trunk.
26. He suddenly heard a sound nearby.
27. He suspiciously looked across the street and saw nobody there.
28. He turned his attention back to the trunk.
29. He pulled out a bag of cocaine.
30. *He also found a few rings.*
31. He put all of the items in his pocket.
32. He then closed the trunk door.
33. *He accidentally slammed the trunk on his right hand.*
34. Furious and in pain, he hit the car.

35. With a pained look on his face and holding his hands together, he walked towards the passenger-side door.
36. He approached the door.
37. He opened the door and got in.
38. He opened the glove compartment.
39. He rummaged through the compartment.
40. He closed the glove box.
41. He then pulled down the sunshade and found a parking permit.
42. Not interested in it, he closed the sunshade.
43. The young man then got out of the car.
44. He closed the door.
45. *He noticed that his right shoe was untied and bent down to tie it.*
46. He stood up and wondered if there was anywhere else to look in the car.
47. Suddenly, he heard police sirens in the distance
48. He looked around to see in which direction it was coming from.
49. He then began to run in the opposite direction.
50. As he ran away, his hat fell off.

Test

[Occurred about one hour after the original slideshows, i.e. 20 minutes after the narratives. Note the **correct answers are in bold,** *misleading information answers are in italic*, and the foil answers are in regular type. This key was not visible to participants]

Memory Test for Picture Slideshow

For each of the following questions, select the answer that you yourself remember seeing in the original slideshows of photographs.
First consider the first slideshow of photographs, which involved a woman named Jane interacting with several people.

1. What is the name of the video store that Jane entered?
   a. Video Internationale
   b. Video Starrz
   c. **Video Americain**
2. After Jane leaves the video store, how does she greet her friend?
   a. She hugs him
   b. They shake hands
   c. They give each other a high five
3. Which DVD does Jane show her friend?
   a. Futurama
   b. South Park
   c. The Simpsons
4. How does her friend react to her DVD selection?
   a. He seems pleased
   b. He seems displeased
   c. He seems neutral
5. Which hand did the man use to take Jane's wallet out of her bag?
   a. **Left**
   b. *Right*
   c. He did not use any hand to take her wallet from her bag.
6. After he takes her wallet out of her purse, where does he hide it?
   a. In his pants pocket
   b. In his sleeve
   c. In his jacket pocket
7. What color is the cell phone Jane takes out of her purse?
   a. Blue
   b. White
   c. Red
8. What color backpack did the other woman have on?
   a. **Red**
   b. Green
   c. Blue
9. Where does the man come out from after the girl is gone?
   a. Inside a car

b. Behind a tree

c. Behind a doorway

Now consider the second slideshow of photographs of the man and the car.

10. What object did the young man use to break into the car?
    a. Screwdriver
    b. Clothes hanger
    c. Credit card
11. What type of bills did the man find in the car's change compartment?
    a. $1 bills
    b. $10 bills
    c. $20 bills
12. Where did the man put the money he found?
    a. Back pocket of his pants
    b. Front pocket of his pants
    c. Under his hat
13. While the man was looking in the trunk, who did he see across the street?
    a. A man walking a dog
    b. Nobody
    c. A couple holding hands
14. In addition to drugs, what did the man find in the trunk?
    a. A few rings
    b. Some diamond earrings
    c. A few necklaces
15. What happened when he closed the trunk?
    a. He slammed the trunk on his left hand
    b. He slammed the trunk on his right hand
    c. He was not hurt by the trunk
16. What did the man take out of the glove compartment?
    a. A cassette tape
    b. Sunglasses
    c. Nothing
17. When the man pulled down the sunshade, what did he find?
    a. A purple parking ticket
    b. A white parking ticket
    c. A key
18. After the man got out of the car, which shoe did he bend down to tie?
    a. He did not tie any shoe
    b. Left
    c. Right

Appendix B: Funneled Source Memory Task