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Digitally Manipulating Memory: Effects of Doctored Videos and Imagination in Distorting Beliefs and Memories

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Abstract

In prior research on false autobiographical beliefs and memories, subjects have been asked to imagine fictional events and they have been exposed to false evidence that indicates the fictional events occurred. But what are the relative contributions of imagination and false evidence toward false belief and memory construction? Subjects observed and copied various simple actions, then viewed doctored videos that suggested they had performed extra actions, and they imagined performing some of those and some other actions. Subjects returned two weeks later for a memory test. False evidence or imagination alone was often sufficient to cause belief and memory distortions; the two techniques in combination appeared to have additive or even superadditive effects. The results bear on the mechanisms underlying false beliefs and memories, and we propose legal and clinical applications of these findings.

Digitally Manipulating Memory: Effects of Doctored Videos and Imagination in Distorting Beliefs and Memories

Memory scientists have amply demonstrated the malleability of people's memories for distant events (e.g. Lindsay, Hagen, Read, Wade, & Garry, 2004; Loftus & Pickrell, 1995) and for recent events (e.g. Loftus & Palmer, 1974; Thomas & Loftus, 2002). Although methodologies have varied from study to study, a substantial number of false memory experiments show that the act of imagining is key to false memory development (Goff & Roediger, 1998; Hyman, Husband, & Billings, 1995; Mazzoni & Memon, 2003). Yet current research suggests that fabricated evidence can produce a similar response (Garry & Wade, 2005; Nash & Wade, in press; Wade, Garry, Read, & Lindsay, 2002). The question we ask here is: How do imagination and false evidence work individually and in combination to produce false beliefs and false memories?

Source Monitoring

Johnson and colleagues' Source Monitoring Framework (SMF) can be used to make predictions about a wide range of false memory phenomena (Johnson, Hashtroudi, & Lindsay, 1993; Johnson & Raye, 1981; Lindsay, 2008). According to the SMF, remembering is an inferential process: people must attribute mental experiences, such as thoughts, images, and feelings that come to mind to particular origins (although typically such attributions are made quickly and without conscious deliberation). False memories arise when mental events from one source are misattributed to another (erroneous) source. People can make source judgments by relying on environmental cues (e.g. official records/documentation; see Wade & Garry, 2005) and various qualitative and quantitative cues from memory itself. For instance, real memories typically contain more sensory information (such as smells, sounds, and visual details) and more contextual cues (information about the time and location) than do imagined events (Johnson, Foley, Suengas, & Raye, 1988). Real memories often also contain details that act as a marker of their veracity; for instance, one would expect a real memory of a conversation with a friend to contain auditory records of the friend's voice rather than another person's voice. When internally generated images are rich with memory-like characteristics such as vivid sensory detail and event-consistent information, though, source monitoring errors can occur.

Laboratory-based False Memories

Memory scientists have developed numerous paradigms for examining false memory phenomena in the laboratory (see Pezdek & Lam, 2007; Wade et al., 2007, for partial reviews). Some studies have distorted memories for non-autobiographical experiences (e.g. DRM studies, Roediger & McDermott, 1995), whereas others have distorted memories for self-involving, moderately significant autobiographical experiences (e.g. Desjardins & Scoboria, 2007). The latter literature reveals two techniques that are commonly used to induce false memories: [1] encouraging individuals to *imagine* counterfactual events and [2] presenting individuals with *false evidence* that implies the counterfactual events occurred.

In terms of imagination, we know that merely imagining a fictitious event can lead people to report that they remember doing something they never did (Hyman & Pentland, 1996; Garry, Manning, Loftus, & Sherman, 1996; Mazzoni & Memon, 2003; Pezdek, Blandon-Gitlin, & Gabbay, 2006). Goff and Roediger (1998), for instance, found that the more times subjects imagined performing non-performed actions, the more likely they were to claim they had actually performed them (see also Johnson, Raye, Wang, & Taylor, 1979). Indeed, this *imagination inflation effect* is a robust phenomenon (Garry & Polaschek, 2000).

With regard to effects of false evidence, recent research reveals that such information can distort memory. Bernstein and colleagues (Bernstein, Laney, Morris & Loftus, 2005a) gave some adults false feedback that suggested they had gotten sick as children from eating hard-boiled eggs, and approximately 25% reported a specific belief or memory for the fictitious event. In a follow-up study, food-related false memories caused people to avoid certain foods later on (Geraerts et al., 2008). Wade and colleagues showed that fake photographs can also induce false memories (Garry & Wade, 2005; Wade et al., 2002). They gave adults photographs of themselves as children and asked them to recall the events depicted in each photo. Unbeknownst to the subjects, the experimenters faked one of the photos by digitally pasting a childhood image of the subject into a hot-air balloon scene. After working at remembering the pseudo-event for one week, 50% came to falsely recall aspects of the balloon ride. Together, these false evidence studies illustrate the powerful impact that environmental influences can have on memory.

Why do imagination and false evidence distort our beliefs and memories? Imagination, according to the SMF, promotes perceptual and contextual details in mental imagery. When we imagine a counterfactual experience we embellish that event with details that are characteristic of a real memory, causing the imagined event to feel phenomenologically similar to a real memory. In line with this account, imagined events are more often misremembered as actual events by individuals with good imagery (Johnson et al., 1979); or if the events are inherently easy to imagine (Finke, Johnson, & Shyi, 1988); or if conditions lead subjects to include sensory details in their imaginings (Thomas, Bulevich, & Loftus, 2003).

From an SMF perspective, false evidence might foster false memories in three qualitatively different ways. First, analogous to imagination, false evidence may reduce differences between imagined events and real memories by providing fluent perceptual details that can be combined with products of imagination. In Lindsay et al. (2004), for example, subjects worked at remembering a childhood prank that they and a classmate had supposedly played (but that almost certainly had not really happened—namely, putting Slime in their teacher's desk). Half of the subjects were given their real class-group photo for that school year to use as a "memory cue." False memories were twice as common among subjects given the class photo. Lindsay et al. speculated that one mechanism for this effect was that the photo enabled subjects to form vivid and perceptually detailed images of their teachers, classmates, and selves which could be combined with products of imagination to create compelling false memories.

False evidence may also foster false memories by increasing the perceived plausibility of the suggested event. Individuals are unlikely to develop false memories unless they accept the suggested event as something that could plausibly have happened (Hart & Schooler, 2006; Johnson & Raye, 2000; Mazzoni & Kirsch, 2002; Pezdek, Finger, & Hodge, 1997; for a discussion of social-influence processes by which implausible ideas can come to seem plausible, see Lynn, Pintar, Stafford, Marmelstein, & Lock, 1998). To the extent that it is persuasive, false evidence by definition will increase the perceived plausibility of the suggested event.

Finally, false evidence might encourage people to lower their criteria for believing a particular event occurred, and for the amount of detail a mental image of that event must possess before attributing it to memory (Mazzoni & Kirsch, 2002). Put differently, even if seeing the doctored video had no effect upon the perceptual detail of their mental imagery or the plausibility of the suggestion, it might nevertheless make a person willing to attribute somewhat less vivid images of suggested events to memory.

In sum, previous research leads us to believe that imagination and false evidence are powerful forms of suggestion. What we do not know, however, is what the individual and combined effects of these two influences are. Almost all false evidence studies to date have confounded false evidence with imagination. In the sole exception of which we are aware, Bernstein, Laney, Morris and Loftus (2005b) gave subjects false feedback that they had become sick from eating strawberry ice-cream, and half were also encouraged to imagine what might have happened. Although the false feedback alone increased subjects' confidence that the suggested event occurred, imagination increased their confidence even more. Bernstein et al.'s research suggests that imagination and false evidence might have unique effects on subjects' beliefs, but because the authors did not independently manipulate these two factors, we cannot say for sure what the separate and combined effects might be.

The Present Experiments

We developed a novel procedure for assessing the effects of imagination and false evidence on beliefs and memories. Subjects observed and copied various simple actions, then viewed doctored videos that suggested they had performed extra actions; they also imagined performing some of the actions in the doctored video and some other non-performed actions. Finally, subjects returned two weeks later for a memory test.

EXPERIMENT 1

Experiment 1 addressed three research questions. First, can doctored video evidence alone change individuals' beliefs and memories about their recent experiences? At least one study (Bernstein et al., 2005b) has shown that false evidence alone can distort people's beliefs about childhood experiences, so we predicted that subjects would be more certain that they performed critical actions shown in the doctored video than those not in the video. Second, which technique—imagination or false evidence—has a greater distortive influence? Because most studies have confounded the two techniques, we had no theoretical reason to predict that one would be more powerful than the other. Finally, what is the combined effect of imagination and false evidence? The answer to this question would allow us to speculate about the cognitive mechanisms that drive the false evidence effect.

In addition, we had a secondary interest in determining whether imagination and false evidence influence beliefs and memories of both memorable and less memorable actions. Several studies have investigated the effects of imagining different types of actions by manipulating the bizarreness of the actions (e.g. Seamon, Philbin, & Harrison, 2006), reasoning that people should be more capable of rejecting bizarre false events than familiar ones. Some researchers more broadly discuss "memorability-based strategies" that incorporate numerous possible characteristics—including bizarreness—that might help a person to reject a false suggestion (Ghetti, 2003; Tousignant, Hall, & Loftus, 1986). In Experiment 1, therefore, we manipulated the memorability of the critical actions to explore this issue. It is worth noting, though, that the memorability of these actions is likely to be highly correlated with their bizarreness, as well as other similar characteristics.

Method

Subjects and Design

Forty-seven University of Victoria (Canada) undergraduates received optional bonus points in a psychology course for individually participating in three sessions over 11-21 days (M = 14.55 days, SD = 2.58)[1]. We used a 2 (video vs. no-video) x 2 (imagine vs. no-imagine) within-subjects design. The procedure is outlined in Appendix A.

Materials and Procedure

Selecting the Critical and Non-critical Actions

We selected 37 actions such as "flip the coin" and "put on the hat." Of those, 16 were taken from Goff and Roediger (1998), 5 (1 familiar and 4 bizarre) were taken from Thomas and Loftus (2002), and 16 were additional actions that we created or adapted (see Appendix B for a full list). We asked 25 volunteers to rate on a scale from 1 (I'd easily remember doing this) to 7 (I'd easily forget doing this) how memorable each action would be to somebody who had performed it 2 weeks earlier. Based on these ratings, we chose four *critical actions* that differed in memorability (all ps < .05): *Kiss the magnifying glass* (M = 2.32, SD = 1.46); *Rub the Q-tip on the toy car* (M = 3.32, SD = 1.73); *Roll the dice* (M = 4.52, SD = 1.50); *Browse the book* (M = 5.48, SD = 1.16). We randomly assigned the critical actions to four within-subject conditions: [1] *Video-Only*, [2] *Imagine-Only,* [3] *Video+Imagine,* and [4] *Control.* Critical Video actions (i.e. Video-Only and Video+Imagine conditions) were actions that subjects would view in a doctored video. Critical Imagine actions (i.e. Imagine-Only and Video+Imagine conditions) were actions that subjects would imagine performing. Finally, the Control action neither appeared in the video nor was imagined. Subjects did not perform the critical actions at any stage. The remaining 33 actions served as non-critical (filler) actions in different stages of the experiment—some were performed in Session 1; some were imagined in Session 2 but not performed; some were new in Session 3—and ranged in memorability at each session. We had no plans to analyse subjects' ratings for the non-critical actions so we did not counterbalance these actions.

Session 1: Event Phase

Subjects were seated at a table opposite a Research Assistant (RA). They were told that the experimenters were interested in mental imagery and that they would be filmed observing and copying the RA performing some actions. The objects necessary for performing the actions (e.g. a coin, a hat) were arranged on the table: one set for the subject, one set for the RA. Subjects familiarized themselves with the objects and the remainder of Session 1 was captured on video (see Figure 1 for a representative still depicting the camera's field of view). The RA began by performing an action for 15 s, then the subject copied the same action for 15 s. A loud beep indicated when the subject and RA should start and stop performing each action. Next, the RA performed a second action, and this process continued until the RA and the subject had performed 26 non-critical actions. All subjects performed the same actions and these ranged in memorability.

Creating the Doctored Videos for Session 2. Immediately after the subject left, we filmed the RA performing two of the four critical actions which would serve as our doctored video clips in Session 2 (the Video+Imagine and Video-Only actions). We created two fake clips by combining these extra video clips with clips of the subject observing the RA at Session 1 (see Figure 1). Note that the fake clips did not show the subject performing the critical actions, only observing the RA perform them. To enhance acceptance of the fake clips, we inserted them into a 5-min sequence made up of 10 untouched clips of the subjects observing the RA perform actions that really had been performed in Session 1. Thus, each subject's video contained twelve 10-s clips separated by 15-s pauses. Clips 7 and 10 were always the fake clips and the remaining clips depicted the same non-critical actions for all subjects.

Session 2: Suggestion Phase

Session 2 was conducted 2 days later and comprised two tasks. In the first task, subjects were exposed to the fake video clips. Subjects were seated in front of a computer and told that they would watch several video clips of themselves watching the RA perform actions at Session 1. They were instructed to write down at the end of each clip the name of the action the RA performed. This task ensured that subjects attended to each clip.

For the second task the subject was instructed to imagine performing some actions. Subjects were told that an action sentence would appear on the monitor, and their task was to close their eyes and imagine performing that action for 10 s, after which they would hear a beep. To encourage subjects to imagine every action, they were asked to rate the vividness of their images as per Thomas and Loftus (2002). Subjects imagined 15 action sentences, each repeated four times (60 actions in total, presented to each subject in the same quasi-random order). Two of the 15 were critical actions: one had been presented in the doctored video (Video+Imagine), and one had not (Imagine-Only). The remaining 13 actions were non-critical actions (9 performed; 4 non-performed actions intended to make salient to subjects that they did not perform all the imagined actions). The imagination task lasted 15 minutes.

Session 3: Memory Test

Session 3 was conducted approximately 2 weeks after Session 1. The memory test contained 28 action sentences, including all 4 critical actions and 24 non-critical actions (17 performed during Session 1; 4 unperformed but imagined in Session 2; and 3 new). Subjects answered two questions about each action, based on Scoboria, Mazzoni, Kirsch and Relyea's (2004) Autobiographical Beliefs and Memory Questionnaire. First, subjects rated the extent to which they *believed* they performed each action, using a scale from 1 (I definitely did not do this) to 8 (I definitely did do this). Next they rated their *memory* of performing each action, from 1 (No memory of doing this) to 8 (Clear and detailed memory of doing this). Finally, subjects wrote down what they thought the aim of the experiment was, and the experimenter debriefed them. Subjects were also invited to attempt to identify which two actions from the memory test were the critical Video actions.

Results and Discussion

Subjects' Acceptance of the Video Evidence

Several reasons led us to be confident that subjects were unaware of the true nature of the experiment. First, no subject reported that the aim of the study was to investigate the effects of false video evidence. Second, many subjects indicated that they were surprised the video had been edited ("It was changed? I didn't notice that at all!" "Oh, it was? I didn't have a clue!"). Third, 47% of subjects failed to identify either of the critical Video actions. On average, subjects identified 0.66 out of 2 critical actions. Together, these findings suggest that subjects generally accepted the video as an accurate record.

Nevertheless, although no subjects claimed the video was edited, some appeared to suspect they were being tricked. We categorized subjects as *suspicious* if they indicated at any stage that there were actions in the video they did not think they performed, or if they successfully identified *both* critical video actions. The 12 subjects who met these criteria did not significantly differ from other subjects in their Belief or Memory ratings for any critical action type (smallest non-adjusted $p = .061$), thus the following analyses include data from all 47 subjects.

Belief and Memory Rating

We now turn to our primary questions. First, was doctored video evidence alone sufficient to change subjects' beliefs and memories? Figure 2 shows that it was: subjects rated Video-Only actions higher than Control actions on both the Belief [$t(46) = 3.50, p < .01, d_z = .51$] and Memory [$t(46) = 2.17, p = .04, d_z = .32$] scales. Second, which technique—imagination or false evidence—had the greater influence upon beliefs and memories? Our data suggest that in isolation, the two techniques had equivalent effects: both influenced beliefs and memories (although the difference between Imagine-Only and Control actions on the Memory measure did not reach conventional significance, $t(46) = 1.73, p = .09, d_z = .25$), and there were no differences between Video-Only and Imagine-Only actions on the Belief [$t(46) = .94, p = .35, d_z = .14$] or Memory [$t(46) = .60, p = .55, d_z = .09$] scale. These results lead us to conclude that watching a 10-s doctored video clip was just as hazardous as imagining a critical action for 40 s.

Finally, by looking more closely at the data represented in Figure 2 to examine how false evidence and imagination interact, we can speculate about the mechanisms responsible for the false evidence effect.[2] Two 2 (video vs. no-video) x 2 (imagined vs. not imagined) within-subjects ANOVAs revealed no significant interactions on either Belief or Memory, although the interaction for Memory ratings approached the conventional significance level [Belief, $F(1, 46) = .40, p = .53, \eta_p^2 = .01$, *95% CI* $= .00 \leq \eta_p^2 \leq .12$; Memory, $F(1, 46) = 3.46, p = .07, \eta_p^2 =$

.07, *95% CI* = .00 ≤ η_p^2 ≤ .24][3]. These null interactions suggest that the combined effects of the two techniques were additive. However, because there was a tendency towards a superadditive combined effect for Memory, and because of the problems inherent in inferring additivity from a null interaction, we conducted some additional analyses to further examine these data. We calculated the mean Video+Imagine ratings that should be predicted given an additive combined effect, by adding the mean ratings for Video-Only and Imagine-Only actions, and subtracting the mean Control rating from this value (note that Video-Only and Imagine-Only ratings both comprise a unique effect plus a baseline, equivalent to the mean Control rating). Table 1 shows that our observed Video+Imagine Memory ratings were significantly greater than the predicted mean, whereas the Belief ratings did not significantly differ. In short, although the analyses generally support an additive account of the effects of false evidence and imagination, there was nevertheless some indication that the two effects may have combined superadditively. We return to these findings in the General Discussion.

Memorability

To examine whether our memorability manipulation affected subjects' Belief and Memory ratings, we classified the two more memorable critical actions (Kiss the magnifying glass, Rub the Q-tip on the toy car) as *high-memorability,* and the two less memorable critical actions (Roll the dice, Browse the book) as *low-memorability*. Across all conditions, subjects gave higher Belief [$t(186) = 2.85$, $p = .005$, $d = .42$] and Memory ratings [$t(186) = 2.112$, $p = .04$, $d = .31$] to low-memorability actions than to high-memorability actions (see *Total* row in Table 2), therefore our subjects could to some extent use a memorability-based strategy to identify critical actions they would not expect to forget performing (Ghetti, 2003; Mazzoni & Kirsch, 2002).

How did imagination and false evidence affect subjects' Belief and Memory ratings for low-memorability and high-memorability actions? Recall that both imagination and false evidence increased subjects' ratings overall (see *Total* columns in Table 2). Our memorability analyses—also shown in Table 2—showed that this pattern was true of both low- and high-memorability actions. Put differently, imagining an action or seeing it in the doctored video caused similar levels of belief and memory distortion for high-memorability actions as they did for low-memorability actions (for all interactions, $p > .19$, all $\eta_p^2 < .01$).

Summary

Even without imagination, our doctored videos were sufficient to cause significant belief and memory distortions. Doctored videos appeared to be at least as powerful as imagination, and when the two forms of suggestion were combined, they had an additive or superadditive effect. The large distortive effects found in previous false evidence studies may, therefore, be just as attributable to the imagination tasks subjects were given as to the false evidence itself. Moreover, both suggestive techniques in Experiment 1 increased subjects' belief in low- *and* in high-memorability actions, providing evidence that the techniques' effects are not limited to forgettable experiences.

EXPERIMENT 2

Experiment 2 examined whether the effects of imagination and false evidence would persist if subjects were warned that videos can easily be tampered with and that imagining counterfactual events can inflate one's confidence. In the false memory literature, a handful of studies have investigated the influence of warnings on subjects' resistance to suggestion, and the results have been mixed. In the misinformation domain, Greene, Flynn, and Loftus (1982) found that warning subjects before, but not after, they were exposed to misinformation helped them to resist suggestion. Chambers and Zaragoza (2001), however, found that warnings helped subjects regardless of when they were delivered. In studies of the Deese-Roediger-McDermott effect, pre-encoding warnings robustly reduced the rate of false memories whereas the efficacy of post-encoding warnings depended on other variables (e.g., Gallo, Roediger, & McDermott, 2001; McCabe & Smith, 2002; Watson, McDermott, & Balota, 2004). Two studies of greatest relevance to the current research have also found mixed results: Landau and von Glahn (2004) found that subjects who received warnings about imagination exhibited a smaller inflation effect than those who received no warning; whereas a study from the communications literature (Kelly & Nace, 1994) revealed that warnings about the capabilities of digital editing software failed to reduce subjects' belief in news articles and photos from disreputable sources. Taken as a whole, these studies show that warnings—and especially post-encoding warnings—work under certain conditions but not others. For now, it is not clear when warnings protect subjects from the effects of suggestive techniques.

Method

Subjects and Design

Forty-eight University of Warwick (United Kingdom) undergraduates received £8 for participating in three sessions over 13-16 days (M = 14.83 days, SD = 1.02). We used a 2 (video vs. no-video) x 2 (imagine vs. no-imagine) within-subjects design, and added a 2 (video warning vs. no video warning) x 2 (imagination warning vs. no imagination warning) between-subjects manipulation. Subjects were randomly allocated to warning conditions.

Materials and Procedure

Selecting the Critical and Non-critical Actions

We selected 45 of Goff and Roediger's (1998) non-object actions (listed in Appendix B) and, because we did not manipulate memorability in Experiment 2, from those we chose four critical actions that 25 volunteers rated as moderately memorable on a scale from 1 (I'd easily remember doing this) to 7 (I'd easily forget doing this). The critical actions were: *Clap your hands* (M = 4.68, SD = 1.93); *Salute* (M = 4.44, SD = 1.58; *Click your fingers* (M = 4.56, SD = 2.22); and *Flex your arm* (M = 5.04, SD = 1.64); all ps > .05. The remaining 41 actions served as non-critical (filler) actions at various stages of the experiment.

The Warnings

Video warning. The video warning served to prime subjects' knowledge about digital image editing. We modified a warning from Dreifus (2007):

> In society today, we're now seeing doctored photos and doctored videos regularly. For example, if tabloids can't obtain a photo of Brad Pitt and Angelina Jolie walking together on a beach, they'll make up a composite from two pictures. As a result, we now live in an age when the once-held belief that photographs and videos were reliable records of events is now gone.

Imagination warning. The imagination warning served to alert subjects to the possibility that a clear memory-like mental image could be an imagined event. We modified Landau and von Glahn's (2004) warning:

> Imagining has been found to alter people's confidence that they performed an action. This happens because after imagining, people often don't carefully scrutinize their memory to decide whether the action was real or imagined. In other words, people are often more likely to believe they performed an action if they imagined doing it, because they confuse the details of the imagined memory as real.

Session 1 (Event Phase) and Session 2 (Suggestion Phase)

These sessions were similar to Experiment 1 with some minor changes. To increase the pace of the task, in Session 1 the RA and the subject performed each action for 12 s rather than 15 s. In addition, we shortened the gaps between clips in the video sequence used in Session 2 to 10 s rather than 15 s. Finally, subjects imagined 64 actions in the imagination task in Session 2, rather than 60 actions.

Session 3: Memory Test

The memory test was similar to that used in Experiment 1. Prior to completing the memory test, subjects (except "no-warning" subjects) were exposed to the appropriate warning(s). They listened to audio recordings of the warning(s) and simultaneously viewed the written warning on a computer monitor. Finally, subjects were instructed to consider the warning(s) as they completed the memory test.

Results and Discussion

Once again, subjects appeared to be unaware that the video had been edited, and they expressed surprise when they discovered the real purpose of the study. Only 17% correctly identified one of the critical video actions, and no subjects correctly identified both. Only one subject (who received the video warning) speculated that the study was investigating false evidence; this is surprising given that 50% of subjects received the video warning.

The Effects of Warnings

We conducted two 2 (video vs. no-video) x 2 (imagined vs. not imagined) x 2 (video warning vs. no-video warning) x 2 (imagination warning vs. no-imagination warning) mixed-factor ANOVAs. These analyses revealed no significant interactions or main effects involving the warning variables on either the Belief or Memory measures (all *p*s > .23, largest $\eta_p^2 = .03$; see Table 3). However, there was a non-significant tendency for video-warning subjects to report lower ratings for the critical Video actions than did no-video-warning subjects (pooling across the Video+Imagine and Video-Only actions, $d_{\text{Belief}} = .27$; $d_{\text{Memory}} = .32$). Despite this trend, video-warning subjects still reported moderately high levels of Belief ($M = 5.08$) and Memory ($M = 3.83$) for the two critical Video actions. These findings lead us to conclude that although explicit information about digital editing might prompt people to more systematically evaluate their beliefs and memories, like in Kelly and Nace's (1994) study the warning in this experiment was insufficient to protect subjects from distortions. A stronger or more explicit warning, therefore, might reveal an effect. Our findings contrast with those of Landau and von Glahn (2004), whose results suggest subjects should have successfully used the imagination warning to resist belief and memory distortions.

Why did our warnings fail to significantly influence subjects' Belief and Memory ratings? One possibility is that many subjects simply did not recognise the information as a "warning" per se. Indeed, most "video warning" subjects did not guess the purpose of the study, which suggests that they were not particularly suspicious. This proposition raises an interesting question for future research on warnings: Do warnings only protect people from misinformation if they already suspect they may have been misled? Moreover, although Landau and von Glahn (2004) effectively reduced imagination inflation by warning subjects *after* they imagined events, it is likely that, as in Greene et al.'s (1982) study and the DRM warning studies cited above, our warnings would be more effective if subjects received them *before* seeing the doctored video and imagining.

Belief and Memory Rating

As Figure 3 shows, we replicated the pattern of results obtained in Experiment 1. Doctored videos alone were sufficient to change subjects' beliefs and memories: subjects rated Video-Only actions higher than Control actions on the Belief [$t(47) = 4.35$, $p < .001$, $d_z = .63$] and Memory scales [$t(47) = 4.30$, $p < .001$, $d_z = .62$]. Similarly, they rated Imagine-Only actions higher than Control actions on the Belief [$t(47) = 3.87$, $p < .001$, $d_z = .56$] and Memory scales [$t(47) = 3.79$, $p < .001$, $d_z = .55$]. The differences between Video-Only and Imagine-Only actions were not significant on either measure [Belief, $t(47) = .89$, $p = .38$, $d_z = .13$; Memory, $t(47) = 1.10$, $p = .28$, $d_z = .16$].

Continuing with the within-subject effects represented in Figure 3, the results of the mixed-factor ANOVAs revealed no significant interactions of imagination and false evidence upon Belief [$F(1, 44) = .001$, $p = .97$, $\eta_p^2 < .01$, *95% CI* = $.00 \leq \eta_p^2 \leq .0001$] or Memory ratings [$F(1, 44) = .04$, $p = .85$, $\eta_p^2 < .01$, *95% CI* = $.00 \leq \eta_p^2 \leq .03$], suggesting that the effects operated additively. A further demonstration of this additivity comes from the data in Table 1, which show that subjects' mean Belief and Memory ratings for Video+Imagine actions were extremely similar to those predicted by the independent effects of the doctored video and imagination.

Experiment 2 provides further evidence that imagination can influence people's beliefs and memories about self-involving, recent actions, but so too can false evidence. Moreover, the combination of these techniques leads to significantly more belief and memory distortion than either technique alone, with the two effects appearing to be additive. Finally, neither an explicit post-suggestion warning about digital image editing nor a warning about imagination inflation were sufficient to significantly reduce these effects.

General Discussion

In two experiments, we assessed the individual and combined contributions of imagination and false evidence to the distortion of beliefs and memories. We found that both forms of suggestion are considerably influential. These experiments are the first to demonstrate that false evidence can create false memories of *recent* actions. Consistent with the findings from distant (childhood) memory studies (e.g. Wade et al., 2002), less than two weeks after seeing our doctored videos many subjects confidently reported performing the suggested actions ("Those [the critical video actions] were particularly clear in my mind that I did them. I was 100% clear!"). Whereas Wade and colleagues' false evidence actually depicted subjects performing the fictional act (Garry & Wade, 2005; Nash & Wade, in press; Wade et al., 2002), and other authors have used explicit and affirmative verbal feedback as evidence (Bernstein et al., 2005a; Desjardins & Scoboria, 2007), the false evidence in the present study was less explicit. Indeed, subjects neither saw themselves perform the critical actions nor did they receive a verbal suggestion. This implicit trickery was highly effective despite the fact that over half of subjects in Experiment 2 (58.3%) reported having used digital-editing software in the past.

The combined effects of imagination and false evidence enable us to speculate about how false evidence might influence beliefs and memories. Certainly, there was no indication in either experiment that imagination and false evidence have subadditive effects. This finding suggests that the false evidence effect is not caused by the videos' ability to help people to imagine counterfactual events, because the effect of imagining typically diminishes as one's mental imagery becomes more detailed (Goff & Roediger, 1998; Henkel & Carbuto, in press; Thomas & Loftus, 2002). Rather, our findings of additivity are most supportive of a criterion-based account of the false evidence effect. Guided by the SMF, Mazzoni and Kirsch (2002) proposed that autobiographical distortions are products of the combination of two factors: [1] a lowered memory criterion (i.e., lower expectations for the amount of memorial information required to attribute a mental experience to memory), and [2] enhanced mental imagery. Doctored videos, we expect, provide the first of these two factors—they cause subjects to lower their criteria for attributing images to memory—whereas imagination provides the second. This criteria-based interpretation of our findings can be reframed as follows: Sometimes our subjects experienced false memories if their mental imagery quality was poor, but they had cause to adopt low criteria (Video-Only); similarly, they sometimes experienced false memories if they had high criteria, but their mental imagery quality was also high (Imagine-Only). However, subjects were naturally most susceptible to false memories if they had cause to adopt low criteria *and* their mental imagery quality was high (Video+Imagine).

Nevertheless, in Experiment 1 we obtained some evidence indicative of a superadditive combined effect. Because imagining plausible events causes more memory distortion than does imagining implausible events (Pezdek et al., 2006), it is likely that superadditivity would occur if false evidence works by increasing the perceived plausibility of suggestions. Perhaps, then, the critical actions in Experiment 2—which could well have been more plausible than those in Experiment 1—might be the reason we did not replicate the evidence of superadditivity obtained in Experiment 1. Future research should examine more directly the mechanisms that drive the false evidence effect.

Our findings have practical implications beyond understanding the mechanisms responsible for false beliefs and memories, and raise several important questions for future research. For instance, can video evidence induce people to testify about events that never happened? This is a question we are currently investigating, and we know of at least one real-life case that speaks to this issue. Loftus and colleagues have discussed the case of “Jane Doe,” who apparently recovered memories of abuse during a clinical interview in which she viewed an 11 year-old video of herself recounting those traumatic events (Corwin & Olafson, 1997; Loftus & Guyer, 2002). Although the validity of Jane Doe’s memories has never been proven (or disproven), there is no doubt that seeing the video played a crucial part in persuading Doe that her original accusations were genuine. The videotape shown to Doe would have provided her with two cues: ostensibly clear evidence that she was abused, and vivid childhood imagery such as her appearance at the time. The results of the present study suggest that these two cues are sometimes sufficient for people to create clear false memories of completely fictional events.

Furthermore, does imagination boost the impact of false evidence in eliciting false confessions from criminal suspects? Several studies have shown that presenting innocent subjects with false evidence—a legal interrogation technique used in some countries to elicit confessions (Gudjonsson, 2003)—can increase their likelihood of falsely confessing to and internalizing guilt for a punishable act (Kassin & Kiechel, 1996; Nash & Wade, in press). To the best of our knowledge, no false confession study to date has involved instructing subjects to imagine the "crime" after exposure to false evidence, most likely because of the ethical concerns such a procedure might raise. Our results suggest that the combination of imagination and false evidence in criminal interrogations might be particularly powerful in eliciting internalized false confessions or even false memories of committing a crime.

False evidence can change the past. In this paper, we have shown that even our memories of recent, self-involving events can be modified by subtle and compelling digital trickeries, as well as by imagination, with the two forms of suggestion combining to cause remarkably high levels of belief and memory distortion. The limits of the false evidence effect remain to be seen.

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Appendix A – Outline of procedure

Day 1 – Event phase

Procedure: Subject is filmed observing and copying a research assistant (RA) who performs 26 non-critical actions. All subjects perform the same actions.

Subject leaves and RA is then filmed performing two of the four critical actions. These video clips are used to create two of the critical actions (i.e., the *Video+Imagine* and *Video-Only* actions). They are doctored to depict the subject observing two actions she never observed or performed in the Event Phase.

Day 3 – Suggestion phase

Procedure: First, subject views video clips of herself observing actions during the Event Phase, including 10 non-critical actions that were performed in the Event Phase and 2 non-performed critical actions (*Video+Imagine; Video-Only)*.

Second, subject imagines 15 actions (16 in Expt. 2) four times each, including 13 (14 in Expt. 2) non-critical and 2 non-performed critical actions *(Video+Imagine; Imagine-Only)*.

The *Control* action is not presented in this phase.

Critical actions:

Action in doctored video?	Action imagined? Yes	Action imagined? No
Yes	VIDEO+ IMAGINE	VIDEO-ONLY
No	IMAGINE-ONLY	CONTROL

Approx. Day 15 – Memory test

Procedure: All subjects take the same recognition memory test consisting of 24 non-critical and 4 critical action statements *(Video+Imagine; Video-Only; Imagine-Only; Control)*.

- How likely is it that you performed this action? (*Belief*)
- Do you actually remember performing this action? (*Memory*)

Appendix B – Action lists

Actions used in Experiment 1

Balance cards on the glass of water; Browse through the book; Clap your hands together; Click your fingers; Count to twenty; Cover your face with your hands; Do an impression of a monkey; Flap your arms up and down; Flex your arm; Flip the coin; Kiss the magnifying glass; Look through the magnifying glass; Make binoculars with your hands; Pick up the dice with the spoon; Play the air guitar; Pull a silly face; Pull the rubber band around the book; Push the toy car; Put on the hat; Put the empty cup over your ear; Rattle the coin in the empty cup; Recite the alphabet; Roll the dice; Rub the Q-tip on the toy car; Rub the Q-tip on your eyebrow; Rub the table; Salute; Scratch your nose; Shuffle the deck of cards; Smell the flower; Stand up and then sit down; Stir the water with the spoon; Stretch the rubber band; Tap the flower on your forehead; Throw the hat in the air; Touch your ear to your shoulder; Tug your earlobe; Wave good-bye.

Actions used in Experiment 2

Bite your lip; Blow a kiss; Clap your hands; Clasp your hands together; Click your fingers; Count the fingers on one hand; Count to twenty; Cross your fingers; Cup your hand over your ear; Draw a stick man in the air; Fake a sneeze; Flex your arm; Fold your arms; Furrow your eyebrows; Lean over forward; Lick your lips; Look under the table; Look up toward the ceiling; Make a tight fist; Make binoculars with your hands; Nod in agreement; Play the piano on the desk; Point to your mouth; Raise your arms; Repeat 5914; Rest your head in your hands; Roll your eyes; Rub your eyes; Rub your stomach; Salute; Scratch your nose; Shake your head back and forth; Shrug your shoulders; Slap your thigh; Smooth your hair in the back; Stick out your tongue; Tap your wrist; Tilt back in the chair; Touch your cheek; Touch your ear to your shoulder; Touch your elbow with your thumb; Tug your earlobe; Turn around in a circle; Wave good-bye; Yawn.

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Footnotes

[1] Subjects returned for Session 3 according to their availability. When we conducted analyses that included only the subjects who completed the study within ±2 days of the 15-day ideal (N = 36), the pattern of results did not differ from the results presented.

[2] Interpreting null and significant interactions always relies on the assumption that there are no scaling effects across levels of the DV(s) (Loftus, 1978). Nonetheless, exploring the pattern of effects is an important first step toward understanding joint effects. We followed the convention of treating the Belief and Memory scales as interval measures in order to analyse our data using parametric procedures, yet it is possible these scales are ordinal measures.

[3] Confidence intervals for effect sizes are calculated using software provided by Mike Smithson, available at http://psychology.anu.edu.au/people/smithson/details/CIstuff/CI.html

Table 1. *Predicted and Observed Mean Ratings for Video+Imagine Actions in Experiments 1 and 2.*

	Predicted mean rating	Observed mean rating	*p* (one-sample t-test)
Experiment 1			
Belief	5.38	5.87	.20
Memory	3.45	4.79	.002
Experiment 2			
Belief	6.13	6.15	.96
Memory	4.83	4.94	.77

Table 2. *Mean Belief and Memory Ratings as a Function of Memorability and of Presence or Absence of Video and Imagination (SD in parentheses).*

	Belief			Memory		
	Memorability					
	High	Low	Total	High	Low	Total
No-video	2.30	3.32	2.81	1.85	2.26	2.05
	(2.23)	(2.49)	(2.40)	(2.16)	(2.19)	(2.17)
Video	4.30	5.55	4.93	3.15	4.36	3.76
	(2.77)	(2.63)	(2.76)	(2.79)	(2.74)	(2.82)
Not imagined	2.30	3.79	3.04	1.55	2.83	2.19
	(2.09)	(2.69)	(2.51)	(1.53)	(2.51)	(2.17)
Imagined	4.30	5.09	4.69	3.45	3.79	3.62
	(2.87)	(2.74)	(2.82)	(3.02)	(2.79)	(2.90)
Total	3.30	4.44	3.87	2.50	3.31	2.90
	(2.70)	(2.78)	(2.79)	(2.56)	(2.68)	(2.65)

Note: Each row represents mean ratings for two critical actions combined. For example, the 'no-video' data combine ratings for Imagine-Only and Control actions.

Table 3. *Mean Belief and Memory Ratings as a Function of the Presence or Absence of Each Warning Type (SD in parentheses).* N *=24 for each row.*

Warning condition	Video+ Imagine	Video-Only	Imagine-Only	Control
Belief				
No Video-warning	6.46 (2.06)	5.00 (2.50)	4.08 (2.38)	2.79 (1.72)
Video-warning	5.83 (2.33)	4.33 (2.79)	4.29 (2.40)	2.67 (1.58)
No Imagination-warning	6.00 (2.52)	4.71 (2.42)	4.21 (2.17)	2.54 (1.38)
Imagination-warning	6.29 (1.88)	4.63 (2.90)	4.17 (2.60)	2.92 (1.86)
Memory				
No Video-warning	5.46 (2.38)	3.88 (2.64)	2.92 (2.43)	1.71 (1.33)
Video-warning	4.42 (2.71)	3.25 (2.69)	3.00 (2.47)	1.67 (1.52)
No Imagination-warning	5.25 (2.59)	3.63 (2.48)	3.04 (2.22)	1.58 (1.21)
Imagination-warning	4.63 (2.58)	3.50 (2.87)	2.88 (2.66)	1.79 (1.62)

Note: Each row represents mean ratings for two warning conditions. For example, the 'no video-warning' data combine ratings for Imagination-Warning-Only and No-Warning subjects.

Figure Captions

Figure 1. The video-doctoring process. In (a), the subject (right) observes the RA perform an action during Session 1; in (b), the RA performs an extra action after the subject has gone; (c) is a composite of the right side of (a) and the left side of (b).

Figure 2. Mean Belief and Memory ratings across conditions in Experiment 1. Error bars represent 95% within-subject confidence intervals (Loftus & Masson, 1994).

Figure 3. Mean Belief and Memory ratings across conditions in Experiment 2. Error bars represent 95% within-subject confidence intervals (Loftus & Masson, 1994).

FIGURE 1

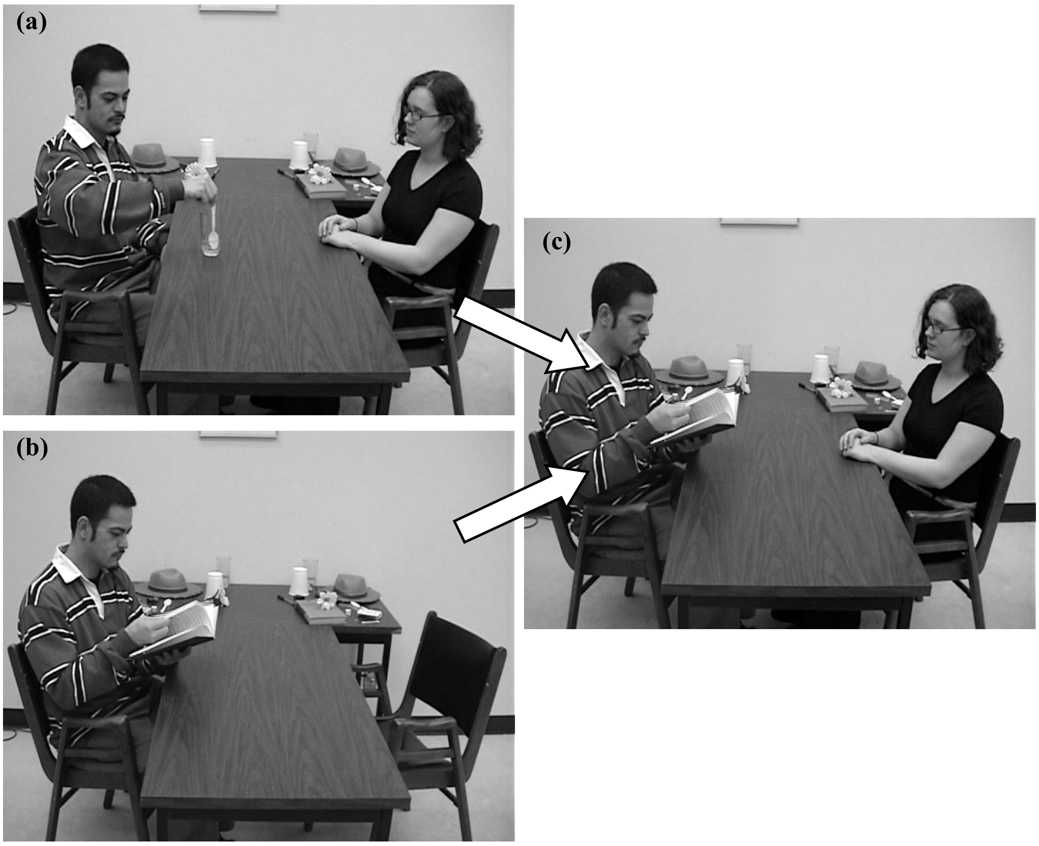
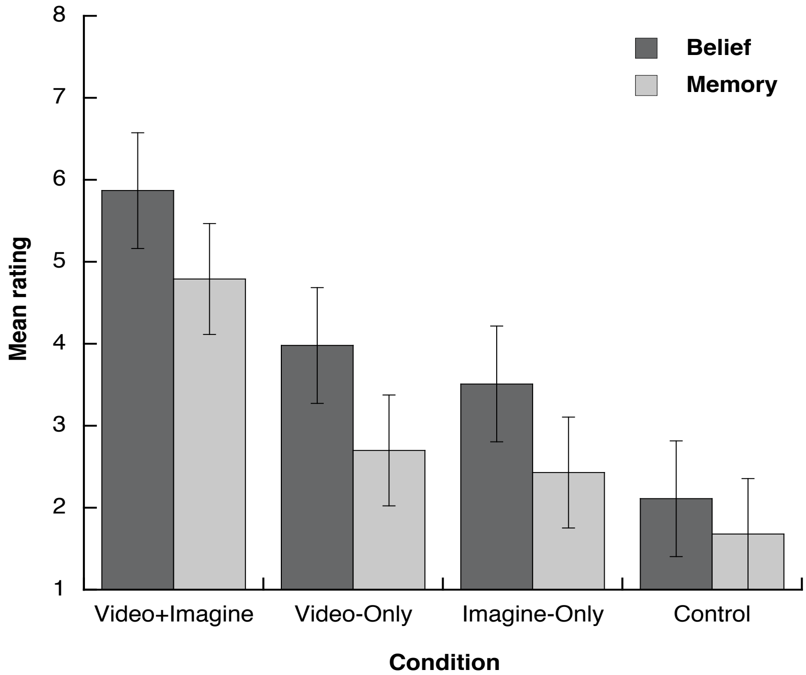


FIGURE 2


8
7
6
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4
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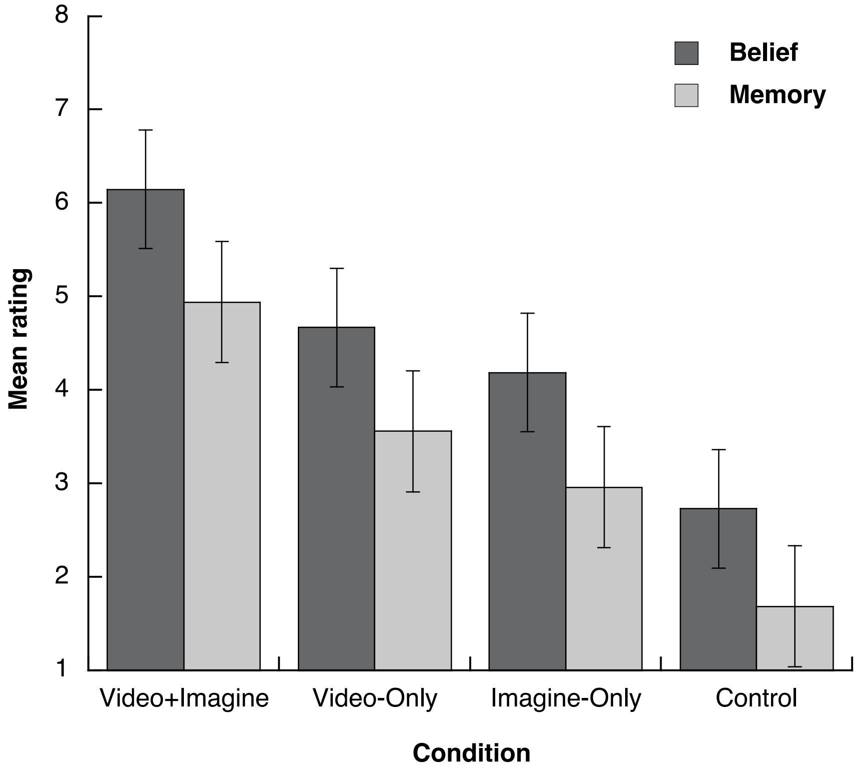
2
1
Mean rating
Belief
Memory
Video+Imagine
Video-Only
Imagine-Only
Control
Condition

FIGURE 3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Mean rating
Belief
Memory
Video+Imagine
Video-Only
Imagine-Only
Control
Condition