

He did it! She did it! No, she did not! Multiple causal explanations and the continued
influence of misinformation

Ullrich K. H. Ecker¹, Stephan Lewandowsky^{2,1}, Candy S. C. Cheung¹ & Murray T. Maybery¹

¹ University of Western Australia, ² University of Bristol

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Contact: Ullrich Ecker, School of Psychology, University of Western Australia (M304),
Crawley 6009, Australia; Phone: +618 6488 3257; Fax: +618 6488 1006; E-mail:
ullrich.ecker@uwa.edu.au

Abstract

Two types of misinformation effects are discussed in the literature—the *post-event misinformation effect* and the *continued influence effect*. The former refers to the distorting memorial effects of misleading information that is presented after valid event encoding; the latter refers to information that is initially presented as true but subsequently turns out to be false and continues to affect memory and reasoning despite the correction. In two experiments, using a paradigm that merges elements from both traditions, we investigated the role of presentation order and recency when two competing causal explanations for an event are presented and one is subsequently retracted. Theoretical accounts of misinformation effects make diverging predictions regarding the roles of presentation order and recency. A recency account—derived from time-based models of memory and reading comprehension research suggesting efficient situation model updating—predicts that the more recently presented cause should have a stronger influence on memory and reasoning. By contrast, a primacy account—derived from primacy effects in impression formation and story recall as well as findings of inadequate memory updating—predicts that the initially presented cause should be dominant irrespective of temporal factors. Results indicated that (1) a cause’s recency, rather than its position (i.e., whether it was presented first or last) determined the emphasis that people place on it in their later reasoning, with more recent explanations being preferred; and (2) a retraction was equally effective whether it invalidated the first or the second cause, as long as the cause’s recency was held constant. This provides evidence against the primacy account and supports time-based models of memory such as temporal distinctiveness theory.

He did it! She did it! No, she did not! Multiple causal explanations and the continued influence of misinformation

Misinformation is known to influence one's memory and inferential understanding of unfolding events and causalities. One frequently studied type of misinformation relates to suggestive misinformation presented to witnesses of an event after they have experienced it. Such *post-event misinformation* is known to qualitatively distort event memories (Ayers & Reder, 1998; Chrobak & Zaragoza, 2013; Frenda, Nichols, & Loftus, 2011; Loftus, Miller, & Burns, 1978; Loftus & Hoffman, 1989; Paz-Alonso & Goodman, 2008). For example, if a witness is questioned about a car accident and a "Stop" sign is wrongfully mentioned, the witness may remember such a sign even if there was none present during the actual event (Loftus et al., 1978). Thus, a post-event misinformation effect on memory is said to occur when people at retrieval rely on misinformation that was encoded *after* the accurate information.

A second type of misinformation, which has attracted increasing research interest over the last few years, relates to information that is initially presented as factual but subsequently corrected. In this case, misinformation can affect people's memory and reasoning after it has been retracted, and even when people acknowledge and demonstrably remember the retraction (e.g., Ecker, Lewandowsky, Swire, & D. Chang, 2011b; Ecker, Lewandowsky, & Tang, 2010; Guillory & Geraci, 2013; H. M. Johnson & Seifert, 1994; Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012; Nyhan & Reifler, 2010; Seifert, 2002; Wilkes & Leatherbarrow, 1988). This effect of misinformation is commonly referred to as the *continued influence effect* (CIE; H. M. Johnson & Seifert, 1994). For example, people may continue to refer to a terrorist attack as the cause of a plane crash even when this initial suspicion is found to be baseless (Ecker, Lewandowsky, & Apai, 2011a). A real world example of the CIE is some people's persistent belief in the debunked claim that autism can

result from childhood vaccinations (Hargreaves, Lewis, & Speers, 2003), or that weapons of mass destruction were found in Iraq after the invasion of 2003 (Lewandowsky, Stritzke, Oberauer, & Morales, 2005; Lewandowsky, Stritzke, Freund, Oberauer, & Krueger, 2013). Thus, a CIE is said to occur when people at retrieval rely on misinformation that was encoded *before* the accurate information.

As misinformation can have potentially serious consequences when it influences our memory, inferential reasoning, and decision making (for a review of the implications of the CIE, see Lewandowsky et al., 2012), it is important to investigate why and how such effects occur. A number of theories have been proposed to explain post-event misinformation effects and the continued influence effect. Not surprisingly, the time of presentation of the misinformation, relative to the encoding of the correct information, has been an influential notion in this theorizing.

In the post-event misinformation literature, memory impairment accounts have suggested that post-event misinformation interferes with the original event memory representation, by either partially overwriting the original memory trace (Belli, Lindsay, Gales, & McCarthy, 1994; Loftus & Palmer, 1974; Loftus et al., 1978; but see McCloskey & Zaragoza, 1985), or by blocking the original memory trace at retrieval (Bowers & Bekerian, 1984; Loftus et al., 1978). This notion predicts that the information that is presented most recently will dominate at retrieval because it can overwrite or block the older memory trace. Likewise, time-based theories of memory argue that more recently encoded information is more strongly activated in memory, and may thus block access to the earlier-encoded original memory trace (cf. Ayers & Reder, 1998; Loftus, 2005).

Recency effects occur in many memory tasks (e.g., see Baddeley & Hitch, 1993, for a review), and there are various reasons why more recently acquired representations should be stronger or more easily accessible in memory. One notion invokes time-based decay of

memory traces (e.g., Barrouillet, Bernardin, Portrat, Vergauwe, & Camos, 2007), although there is now growing evidence against a role of trace decay in forgetting (especially in the case of verbal memoranda in short-term working memory, but also on longer time-scales; see Berman, Jonides, & Lewis, 2009; Brown & Lewandowsky, 2010; Brown, Neath, & Chater, 2007; Ecker & Lewandowsky, 2012; Oberauer & Lewandowsky, 2013). Even if memory traces do not literally decay, access to details may decline over time, making reliance on more recently encoded information more likely (for an application of this notion to post-event misinformation effects, see Pansky, Tenenboim, & Bar, 2011; Reyna & Brainerd, 1995).

Another time-based account that predicts more recently encoded information to be more accessible is temporal distinctiveness theory (cf. Bjork & Whitten, 1974; Brown et al., 2007; Crowder, 1976; Ecker, Brown, & Lewandowsky, in press; Ecker, Tay, & Brown, 2015; Neath & Crowder, 1990). Temporal distinctiveness theory assumes that items in memory are organized by their time of encoding and that this temporal context can serve as a retrieval cue for memory access. The theory assumes that psychological time is compressed such that older memory traces become more difficult to discriminate as time passes, resulting in facilitated retrieval of more recent information. J. R. Anderson and Schooler (1991) showed that a memory system following the core principles of temporal distinctiveness theory—in particular facilitated access to recent information—would result naturally from adaptation to the environment humans have evolved in.

A final line of research that predicts a strong impact of recent (e.g., post-event) misinformation on reasoning is research on reading comprehension, suggesting that by-and-large, people are highly efficient at keeping their mental models of unfolding situations up-to-date. In general terms, this approach argues that when people encode information about causal interrelations or an unfolding event, they build a situation model based on the initial information they receive (Bower & Morrow, 1990; van Dijk & Kintsch, 1983). When

presented with new information that indicates change, this situation model is continuously updated in order to accurately reflect the current state-of-affairs (e.g., Albrecht & O'Brien, 1993; Glenberg, Meyer, & Lindem, 1987; Hamm & Hasher, 1992; Morrow, Bower, & Greenspan, 1989; Radvansky, Lynchard, & von Hippel, 2008; Rapp & van den Broek, 2005; Theriault & Rinck, 2007). Updating can be incremental or global in nature (Kurby & Zacks, 2012): When there are minor changes that occur within a broader event or situation, the additional information is integrated in the current situation model in an incremental fashion—for example, when following the protagonist of a novel, an incremental update may reflect the protagonist interacting with a new person or object in the same situation. When faced with an entirely new situation, however, a new situation model is created from scratch—such a global update may reflect the protagonist moving into a different situation such as another place or time. The new situation model is then “foregrounded” in memory, while the outdated situation model is “moved to the background,” that is, its activation decreases to a background level (Glenberg et al., 1987; Radvansky, Krawietz, & Tamplin, 2011).

This recency view can naturally explain post-event misinformation effects; however, it cannot explain the CIE. Obviously, preferential reliance on more recently provided information cannot explain why people continue to be influenced by subsequently corrected misinformation. The CIE thus seems at odds with a recency view and instead suggests a primacy account of misinformation effects.

Primacy effects are well-known in short-term list recall (cf. Jones & Oberauer, 2013); they may occur because initial information receives more rehearsal (Tan & Ward, 2008), more attention at encoding (Farrell & Lewandowsky, 2002; Page & Norris, 1998), or because initial information is more distinct in the absence of proactively interfering information (Brown et al., 2007; Henson, 1998). Importantly, primacy effects have also been reported in impression formation (N. H. Anderson & Hubert, 1963; Ash, 1946; Belmore, 1987; Dreben,

Fiske, & Hastie, 1979; Jackson & Greene, 2014; also see Hogarth & Einhorn, 1992; van Overwalle & Labiouse, 2004) and long-term memory (Copeland, Radvansky, & Goodwin, 2009; Li, 2010; Nairne, 1991; Neath, 2010; Rubin, 1977). For example, when judging a person after receiving a series of descriptors, initial items have a stronger influence on the retrospective judgment than later ones (e.g., Drebien et al., 1979); when recalling a novel, the first chapters of the novel show a recall advantage (Copeland et al., 2009). In this context, it has been argued that early information is more thoroughly processed in order to create an early person impression or situation model that can serve as a framework or anchor for the organization, interpretation, and integration of subsequent information (Belmore, 1987; Copeland et al., 2009; Hogarth & Einhorn, 1992).

In a similar vein, it has been proposed in the context of the CIE that the primary situation model that people build when encoding narratives or news reports is particularly well integrated in memory, with people showing a primacy effect, viz. a bias towards their initial interpretation (Schul & Mayo, 2014). Moreover, various researchers have suggested that primary situation models are resistant to subsequent change if the change involves the invalidation of information previously believed to be accurate (H. M. Johnson & Seifert, 1994, 1999; Rapp & Kendeou, 2009; van Oostendorp, 1996; Wilkes & Leatherbarrow, 1988; also see Zwaan & Radvansky, 1998). Schul and Mayo (2014) argued that most corrections in this case are superficial and occur at the response level rather than through substantial reinterpretation and reintegration of the situation model. In terms of the distinction between incremental and global updating discussed earlier, one explanation for the CIE might thus be that people engage in incremental updating when faced with corrections that actually require more fundamental global updating. This applies in particular if there is no information available to readily replace the retracted misinformation, in which case the invalidated information may merely be tagged as incorrect in the existing situation model (Ecker et al.,

2011b; Gilbert, Tafarodi, & Malone, 1993; Mayo, Schul, & Burnstein, 2004; Nadarevic & Erdfelder, 2013). This implies that, while a retraction creates a “gap” in the situation model, the misinformation—which is tagged as false but not removed—remains available and may influence reasoning if the tag is not retrieved alongside the misinformation (see Ecker et al., 2010, 2011a; O’Brien, Rizella, Albrecht, & Halleran, 1998).

By contrast, global updating may be facilitated when a plausible alternative explanation is available, which reduces CIEs—in the plane crash example, if evidence of a mechanical fault is presented together with the retraction of the initially assumed terrorist attack, references to the attack are diminished (Ecker et al., 2010, 2011a; H. M. Johnson & Seifert, 1994; Seifert, 2002; also see Mayo et al., 2004). Small CIEs still occur, however (e.g., Ecker et al., 2010, 2011a), perhaps because after a global update, out-dated situation models may just be moved to the “mnemonic background” rather than being removed altogether (Radvansky et al., 2011). Various authors (Ayers & Reder, 1998; Kendeou & O’Brien, 2014; Schul & Mayo, 2014) have proposed that reliance on misinformation arises in such situations because valid and invalidated memory representations (i.e., current and out-dated situation models) coexist and compete for activation, and that the more active or accessible representation may determine responses even when it is evidently incorrect.

In sum, we have reviewed two models that have been used to explain misinformation effects. The *recency model* predicts that misinformation that is presented more recently than the corresponding valid piece of information will be stronger in memory. The recency model offers a natural explanation of post-event misinformation effects in general, and for the CIE paradigm it predicts that misinformation may be more difficult to retract if it is relatively recent. The recency model is supported by the memory-impairment theory of post-event misinformation effects and time-based theories of memory, as well as findings relating to the ease with which people generally update their situation models. By contrast, the *primacy*

model naturally explains the CIE in general, and predicts that misinformation that is part of the initial situation model will be strongly integrated in memory and will thus be most difficult to retract. The primacy model is supported by the primary-situation-model account of continued-influence effects, as well as primacy effects in impression formation and long-term story recall. These two models make straightforward predictions concerning the question of whether more or less recent information will dominate reasoning, in part because they pertain to different phenomena (viz. the post-event and CIE misinformation effects) that coincidentally involve different orders of valid and invalid information.

The Present Study

The present study was designed to test the contrasting predictions of the recency and primacy models. We applied a novel experimental approach, merging elements of the post-event misinformation and CIE paradigms. To this end, we utilized reports describing a series of events and manipulated whether the misinformation came before or after the valid event description. In Experiment 1, we presented verbal reports containing two independent but not mutually exclusive causal explanations for an event, and then retracted either the initially or the more recently given cause (or neither). We used an open-ended questionnaire to test whether reliance on misinformation during later reasoning was influenced by the presentation order, that is, by whether the later-retracted misinformation was presented before or after the valid information. Experiment 2 replicated Experiment 1, but with a tighter control of the retention interval of the retracted cause, and the interval between misinformation and retraction.

Experiment 1

Experiment 1 used reports presenting two causal explanations for an event and then retracting either the first or the second cause (or neither in the no-retraction control

condition). It tested whether reliance on retracted misinformation during later reasoning was affected by whether the retraction targeted the initial or the recent cause.

Method

Each participant received a report describing an event—a school bus accident—with two potential causes, namely a blown tyre (cause A) or a violently merging car (cause B). The two causes were presented one after the other; the cause mentioned first (irrespective of whether it is A or B) will be referred to as cause 1 from here on, and the second cause will be referred to as cause 2. Presentation order of causes A and B was counterbalanced (i.e., A-B, B-A) and entered as a control factor into the analysis. The main factor of interest was the retraction variable (no-retraction, retract-1, retract-2) that manipulated which of the two causes was retracted and hence deemed to be misinformation. The no-retraction condition served as a control condition against which the effects of the retraction were assessed. Experiment 1 thus used a 2 (control factor: presentation order of actual causes) \times 3 (retraction condition) between-subjects design.

Participants. A priori power analysis suggested a minimum sample size of 114 participants to detect a medium size effect ($\eta_p^2 = .08$, $\alpha = .05$, $1-\beta = .80$). A total of 126 undergraduate students from the University of Western Australia participated in this study for course credit (96 females, 30 males; mean age was $M = 18.56$ [$SD = 3.34$] years). Participants were randomly assigned to one of six experimental conditions (detailed below).

Stimuli. A report consisting of 15 messages detailing a fictitious scenario of a school bus accident (see Appendix A) was presented using a Microsoft PowerPoint presentation. Each slide presented one message for a fixed time; based on pilot testing, presentation time for each message was set to $350 \text{ ms} \times$ the number of words in the message—this allowed for comfortable reading without excessive slack time.

In all conditions, Message 4 provided the first causal explanation. For cause A-B conditions, it provided cause A: “...*the driver lost control of the bus because a front tyre burst...*”. In cause B-A conditions, Message 4 presented cause B: “...*the bus driver...lost control during an emergency braking...after a car had violently merged into his lane*”. Message 9 provided the second causal explanation (i.e., cause B in cause A-B conditions and cause A in cause B-A conditions).

Message 13 provided the retraction of either cause A (...*the burst tyre was not the cause of the accident*) or cause B (...*though there had been other vehicles present...none were causally involved in the accident*), depending on the condition. In the no-retraction control conditions, this message provided a neutral statement.

A pilot test using 22 participants (15 females, 7 males, mean age $M = 19.50$ [$SD = 3.41$] years; none of whom participated in Experiment 1) was performed to ensure equal plausibility of the two causal explanations. Participants read the first four messages of the scenario in which Message 4 presented either cause A or cause B, and rated the plausibility of the accident cause on a 5-point Likert scale from ‘very implausible’ to ‘very plausible’. There was no difference between the plausibility of cause A ($M = 3.64$, $SD = .81$) and cause B ($M = 3.36$, $SD = .92$), $t < 1$.

Procedure. Participants were tested individually. They first viewed the slideshow, aware of an upcoming comprehension test. After an unrelated five-minute distractor task (a word puzzle), participants completed a 20-item open-ended questionnaire designed to test memory and understanding of the report. The questionnaire contained nine inference questions, followed by eight fact-recall questions, an additional tenth inference question (which was phrased like a fact-recall question directly targeting the cause of the crash and was therefore presented after the fact questions) as well as two retraction-awareness questions. All questions are given in Appendix B.

The inference questions were designed to elicit references to the critical information (i.e., aspects of the incident that were directly or indirectly linked to the cause of the school bus accident). For example, the questions “*Why was the bus-driver unable to avoid the crash?*” and “*What do you think caused the squeaking and rumbling sounds before the bus hit the bicycle?*” could be answered by referring to the school bus’ burst tyre (i.e., cause A), the car that merged in front of the bus (i.e., cause B), both, or neither.

The fact-recall questions were designed to target memory for the factual details presented in the scenario, such as “*On which day did the accident occur?*” and “*Which hospital were the injured taken to?*” These questions were not directly related to the cause of the accident and were included mainly to check adequate encoding of the scenario. The retraction-awareness questions (e.g., “*Was any of the information in the story subsequently corrected or altered? And if so, what was it?*”) served to check participants’ awareness of the retraction.

Results

Coding procedure. Questionnaires were scored by a scorer who was blind to experimental conditions, following a standardized scoring guide. A second scorer scored a set of 24 randomly selected questionnaires (four from each condition) to assess inter-rater reliability, which was found to be high ($r = .91$ and $.90$ for the inferences made with reference to cause A and B, respectively; $.93$ for the fact-recall questions; $.90$ for the retraction awareness questions).

Analysis focused on four dependent measures: the fact-recall score, recall of the retraction, and the two inference scores, coding the mean number of references made to cause 1 (refs-to-1) and cause 2 (refs-to-2). Fact-recall questions were given a score of 1 for a correct response and 0 for an incorrect response. Responses containing partially correct information were given a score of 0.5. For example, for the question “*What did the bus crash*

into after hitting the cyclist?”, participants received a score of 1 if they responded with *“window of a music store”* but only received a score of 0.5 if they responded with *“a store”*. The maximum fact-recall score was 8. Fact-recall scores were used to ensure adequate encoding; no participant scored lower than 1, and thus all participants were retained for analysis. The retraction awareness questions were scored 1 if they indicated recall of the retraction; maximum score was 2.

For the inference scores, any uncontroverted reference made to a faulty tyre causing the crash was given a score of 1 for cause A. Examples of such inferences included *“[the accident was caused by] scrap metal left lying on the road which burst the tyre”* and *“the accident would have been avoidable if the construction site company kept the roads free of scrap metal”*. Any uncontroverted reference to another car as the cause of the crash was given a score of 1 for cause B. Examples of such inferences included *“the other driver should pay for the damages”* and *“the bus-driver was cut off by another car”*. It is important to stress that only causal and uncontroverted references were scored as reference to the critical information. For example, responses like *“first it was stated it was a burst tyre but this was later changed”* were given a score of 0 for cause A. The maximum inference score was 10.

Fact recall. Fact-recall scores across conditions were $M = 4.75, 4.29, \text{ and } 4.18$ (out of 8; $SE = .24, .22, .24$) in the no-retraction, retract-1, and retract-2 conditions, respectively. A one-way between-subjects ANOVA found no main effect of retraction condition, $F(2,123) = 1.66, MSE = 2.33, p = .19$.

Retraction awareness. The no-retraction control condition did not feature a retraction and was thus excluded from this analysis. Retraction awareness was generally high, with 89 % of participants in the retraction conditions reporting awareness of the retraction (i.e., retraction awareness scores of 1 or 2). Mean retraction awareness scores were $M = 1.26$

and 1.29 (out of 2, $SE = .11$ and $.11$) in the retract-1 and retract-2 conditions, respectively. A one-way ANOVA found no effect of retraction condition, $F < 1$.¹

Inference scores. A multivariate analysis of variance (MANOVA) was used to assess the effects of presentation order (A-B, B-A) and retraction condition (no-retraction, retract-1, retract-2) on the number of references to cause 1 (refs-to-1) and references to cause 2 (refs-to-2). As expected, there was no main effect of presentation order, $F < 1$, nor a significant interaction with retraction condition, Wilks' Lambda = .94, $F(4,238) = 1.73$, $p = .14$. Hence, Figure 1 shows the mean number of references to cause 1 and references to cause 2 in the three retraction conditions, collapsed across cause A-B and B-A versions of the scenarios (resulting in $N = 42$ per condition)². The MANOVA showed a reliable effect of retraction on the number of refs-to-1 and refs-to-2, Wilks' Lambda = .87, $F(4,238) = 4.27$, $MSE_1 = 4.07$, $MSE_2 = 5.26$, $p = .002$, $\eta_p^2 = .07$.

The omnibus analysis was followed up with planned contrasts. First, we explored the extent to which the first or the second cause prevailed when neither cause was retracted. We compared the number of references to cause 1 ($M = 2.07$, $SE = .29$) with the number of references to cause 2 ($M = 2.64$, $SE = .41$) in the no-retraction condition and found no significant difference between the two, $F(1,41) = 1.13$, $MSE = 6.05$; $p = .29$.

We then investigated the effectiveness of retractions to reduce references to misinformation. To this end, we compared the number of references to cause 1 and cause 2 in the no-retraction control condition with the condition where the respective cause was retracted. As expected, this showed that the number of references to cause 1 in the no-

¹ Excluding participants who did not indicate awareness of the retraction from the subsequent analysis of inference scores did not change the obtained result pattern; the means obtained from this analysis are shown as dots in Figure 1.

² Presentation order was also included as a control factor in the subsequent analyses but had no significant impact. Hence, in the following, presented data are collapsed across A-B and B-A versions.

retraction control condition was higher than the number of references to cause 1 after its retraction ($M = 1.26, SE = .22$), $F(1,82) = 4.89, MSE = 2.82; p = .03; \eta_p^2 = .06$, demonstrating that the retraction of cause 1 reduced references to it. By contrast, however, we found no difference between the number of references to cause 2 in the no-retraction control condition and the number of references to cause 2 after it was retracted ($M = 2.48, SE = .31$), $F < 1$. This suggests the retraction of cause 2 was ineffective in reducing references to cause 2.³

We then contrasted the effectiveness of the cause-1 and cause-2 retractions directly by comparing the number of references to cause 1 after cause 1 was retracted with the number of references to cause 2 after cause 2 was retracted. There were more references to cause 2 after the cause-2 retraction than references to cause 1 after the cause-1 retraction, again suggesting a greater post-retraction CIE (i.e., a less effective retraction) of the second cause, $F(1,82) = 10.30, MSE = 3.01; p = .002; \eta_p^2 = .11$.

To examine the extent to which one cause prevailed after the *alternative* cause was retracted, we compared the number of references to cause 1 after a retraction of cause 2 with the number of references to cause 2 after a retraction of cause 1. The number of references to cause 2 after a cause-1 retraction ($M = 3.76, SE = .36$) was somewhat larger than the number of references to cause 1 after a cause-2 retraction ($M = 2.81, SE = .39$), suggesting that the second cause tended to have a stronger impact on reasoning than the first, even when the alternative cause was retracted, $F(1,82) = 3.25, MSE = 5.85; p = .07; \eta_p^2 = .04$.

Based on the observed superiority of cause 2 over cause 1, we explored whether this might be a result of time, and thus ran a stepwise linear regression, recoding the refs-to-1 and refs-to-2 variables into a single 'references' variable, predicted by presentation order (A-B, B-A), retraction (yes, no), and retention interval coded as the number of messages between

³ The interaction effect was not tested because the comparison of the number of refs-to-1 and refs-to-2 was within-subjects in the no-retraction condition but between-subjects in the retraction conditions.

presentation of the referred-to cause and test (i.e., 6 vs. 11). This analysis yielded a significant effect of retention interval ($B = -.15$ [$SE = .06$], $\beta = -.16$, $t(249) = -2.59$, $p = .01$) and a retention interval \times retraction interaction ($B = -.11$ [$SE = .03$], $\beta = -.21$, $t(249) = -3.34$, $p = .001$; overall model: $R^2 = .081$, adjusted $R^2 = .074$, $F(2,249) = 11.04$, $p < .001$). This suggests that references were more likely to be made to a more recently presented cause.

Discussion

Experiment 1 examined the effects of two competing causal explanations for an event on the continued influence effect of misinformation. The data suggest that when two causes of an event are presented, the more *recently* encoded second cause is dominant in memory and attracts greater reliance in later reasoning. This conclusion arises from two features of the data: First, a retraction reduced the number of references to a critical piece of information compared to no retraction only when the misinformation was presented *before* the valid event information (i.e., as the first cause); the size of this effect is comparable to previous research on misinformation retractions (e.g., Ecker et al., 2010, 2011a). By contrast, a retraction had no effect if the retracted misinformation was presented *after* the valid event information (i.e., as the second cause). Second, when an alternative cause was retracted, the more recent second cause influenced inferential reasoning to a greater extent than the first cause. That is, there were more references to cause 2 after cause 1 had been retracted, compared to the number of references to cause 1 after cause 2 had been retracted. Thus, participants clearly favoured the most recent cause after a retraction of an earlier-presented alternative cause, but there was no clear preference for either cause after retraction of the more recently presented one.

We address a potential criticism of Experiment 1 before discussing its theoretical implications: One could argue that participants simply assumed that the second cause superseded the first because it was presented more recently, and that an explicit retraction of

cause 1 was effective only because it retracted an already implicitly retracted cause. We acknowledge that this supersession account may offer a viable explanation of our data. However, we note that the two causes were designed not to be mutually exclusive; that is, there was no strong reason for participants to assume that the second cause invalidated the first. Moreover, and more important, in the no-retraction condition, the number of references to the two causes did not differ significantly; this replicates earlier research presenting two plausible explanations for a target event without a retraction (Blanc, Kendeou, van den Broek, & Brouillet, 2008). If it were true that presentation of a second cause effectively acted as an implicit retraction of the first, one would have to assume a difference in the number of references to the two causes in the no-retraction condition. Our results suggest that such an effect either does not exist or was too small to be detected with the available power of Experiment 1, and thus we conclude that there is little evidence in the present data to suggest that this simple supersession explanation can account for the observed continued-influence effects. We will return to this issue in the Results section of Experiment 2.

The primacy model predicted that initially presented information should prevail in memory. Misinformation presented early should thus be more difficult to retract or correct than misinformation that is presented later. The results of Experiment 1 clash with the predictions of this model. Instead, they are more in line with the recency model derived from memory theories that explain forgetting with reference to time and interference. Interference theory predicts that stronger memory items interfere with the retrieval of weaker memory items (e.g., cf. Marche, 1999; Ratcliff, Clark, & Shiffrin, 1990). The strength of memory items is in turn related to their recency, as emphasized by time-based theories of memory. Temporal distinctiveness theory, for example, argues that psychological time is compressed as it passes, making memories more difficult to retrieve because interference from neighboring items increases with longer retention intervals (Brown et al., 2007; Ecker et al.,

in press). Our finding that the more recently presented cause is both more resistant to retraction, and more dominant if the alternative cause is retracted, thus supports the recency model predictions derived from time-based theories of memory.

However, the report structure in Experiment 1 made it difficult to assess the effects of all the temporal factors involved. This is because we held constant the intervals between the first cause and test, the second cause and test, and the retraction and test, but we did not control the retention interval of the retracted and the non-retracted cause, or the misinformation-retraction interval (cf. Table 1, top panel). Thus, in Experiment 1, three relevant temporal intervals differed across retract-1 and retract-2 conditions: If the first cause was retracted, the retention intervals of the retracted and the non-retracted causes were 11 and 6 messages (plus the distractor-task interval), respectively, and the misinformation-retraction interval was 9 messages. If the second cause was retracted, the retention intervals of the retracted and the non-retracted causes were 6 and 11 messages (plus the distractor-task interval), respectively, and the misinformation-retraction interval was 4 messages. Because of this difference, it was not possible to unequivocally infer from Experiment 1 whether effects were conveyed by order or absolute recency.

In particular, the variation of the retracted-cause retention interval could explain some of the results of Experiment 1. The retention interval was shorter (and arguably, memory strength greater) for the retracted cause in the retract-2 condition compared to the retract-1 condition. Likewise, the variation of the non-retracted-cause retention interval can explain the dominance of the more recent cause after retraction of the alternative—the retention interval was shorter (and arguably, memory strength greater) for the non-retracted cause in the retract-1 condition than the retract-2 condition. It is therefore unclear from Experiment 1 whether the dominance of the more recent cause after a retraction is due to its position within the script or its recency. Finally, the misinformation-retraction interval variation in

Experiment 1 might have affected the results to the extent that retractions are more effective when they occur soon after misinformation is presented. This is a reasonable hypothesis, despite some evidence to the contrary—for example, H. M. Johnson and Seifert (1994) found equivalent CIEs after immediate and delayed retractions (also see Wilkes & Reynolds, 1999).

Not all of these three temporal intervals can be equated concurrently. In Experiment 2, we therefore decided to equate the retention interval of the retracted cause and the misinformation-retraction interval, while maximizing the between-condition difference in the retention interval of the non-retracted cause. If the number of references to a given cause is based on the presence (or absence) of a retraction and the *position* of a cause, rather than its recency, then we would expect a replication of the results of Experiment 1: the second cause should always dominate subsequent reasoning and a retraction should be less effective for the second cause. If, however, the number of references to a cause is based on the presence (or absence) of a retraction and the absolute *recency* of the cause, rather than its position, then we would expect a retraction of cause 1 to be as effective as a retraction of cause 2 because the retention interval of both causes is the same across conditions. By contrast, we would expect that cause 2 should dominate after the retraction of the alternative cause 1 (relative to reliance on cause 1 after retraction of the alternative cause 2), due to the large retention interval difference for non-retracted causes between retract-1 and retract-2 conditions.

Experiment 2

Experiment 2 was a conceptual replication of Experiment 1, controlling the retention interval of the retracted cause, and the interval between misinformation and retraction. Like Experiment 1, Experiment 2 used reports presenting two causal explanations for an event and then retracting either the first or the second cause (or neither in the no-retraction control conditions). It tested whether reliance on retracted misinformation during later reasoning was affected by whether the retraction targeted the initial or the recent cause.

Method

Experiment 2 was identical to Experiment 1, with two differences: (1) the report structure (i.e., the number and order of messages) was changed, with associated changes in temporal intervals (detailed below), and (2) a second no-retraction control condition was added to allow for retraction vs. no-retraction condition comparisons unconfounded by temporal differences. Thus, Experiment 2 used a 4 (retraction condition: no-retraction-1, no-retraction-2, retract-1, retract-2) \times 2 (presentation order: A-B, B-A) between-subjects design. The four different retraction conditions are illustrated in Figure 2 and the lower panel of Table 1.

Participants. Given the non-significance of the presentation order control factor in Experiment 1, we expected that data would again be collapsed across the two different orders (A-B, B-A); we thus reduced the number of participants to $N = 30$ per retraction condition. A total of 120 undergraduate students from the University of Western Australia participated in this study for course credit (90 females, 30 males; mean age was $M = 20.48$ [$SD = 6.86$] years).

Stimuli and procedure. Stimuli and procedure were identical to Experiment 1 with the following exceptions. Messages were re-arranged such that (a) the distance between the retracted cause and test was constant at 10 messages (plus the distractor task interval), and (b) the distance between a misinformation message and the associated retraction message was constant at 8 messages (containing a total of between 277 and 284 words, depending on condition). The retention interval of the non-retracted cause was 6 messages (plus the distractor-task interval) in the retract-1 condition and 14 messages (plus the distractor-task interval) in the retract-2 condition (see bottom panel of Table 1, and Figure 2).

To this end, the two causes and the retraction were presented in different messages across conditions. Two messages with arbitrary information were added to the materials of

Experiment 1 to allow for the required reordering of messages across conditions; the report thus contained 17 messages (see Appendix A). Re-ordered messages contained only arbitrary, cause-neutral information; two messages were re-worded slightly from Experiment 1 for this purpose. In general, care was taken to ensure that the re-ordering of messages across conditions did not disrupt the report's flow. The retraction-test interval was also constant (2 messages plus the distractor-task interval), as in Experiment 1. Two no-retraction control conditions were used to allow a comparison of both retract-1 and retract-2 conditions with an equivalent no-retraction condition.

Results

Coding procedure. The coding procedure was identical to Experiment 1. A second scorer scored a set of 24 randomly selected questionnaires (3 from each condition) to assess inter-rater reliability, which was found to be very high ($r = .97$ and $.94$ for the inferences made with reference to cause A and B, respectively, $.98$ for the fact-recall questions and $.93$ for the retraction awareness questions).

Fact-recall. Fact-recall scores across conditions were $M = 4.57, 4.75, 4.48,$ and 4.07 (out of 8; $SE = .26, .28, .27,$ and $.28$) in the no-retraction-1, no-retraction-2, retract-1, and retract-2 conditions, respectively. A one-way between-subjects ANOVA found no main effect of retraction condition, $F(3,116) = 1.20, MSE = 2.09, p = .31$.

Combining the fact recall data across both experiments (pooling the two no-retraction conditions of Experiment 2), there was a significant effect of retraction condition on fact recall, $F(2,243) = 3.18, MSE = 2.18, p = .04, \eta_p^2 = .03$. Specifically, a post-hoc Tukey's HSD test found that the no-retraction condition produced better recall than the retract-2 condition ($p = .04$).

Awareness of retraction. The no-retraction control conditions did not feature a retraction and were thus excluded from this analysis. Retraction awareness was generally

high, with 83% of participants in the retraction conditions reporting awareness of the retraction (i.e., retraction awareness scores of 1 or 2). Mean retraction awareness scores were $M = 1.10$ and 1.13 (out of 2; $SE = .12$ and $.11$) in the retract-1 and retract-2 conditions, respectively; A one-way ANOVA found no effect of retraction condition, $F < 1$.⁴

Inference scores. A multivariate analysis of variance (MANOVA) was used to assess the effects of retraction condition (no-retraction-1, no-retraction-2, retract-1, retract-2) and presentation order (A-B, B-A) on the number of references to cause 1 (refs-to-1) and references to cause 2 (refs-to-2). As expected, the main effect of presentation order and the interaction between presentation order and retraction were non-significant, $F < 1$. Figure 3 shows the mean number of references to cause 1 and 2 across retraction conditions, collapsed across presentation orders. The MANOVA showed a marginal effect of retraction on the overall number of references to cause 1 and 2, Wilks' Lambda = .89, $F(6,222) = 2.11$, $MSE_1 = 3.55$, $MSE_2 = 4.18$, $p = .053$, $\eta_p^2 = .05$.

The omnibus analysis was followed up with planned contrasts. First, we explored the extent to which the first or the second cause prevailed when neither cause was retracted. We compared the number of references to cause 1 ($M = 2.60$, $SE = .38$) with the number of references to cause 2 ($M = 3.03$, $SE = .40$) in the no-retraction-1 condition, as well as references to cause 1 ($M = 2.43$, $SE = .35$) with references to cause 2 ($M = 2.87$, $SE = .36$) in the no-retraction-2 condition. We found no significant differences in the number of references to causes 1 and 2, both $F < 1$.

We next investigated the effectiveness of retractions. To this end, we compared the number of references to cause 1 and cause 2 in the no-retraction control conditions with the temporally equivalent condition where the respective cause was retracted. As expected, this

⁴ Excluding participants who did not indicate awareness of the retraction from the subsequent analysis of inference scores did not change the obtained result pattern; the means obtained from this analysis are shown as dots in Figure 3.

showed that the number of references to cause 1 in the no-retraction-1 control condition was higher than the number of references to cause 1 after its retraction ($M = 1.63$, $SE = .29$), $F(1,58) = 4.14$, $MSE = 3.38$; $p = .05$; $\eta_p^2 = .07$. Likewise (and in contrast to Experiment 1), the number of references to cause 2 in the no-retraction-2 control condition was greater than the number of references to cause 2 after it was retracted ($M = 1.90$, $SE = .32$), $F(1,58) = 4.02$, $MSE = 3.49$; $p = .05$; $\eta_p^2 = .06$. This demonstrates that the retraction of a cause reduced references to it for both causes; the reduction was numerically identical (0.97) for causes 1 and 2, respectively.

We next contrasted the effectiveness of the cause-1 and cause-2 retractions directly by comparing the number of references to cause 1 after cause 1 was retracted with the number of references to cause 2 after cause 2 was retracted. The number of references to cause 2 after the cause-2 retraction was not higher than the number of references to cause 1 after the cause-1 retraction, $F < 1$, again unlike Experiment 1 and suggesting equivalent post-retraction CIEs (i.e., equally effective retractions) for both causes.

To examine the extent to which one cause prevailed after the *alternative* cause was retracted, we compared the number of references to cause 1 after a retraction of cause 2 with the number of references to cause 2 after a retraction of cause 1. The number of references to cause 2 after a cause-1 retraction ($M = 3.30$, $SE = .39$) was larger than the number of references to cause 1 after a cause-2 retraction ($M = 2.10$, $SE = .34$), $F(1,58) = 5.82$, $MSE = 4.03$; $p = .02$; $\eta_p^2 = .09$, suggesting that the second cause had a stronger impact on reasoning than the first when the alternative cause was retracted.

To corroborate these findings, we ran a stepwise linear regression, recoding the refs-to-1 and refs-to-2 variables into a single 'references' variable, predicted by presentation order (A-B, B-A), retraction (yes, no), and retention interval (coded as number of messages between presentation of the referred-to cause and test, i.e., 6 vs. 10 vs. 14). This analysis

yielded significant effects of retention interval ($B = -.11$ [$SE = .04$], $\beta = -.16$, $t(237) = -2.55$, $p = .01$) and retraction ($B = -.96$ [$SE = .29$], $\beta = -.21$, $t(237) = -3.31$, $p = .001$; overall model: $R^2 = .069$, adjusted $R^2 = .061$, $F(2,237) = 8.74$, $p < .001$). This suggests that references are more likely to be made to a more recently presented cause, and that a retraction is generally effective in reducing references to a cause, unlike the pattern in Experiment 1 where we found a retraction to be differentially effective for initial and more recent causes.

In a final analysis, we aimed to corroborate our finding that with no retraction, there was an equivalent number of references to both causes. To this end, we pooled the data of the no-retraction condition of Experiment 1 with the data of both no-retraction conditions of Experiment 2, and ran a repeated-measures ANOVA on the number of references to cause 1 vs. cause 2. The analysis yielded no significant effect, $F(1,101) = 2.18$, $MSE = 5.61$, $p = .14$. Thus, even with increased power, our data do not suggest that a second cause acts as an implicit retraction of the first. We acknowledge again, however, that there may be a small effect of this kind, which we may have failed to detect with the available power of the present experiments. Additionally, we performed a Bayesian analysis, which allows further specification of whether the probability of the observed data is higher under the null hypothesis or the alternative hypothesis. Using an objective prior (the *JZS* prior conservatively scaled with $r = 0.5$ according to the expected small effect size, as suggested by Rouder, Speckman, Sun, Morey, & Iverson, 2009), this analysis yielded a Bayes Factor of $BF = 2.37$. This means that the probability of the observed data is about 2.37 times higher under the null hypothesis than the alternative hypothesis. Thus while this is admittedly weak evidence, we note that it is evidence *in favor* of the null hypothesis.

Discussion

Experiment 2 tested the effects of presentation order and recency on the continued influence effect of misinformation, holding constant the retention interval for retracted causes

and the misinformation-retraction interval. As in Experiment 1, there was no significant tendency for participants in the no-retraction condition to refer more often to the more recently presented cause, arguing against the assumption that readers would generally take the second cause to effectively supersede the first cause.

Experiment 1 suggested that the second cause dominated subsequent reasoning, both in the references to the retracted cause and the references to the non-retracted cause, and thus that a retraction was more effective when applied to the initial cause presented rather than the second cause. Experiment 2 replicated Experiment 1 in some aspects but produced additional insights. The pattern obtained in Experiment 2 was similar to Experiment 1 in that participants favoured the most recent cause after the initially-presented cause was retracted, but where there was no clear preference for a cause after retraction of the more recently presented one. In addition, Experiment 2 demonstrated that it was a cause's actual *recency* rather than its *position* within the script that determined subsequent reliance on the cause, implying that retractions were equally effective for the first and the second cause if recency was equated.

Like Experiment 1, the results of Experiment 2 are thus inconsistent with the predictions of the primacy model, and more in line with the recency model's predictions derived from time-based theories of memory. More specifically, Experiment 2 suggests that it is a cause's recency, rather than its position, that determines reliance on it. Replicating much previous research, a retraction was effective in reducing but not eliminating references to a cause, with retraction effects comparable to previous research (Ecker et al., 2010, 2011a; see Lewandowsky et al., 2012, for a review).

General Discussion

In this study, we applied a novel paradigm that blended elements of the post-event misinformation and the CIE paradigms. Participants were presented with verbal reports

describing a series of events, in which the misinformation came either before or after the valid event description. To this end, the study investigated the role of presentation order and recency when two competing causal explanations for an event are presented and one is subsequently retracted. By selecting two equally plausible and counterbalanced causes and having all relevant information communicated by the same source, we attempted to control for the factors of plausibility and source credibility, which are known to affect the processing of misinformation and retractions (see Guillory & Geraci, 2013; Seifert, 2002).

Before addressing the main question of interest—the impact of retraction conditions on inference scores—we briefly note that across experiments, we found an unexpected difference in fact recall between conditions featuring the retraction of the most recent, second cause and the no-retraction control condition. We can only speculate that a retraction may have resulted in an increased requirement for conflict resolution, which in turn may have drawn away cognitive resources from encoding of the event details (for a similar finding, see Ecker, Lewandowsky, E. P. Chang, & Pillai, 2014). Alternatively, processing of the retraction message may have generated stronger interference at retrieval than a neutral message. However, it remains unclear why we did not observe a significant recall deficit in the conditions featuring a retraction of cause 1, and hence these explanations remain speculative.

Turning to the findings of greatest interest, our results indicate that a cause's recency, rather than its position (i.e., whether it was presented first or last) determined the emphasis that people place on it in their later reasoning. We found a retraction to be equally effective whether it invalidated the first or the second cause, as long as the retention interval from presentation of a cause to test (and the misinformation-retraction interval) was held constant (Experiment 2). However, when retention interval was permitted to vary, then the more recent cause predominated, with the retraction less effective with a more recent cause (Experiment 1).

Our results suggest that recency is an important contributor to post-event misinformation effects, which generally reflect reliance on more recent over less recent information. This is in line with time-based theories of the post-event misinformation effect that emphasize the strength of the post-event misinformation at retrieval (cf. Ayers & Reder, 1998; Loftus, 2005). In apparent conflict is some research from the source confusion or source misattribution view (M. K. Johnson, Hashtroudi, & Lindsay, 1993; Lindsay, 2008; Zaragoza & Lane, 1994), which has been influential in both the post-event and continued influence literatures. This account suggests that at the time of retrieval, people may confuse competing sources of information and erroneously assume a piece of invalid information to have been part of a witnessed event or valid statement. This view makes a prediction regarding the overall retention interval—namely, the longer the interval between encoding (of valid and invalid information) and retrieval, the more likely the occurrence of source misattribution—but it makes no specific prediction regarding the order of valid and invalid information. In support, when the misleading information is presented *before* the event is witnessed, misinformation effects of comparable magnitude have been found (Lindsay & M. K. Johnson, 1989; Rantzen & Markham, 1992). The findings from this “reverse post-event misinformation” paradigm suggest that information can be misattributed to both more and less recent sources, and is thus seemingly at odds with memory-impairment and time-based theories of misinformation effects. However, a re-investigation of these findings from the reverse post-event misinformation paradigm may be warranted, manipulating the time between the misdirection and the event, to more specifically examine the impact of recency on the post-event misinformation effect.

In terms of the CIE, our results are at odds with a primacy account of the continued influence effect (cf. Ecker et al., 2010, 2011b; H. M. Johnson & Seifert, 1994, 1999; van Oostendorp, 1996; Wilkes & Leatherbarrow, 1988), which predicted that the initial causal

explanation would be particularly difficult to retract and would thus dominate post-retraction reasoning. Our results appear inconsistent with findings that imply that misleading information has particularly strong impact if encoded early. For example, when forming a person impression, misleading behavior observations made early in the impression formation process seem to be particularly influential even when they are later explicitly retracted (e.g., Wyer & Budesheim, 1987). Another example of early misinformation being particularly powerful are misleading headlines of news articles that can affect people's processing of the article (Ecker, Lewandowsky, E. P. Chang, & Pillai, 2014). However, in both these scenarios, the misleading information serves the function of "setting the stage" for subsequent information: An initial behavioural observation or a newspaper headline provides an anchor and sets expectations about what follows (Belmore, 1987; Copeland et al., 2009; Hogarth & Einhorn, 1992) in a way that is not true of explanations in the present study, where the actual event was described first, and the critical information merely offered an explanation regarding the event's cause.

Our results are more consistent with findings of efficient situation-model updating (Albrecht & O'Brien, 1993; Glenberg et al., 1987; Hamm & Hasher, 1992; Kurby & Zacks, 2012; Morrow et al., 1989; Radvansky et al., 2008; Rapp & van den Broek, 2005; Theriault & Rinck, 2007) and time-based theories of memory (Bjork & Whitten, 1974; Brown et al., 2007; Neath & Crowder, 1990), which predicted that the more recent cause would be more difficult to retract and more dominant in post-retraction reasoning. In particular, our study suggests that a cause's actual recency is more important than its relative position in determining ongoing reliance on it, arguably due to its greater availability in memory. Time-based memory theories that emphasize the role of recency, such as temporal distinctiveness theory can thus be useful in explaining the persistence of misinformation in memory and its effect on inferential reasoning.

However, two lines of reasoning suggest that recency by itself cannot provide a satisfactory explanation of misinformation effects. First, there are suggestions in the post-event literature that absolute recency is not the crucial predictor of misinformation effects, drawing on temporal distinctiveness theory's emphasis on the discriminability (and thus retrievability) of items. In temporal distinctiveness theory, an item's discriminability is determined by the ratio of the intervals surrounding its presentation (i.e., the inter-presentation interval) and the retention interval (Bjork & Whitten, 1974; Brown et al., 2007; Ecker et al., in press; Neath & Crowder, 1990). Drawing upon this principle in a post-event misinformation study, Bright-Paul and Jarrold (2009) manipulated the temporal spacing between event information and misinformation, and the delay between misinformation and retrieval. They found that temporal discriminability, viz. the ratio of the two manipulated intervals, was a strong predictor of reliance on misinformation (cf. also Lindsay, 1990; Roberts & Powell, 2007). In our paradigm, it would be difficult to test temporal distinctiveness theory directly in this manner because of the presence of arbitrary but event-related messages interleaved between misinformation, retraction, and test, thus making it difficult to define the inter-presentation interval. However, in light of the present results, future work should endeavour to apply the temporal distinctiveness principle more precisely to the investigation of the continued influence effect.

Second, it is unclear how recency by itself could generally explain the occurrence of a CIE—simply because a CIE implies that a person relies on a piece of information that is subsequently retracted and a pure recency account might therefore predict that people preferably retrieve the retraction rather than (or at least along with) the less recent misinformation. When there is no alternative available, the primacy model is well-equipped to explain ongoing reliance on retracted misinformation; this is because in the absence of an alternative, people tend to rely on retracted misinformation quite routinely—in other words,

they revert back to the initial, incorrect situation model rather than considering the more recent retraction (cf. H. M. Johnson & Seifert, 1994; Lewandowsky et al., 2012; Seifert, 2002). Hence there is still merit in the view that the CIE results from a failure of situation model updating. However, it seems that when an alternative is available, recency is a factor that needs to be taken into account.

Failure of strategic memory processes such as memory updating—which is typically considered an effortful and strategically controlled process (De Beni & Palladino, 2004; Ecker, Lewandowsky, & Oberauer, 2014; Ecker, Oberauer, & Lewandowsky, 2014; Vannucci, Mazzoni, Marchetti, & Lavezzini, 2012)—lie at the heart of the dual-processing account of the CIE (Ecker et al., 2010; Wilson & Brekke, 1994; see Lewandowsky et al., 2012, for a review). The dual-processing account argues that continued reliance on misinformation occurs when misinformation is automatically activated in response to cues, but strategic memory processes fail, either after encoding of the retraction (i.e., failure of memory updating, in particular failure to engage in a global update when appropriate, cf. Kurby & Zacks, 2012), or at retrieval (e.g., failure to recollect the retraction, or failure to recollect the misinformation's correct context or source; also see M. K. Johnson, Hashtroudi, & Lindsay, 1993; Kendeou & O'Brien, 2014; Lindsay, 2008; Zaragoza & Lane, 1994). In support, Putnam, Wahlheim, and Jacoby (2014) recently demonstrated that when expressions of a person's position regarding a particular issue change over time, accurate recall of the person's current position is best when people not only notice the change during encoding but also recollect the change at the time of retrieval. If change recollection fails, the out-dated position is often erroneously recalled. A prediction of the dual-processing account is that a CIE becomes more likely the easier the misinformation is activated. Thus, assuming that more recent information is more likely to be automatically activated, an integration of the dual-process and recency accounts currently seems the best available model to account for

the CIE in cases where an alternative explanation is available in addition to the retracted explanation.

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Table 1

Report Structure in Experiments 1 and 2.

Experiment	Retraction Condition	Cause 1 Message	Cause 2 Message	Retraction Message	MI-R interval	R-T interval
1	No	4	9	-	-	-
	R1	<i>4</i>	9	13	9 messages	2 messages + DTI
	R2	4	<i>9</i>	13	4 messages	2 messages + DTI
2	No (1)	7	11	-	-	-
	No (2)	3	7	-	-	-
	R1	<i>7</i>	11	15	8 messages	2 messages + DTI
	R2	3	<i>7</i>	15	8 messages	2 messages + DTI

Note. R1, Retraction of cause 1; R2, Retraction of cause 2; MI, Misinformation; R, Retraction; T, Test; DTI, Five-minute distractor-task interval. Bold numbers indicate non-retracted causes, italicized numbers indicate retracted causes.

Figure 1

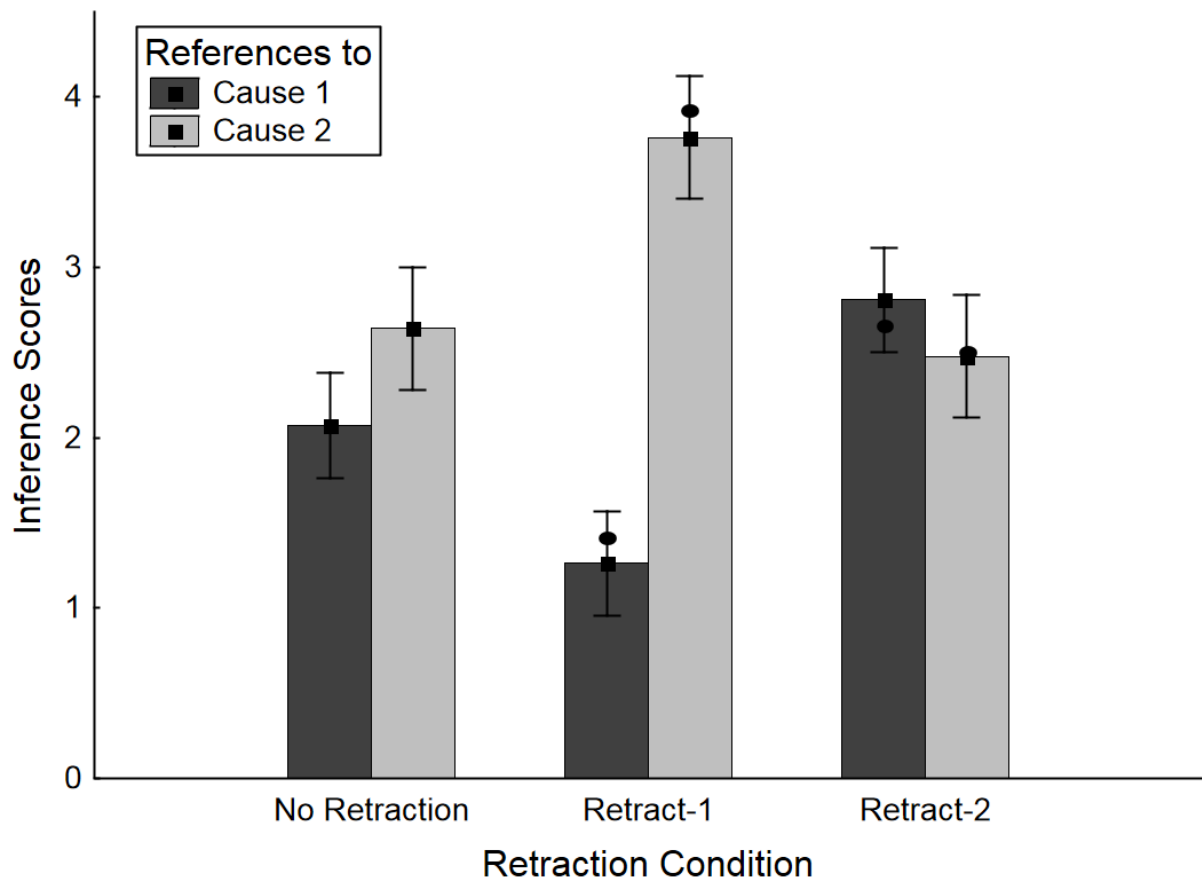


Figure 1. Mean inference scores across retraction conditions in Experiment 1. Error bars denote standard errors of the mean. Dots represent means when excluding participants from the retraction conditions who failed to indicate awareness of the retraction. $N = 42$ per condition. *Note.* Retract-1, first cause retracted; Retract-2, second cause retracted.

Figure 2

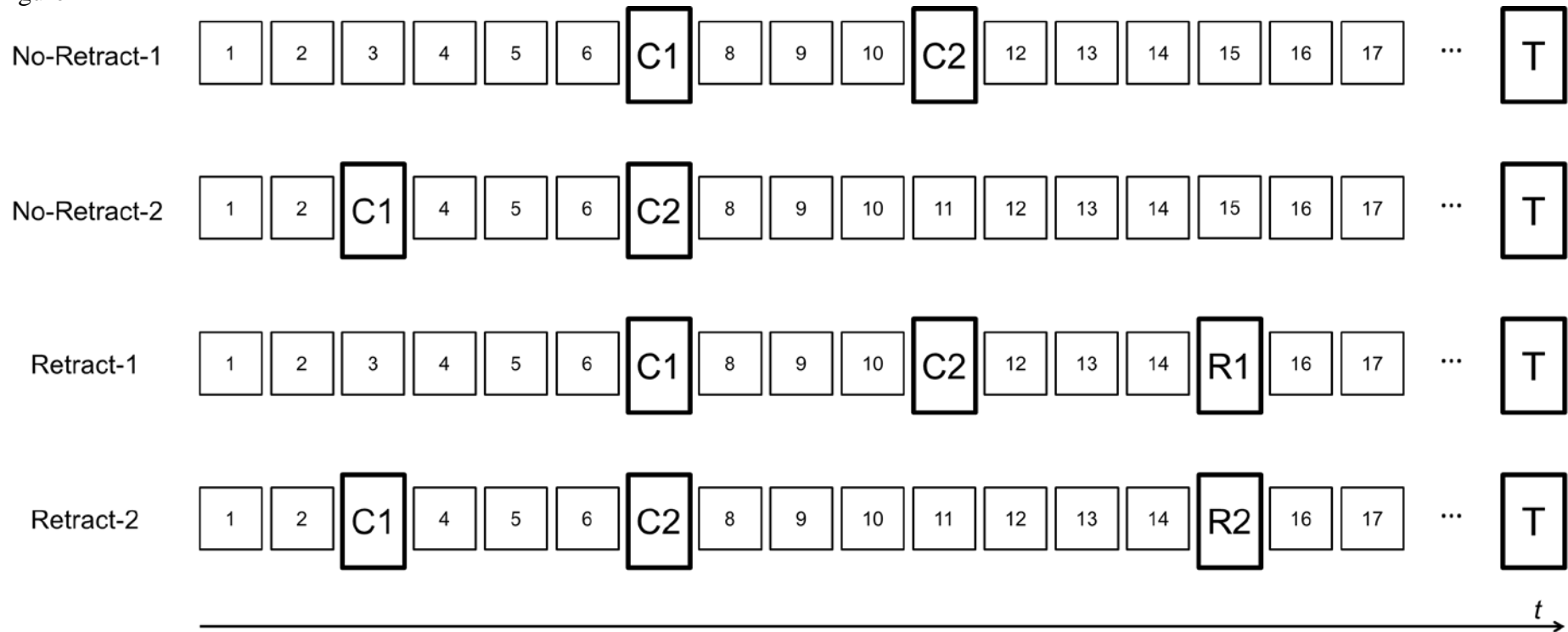


Figure 2. Schematic depiction of the four conditions in Experiment 2. The 17 numbered boxes on the left depict individual messages, the box on the right labelled “T” represents the test phase. *Note.* No-Retract-1, no retraction condition with cause ordering as in Retract-1 condition; No-Retract-2, no retraction condition with cause ordering as in Retract-2 condition; Retract-1, first cause retracted; Retract-2, second cause retracted; C1, first cause; C2, second cause; R1, retraction of first cause; R2, retraction of second cause; T, test.

Figure 3

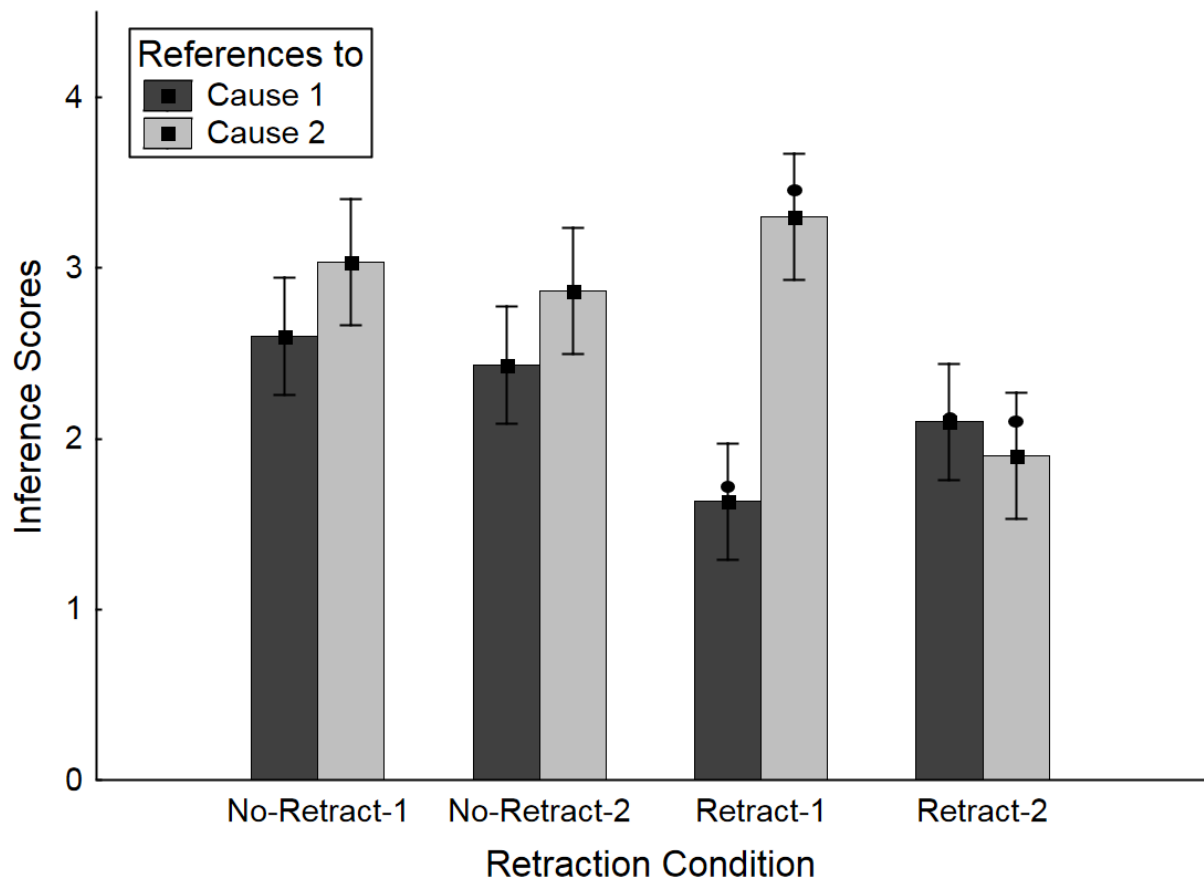


Figure 3. Mean inference scores across retraction conditions in Experiment 2. Error bars denote standard errors of the mean. Dots represent means when excluding participants from the retraction conditions who failed to indicate awareness of the retraction. $N = 30$ per condition. *Note.* No-Retract-1, no retraction condition with cause ordering as in Retract-1 condition; No-Retract-2, no retraction condition with cause ordering as in Retract-2 condition; Retract-1, first cause retracted; Retract-2, second cause retracted.

Appendix A—Account of School Bus Accident

Messages Used in Experiment 1

Message 1. A report has come into the police headquarters on Tuesday about a serious accident involving a school bus on Spring St. The school bus had hit a cyclist on the side of the road before crashing into the window of a music store. The report was made by a driver who was driving past the scene of the accident.

Message 2. An ambulance was dispatched to the scene immediately upon the report of the accident but due to bad road conditions from roadworks in the area, they arrived at the scene only after 15 minutes. Upon arrival, they began assessing the cyclist and the bus-drivers' injuries, both of whom were found unconscious.

Message 3. Police have stated the school bus was apparently on its way back to Spring Oaks Primary School after an outing at the bowling centre. The school's headmaster was contacted and he explained that the bus-driver was a very reliable long-time employee.

Message 4 [First cause; cause A]. Police investigating the cause of the accident have released a report, stating that the driver apparently lost control of the bus because a front tyre burst after a piece of scrap metal, believed to have originated from the adjacent construction site, lodged in the tyre.

Message 4 [First cause; cause B]. Police investigating the cause of the accident have released a report, stating that the bus-driver apparently lost control during an emergency braking on loose gravel after a car had violently merged into his lane.

Message 5. The police further stated that both the cyclist and the bus-driver were seriously injured and had been taken to hospital immediately. A few of the school kids who had been in the bus sustained minor injuries.

Message 6. The injured arrived at the nearby St. Joseph's hospital, where the cyclist and the bus-driver were warded for further observation while all school kids were discharged

after treatment. Family members of the victims involved in the accident had been contacted and informed of the situation.

Message 7. At the scene of the accident, police interviewed a number of eyewitnesses, some of whom claimed to have heard squeaking and rumbling sounds and then saw the bus hit the cyclist.

Message 8. There was a gradual build-up of traffic in the Spring Street area due to the roadworks and police cordoning off the area of the accident. Drivers were advised to avoid the area and bystanders were advised not to crowd around the area.

Message 9 [Second cause; cause B]. The police released a second statement regarding the cause of the accident, stating that the bus-driver apparently lost control during an emergency braking on loose gravel after a car had violently merged into his lane.

Message 9 [Second cause; cause A]. The police released a second statement regarding the cause of the accident, stating the driver apparently lost control of the bus because a front tyre burst after a piece of scrap metal, believed to have originated from the adjacent construction site, lodged in the tyre.

Message 10. The media released a statement that this had been the third accident on Spring Street within 6 months and urged the local council to attend to this issue. They also appealed to all cyclists to wear a helmet at all times.

Message 11. Police had to calm the owner of the music store, who was very upset about his shop window being broken and a limited edition guitar being destroyed. He was attended to by paramedics.

Message 12. Police continued to review evidence and interview witnesses, including the school kids, but were under some pressure to clear the scene as quickly as possible due to the upcoming rush hour.

Message 13 [No-retraction control condition]. A special report made by the police stated that both the cyclist and the bus-driver were in a stable condition.

Message 13 [Retract cause 1 condition]. A special report made by the police stated that the burst tyre was not the cause of the accident. It had actually burst upon impact with the road kerb after hitting the cyclist.

Message 13 [Retract cause 2 condition]. A special report made by the police stated that though there had been other vehicles present at the scene, none had been causally involved in the accident.

Message 14. More than three hours after the time of the accident, the police have cleared the scene and traffic on Spring Street slowly restored itself to normal.

Message 15. Several days later, it has been revealed that both the cyclist and the bus driver were making good progress in their recovery from the injuries sustained in the accident. The total damage was estimated to lie over \$50,000.

Additional/Amended Messages Used in Experiment 2

Message 3/7/8. Police have stated the school bus was apparently on its way back to Spring Oaks Primary School after an outing at the bowling centre. The school's headmaster was contacted and he explained that the bus-driver has not been involved in an accident before.

Message 10/12. Police continued to review evidence and interview witnesses, including the school kids. Police had difficulty interviewing some school kids as some of them were distressed and crying due to the shock and were asking for their parents.

Message 12/13. After police had interviewed the school kids, a police van took them to the nearest police station. Their parents had been informed to pick their children up from the police station.

Message 14. The police were under some pressure to clear the scene as quickly as possible due to the upcoming rush hour. A tow truck had been called to tow the bus out of the music store but there was a delay due to the roadworks.

Appendix B—Open-ended Questionnaire

Inference Questions

1. Who will most likely have to pay for the repairs of the school bus?
2. Why was the bus-driver unable to avoid the crash?
3. What caused the squeaking and rumbling sounds before the bus hit the bicycle?
4. Why would the driver of the school bus be angry or upset?
5. What was the relevance of the road conditions?
6. Apart from the bus-driver and the pedestrian witnesses, who else should the police question?
7. Why would the school bus insurance refuse payments of the bicycle damage?
8. Why did the police investigations at the scene take so long?
9. Do you think this accident should lead the council to take any traffic-related measures? Why / Why not?

Fact Questions

1. On which day did the accident occur?
2. Who reported the accident to the police?
3. What did the school bus crash into after hitting the cyclist?
4. Where did the accident occur?
5. Which hospital were the injured taken to?
6. Why did the owner of the music store require medical assistance?
7. Where was the school bus coming from?
8. How long did it take until police had cleared the scene?

9. Why did the school bus hit the cyclist? [coded as inference question]

Retraction Awareness Questions

1. What was the point of the last special report made by the police?
2. Was any of the information in the story subsequently corrected or altered? And if so, what was it?