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Tactics for increasing resistance to misinformation

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Summary

This study was the first to test both the independent and additive effects of change-detection prompts and warnings about potential discrepancies between an event and post-event information on susceptibility to misinformation. Participants (N = 239) viewed a mock crime video, read a post-event narrative containing misinformation, and completed a memory test about the video content. Participants were randomly assigned to change-detection and warning conditions. Ecological validity was enhanced by describing the materials as a police training exercise and by examining effects of one versus four misinformation items (opposed to typically higher rates in experimental research). Using a novel statistical approach for this topic (GLMM), we compared across the misinformation quantities participants received. Change-detection prompts, but not a pre-warning, decreased misinformation rates, and the effect of change-detection was not enhanced by a pre-warning. Results held regardless of misinformation quantity. These findings emphasize the utility of change-detection mechanisms for increasing misinformation resistance.

KEYWORDS

change-detection, eyewitness memory, misinformation, warning

1 | INTRODUCTION

After a person experiences an event, but before they try to recall it, the stored memory can be influenced by subsequent experiences. Sometimes people are exposed to false information, which may be introduced in a variety of contexts, such as in advertising and marketing campaigns, news reports, and legal proceedings. When people accept misinformation as truth, it can be damaging to memory accuracy and can have far-reaching consequences, such as when a now infamous study falsely linked the MMR vaccine with autism, causing widespread panic and prompting many parents to choose not to vaccinate their children (Lewandowsky et al., 2012). Therefore, it is important to learn what factors may increase resistance to misinformation.

Susceptibility to misinformation is often studied in the context of the misinformation paradigm, where participants witness an event and receive post-event information, some of which may contain incorrect details, and finally, complete a memory test to examine whether they accept the misinformation by incorporating it into their memory of the event (Loftus et al., 1978; McCloskey & Zaragoza, 1985). The current study utilized the misinformation paradigm to investigate two tactics that could potentially bolster resistance to misinformation; change-detection and warnings. Of particular interest was directly comparing the two methods and testing their combined effectiveness using a novel methodological and statistical approach.

1.1 | Tactics to bolster misinformation resistance

Change-detection and warnings have been investigated independently as tactics to reduce misinformation susceptibility (Loftus, 2005), but they have yet to be studied within the same study, preventing understanding of relative, and combined, effectiveness. Change-detection refers to when participants have the opportunity to indicate discrepancies between the original event and the post-event information as they are being exposed to this post-event information (Putnam et al., 2017). Another potential buffer against misinformation acceptance is a warning indicating that there may be differences between an event and post-event information. Both tactics likely

operate through similar mechanisms, as they both heighten attention to post-event information and increase the likelihood that misinformation will be detected. They operate on different time scales, with change-detection techniques occurring concurrently with post-event information processing and warnings occurring either before or after the presentation of post-event information. By assessing the effectiveness of these techniques simultaneously, we have the opportunity to test the relative importance of this timing and to investigate whether the potential benefits of these techniques are additive.

1.1.1 | Change-detection

The theoretical basis for change-detection stems from early work showing that when individuals are forced to slow down and engage in effortful processing of post-event information, they are more likely to detect misinformation (Tousignant et al., 1986). Tousignant et al. (1986) found that naturally slow readers were better at detecting discrepancies in post-event information than naturally fast readers. This effect was replicated when researchers instructed participants to either read slowly or quickly. Another clever study found that psychotropic placebos increased effortful processing of post-event information when participants were told that the drug enhanced their cognition. As a result, participants were more resistant to misinformation (Parker et al., 2008).

Change-detection may increase resistance to misinformation because it helps individuals monitor the original source of their memory. The source monitoring framework posits that false memories result from confusion over the source of the original information (Johnson et al., 1993). People are less susceptible to misinformation when they can accurately attribute their memory to the appropriate source (Lindsay & Johnson, 1989). Change-detection techniques in the misinformation paradigm require individuals to monitor their original memory of the event when presented with misinformation, which encourages more active cognitive processing than passively reading a post-event narrative, and therefore, can result in more accurate source attributions.

Previous work has indeed found that giving participants the ability to indicate change can increase resistance to misinformation. In a list memorization study, participants were instructed to memorize word-pairs and were later presented with a list in which some words had been changed. In Experiment 1, participants indicated that they detected a change by selecting a box on the screen. In Experiment 2, participants indicated their confidence that a word pair had changed on a Likert scale. The authors found that participants had more accurate memory during recall for the changed words in Experiment 1 when they selected the box to indicate the change than in Experiment 2 when participants only indicated confidence level as opposed to the change itself (Jacoby et al., 2013). More recently, change-detection techniques utilized in the misinformation paradigm increased resistance to misinformation when participants were able to press a key to indicate discrepancies between their original event memory and the post-event information (Butler & Loftus, 2018; Putnam et al., 2017).

The timing of the opportunity to recall a witnessed event seems to be an important element in reducing the influence of misleading post-event information. Gabbert et al. (2012) found that participants who were provided with an opportunity to recall an event they had just witnessed (through the form of a self-administered interview) were less likely to report misinformation one week later than participants who did not participate in a self-administered interview. Similarly, in the choice blindness literature, when participants initially select one face out of a lineup and are later presented with a different face, those who are asked to immediately justify why they selected the second, changed face, are more likely to detect a change than participants who are not promptly asked to make this justification (Sagana et al., 2014, 2017).

Taken together, these findings demonstrate that when participants are promptly presented with post-event information and some type of change-detection technique, they are more likely to detect discrepancies between the original information and the post-event information. Additionally, people may need constant reminders to be vigilant for inaccuracies, particularly in the context of post-event misinformation when source monitoring may already be impaired. Therefore, presenting people with a means to report changes while they are processing post-event information could be a valuable way to reduce misinformation susceptibility.

1.1.2 | Warnings

Warnings about the possible presentation of misinformation have been shown to be effective in reducing the misinformation effect (see Blank & Launay, 2014, for a review). However, warning studies vary widely in the degree of specificity of the warning message, with some explicitly describing the misinformation (e.g., Ecker et al., 2010), and others only alluding to potential inaccuracies (e.g., Karanian et al., 2020). Blank and Launay (2014) found that warning specificity failed to moderate the misinformation effect, though they note that the small number of studies on which they conducted their analyses limit the generalizability of this conclusion. In applied contexts (e.g., police interviews, news reports) the source of the misinformation may be unaware of potential inaccuracies, which would limit opportunities to provide explicit warnings describing misinformation. Thus, a general warning regarding the potential for misinformation may be more ecologically valid.

Furthermore, studies have varied in whether the warning is placed before or after the post-event information. Pre-warnings, warnings presented before exposure to misinformation, may function via similar mechanisms as change-detection opportunities, specifically, enhanced attention and effortful control. For example, in one of the first studies to examine the effectiveness of warnings, the researchers found that those who received a warning prior to receiving the post-event information had slower reading times, which resulted in a slight increase in resistance to misinformation (Greene et al., 1982). As

demonstrated in a more recent study, warnings can also increase response latency, suggesting that individuals who receive a warning may be taking more time to monitor their responses on memory tests (Thomas et al., 2010). Indeed, a number of studies have demonstrated that pre-warnings can reduce susceptibility to misinformation (Chambers & Zaragoza, 2001; Gallo et al., 2001; Karanian et al., 2020; Marsh & Fazio, 2006; McCabe & Smith, 2002; McDermott & Roediger, 1998; Neuschatz et al., 2003; Westerberg & Marsolek, 2006). Thus, when participants are forewarned about potential discrepancies between an event and post-event information, the warning causes relevant behavioral changes when the misinformation would otherwise be encoded that may help inoculate individuals against misinformation.

1.2 | Misinformation resistance tactics in combination

The present study is the first to test whether two promising attention-enhancing techniques combine to create a more potent buffer against misinformation than when presented in isolation, and to test the relative effectiveness of these techniques. If, in fact, pre-warnings heighten attention and vigilance for misinformation, they may enhance the protective effects of change-detection. Specifically, pre-warnings may prime initial source monitoring, which is then further-enhanced with a change-detection mechanism, causing participants to engage in effortful processing as they evaluate each piece of post-event information, thereby reducing misinformation susceptibility. Furthermore, pre-warnings have a timing advantage in that they increase the likelihood that misinformation is detected concurrently with the presentation of misleading post-event information (Sagana et al., 2018). Consequently, if participants are given a mechanism to point out this change as they notice it, they may be even more likely to resist the encoding of misinformation than if they cannot explicitly indicate these discrepancies. The design of the current study allows us to test whether a pre-warning combined with a specific mechanism to indicate change can reduce misinformation susceptibility to a greater extent than when these techniques are presented in isolation.

1.3 | Amount of misinformation

Change-detection and warning studies have found that these techniques are effective against a range of misinformation quantities (e.g., 1 out of 15 items, Tousignant et al., 1986; 8 out of 24 items, Thomas et al., 2010), but to our knowledge, only one misinformation study has manipulated the amount of misinformation that participants receive. Pena et al. (2017) exposed participants to varying amounts of misinformation and found that those who received a large amount of misinformation (e.g., 80%, 32 items) of the post-event narrative contained misinformation) were the most misled compared with the group that received the lowest amount (20%, 8 items). However, participants who received a large amount of misinformation and were skeptical of the source were less likely to accept misinformation relative to those who were less skeptical, suggesting that greater quantities of misinformation can increase mistrust of the source, thereby indirectly increasing misinformation resistance. On the other hand, the findings of Pena et al. may lack ecological validity, for in a real-world scenario, it is unlikely that people will be exposed to such a large proportion of misinformation. Therefore, the current study examines participants' ability to resist misinformation when it is presented in smaller quantities, specifically, one versus four misinformation items.

1.4 | The current study

The current study investigated how change-detection and warnings, independently and in conjunction, increase resistance to varying amounts of misinformation. Participants watched a video and then read a post-event narrative about the video containing misinformation. Ecological validity was enhanced relative to prior research by presenting the study materials as part of a police training exercise (e.g., the video was described as a staged crime used for training purposes, the narrative was described as a practice police report by a police officer), and by presenting either a single, or four, misinformation item(s) opposed to typically higher rates in prior experimental research. While reading the narrative sentence-by-sentence, half of the participants had the ability to indicate whether or not each sentence corresponded with their memory of the video. The other half of participants simply read the narrative without the ability to indicate discrepancies. Prior to the presentation of the narrative, half of the participants received a warning that differences between the narrative and the video may be present, while the other half of participants were given no such warning. Participants received either a single misinformation item or four misinformation items, and acceptance of misinformation was assessed using a recognition questionnaire. Primary analyses were conducted with general linear mixed models (GLMM), a novel approach to this research area, allowing us to examine participants' binary responses and to control for the salience of items. This approach allows us to examine nonnormal data (as opposed to the more frequently used ANOVA) and control for participants' individual response patterns.

We hypothesized main effects for change-detection and warning, replicating previous findings with a novel methodological and statistical approach. Specifically, we expected that participants who were directed to indicate changes in the post-event information, or those who were warned about potential misinformation, would be less likely to accept misinformation compared to those who could not indicate changes or did not receive a warning. We also expected an additive effect between change-detection and warning, such that participants who received both tactics would be even less likely to accept misinformation than those who received only one.

2 | METHOD

2.1 | Participants

A total of 269 undergraduates participated in the study for extra credit in various social science courses. The mean age was 21.03 years (*SD* = 3.82 years) and 78% of the sample was female. Participants were required to be at least 18 years of age and to be fluent in English. Participants were excluded for claiming to have seen the video before (*n* = 2), indicating they did not want their data included in the analysis after being debriefed (*n* = 2), and for failing the mid-survey attention check (*n* = 26), resulting in a final sample of 239 participants.

2.2 | Design

This study was a 2 (change-detection: change-detection, non-change-detection) × 2 (warning: warning, no warning) × 2 (amount of misinformation: one item, four items)[1] between-subjects design, with participants randomly assigned across the cells. Participants either received no misinformation resistance tactics (*n* = 61), warning only (*n* = 58), change-detection only (*n* = 58), or both (*n* = 62). The main dependent variable was whether participants selected the misinformation response for any given misinformation item on the recognition questionnaire.

2.3 | Materials

2.3.1 | Video

The key event that participants witnessed was a video originally created by Takarangi et al. (2006) and used in previous misinformation studies (e.g., Pena et al., 2017). The video is 7 minutes long and depicts an electrician reporting for a house call without the owners present, rummaging through the house, and stealing small items. In order to enhance ecological validity, participants were told that the video was a police training video and the post-event narrative was a police report written as part of officer training. The narrative and the accompanying recognition memory test were adapted from those used in Pena et al. (2017) to correspond more closely with language used in police reports (e.g., referring to the electrician as the 'suspect'). The narrative was developed in consultation with a local police department staff member with experience reviewing police reports.

2.3.2 | Post-event narrative

The post-event narrative described central and peripheral details presented in the video and was similar to that used in Pena et al. (2017). All participants read a post-event narrative with 37 total sentences, however, for 4 of the 37 sentences, participants could receive a version with a misinformation item or a neutral version (see Table 1). All misinformation items concerned peripheral details (e.g., the color of the suspect's cap). To create a more plausible post-event narrative, misinformation items were selected based on their likelihood of being included in a police report. Each of the four misinformation items also corresponded with a distinct type of detail (actions of subject, false objects, color of objects, and location of objects) so as to reduce the chance that participants in the multiple misinformation item condition became suspicious of a certain type of detail.

Attention check

In order to briefly assess participant attention, an attention check was embedded approximately half way through the protocol, between the narrative and recognition questionnaire. The last sentence of the narrative (sentence 38) stated, 'You are about to be asked a random question and the answer is potato chips'. Participants then read the recognition questionnaire instruction, advanced to the next page, and were prompted with, 'What is the answer?' Participants were provided with four response options, one of which was 'potato chips'. Participants who did not answer this question correctly were excluded from analyses.

Change-detection condition

Participants in the change-detection condition were given a dichotomous selection under each sentence of the post-event narrative. The options were, 'This information corresponds with what I saw in the video' or 'This information does not correspond with what I saw in the video'. Participants were prompted to pick a response before moving on to the next page. Participants in the non-change-detection condition were not provided with an option to indicate whether or not the sentences corresponded with their memory of the video.

Warning condition

Half of the participants were randomly assigned to receive a general warning between viewing the video and reading the post-event narrative (warning condition). The warning was presented following the instructions to read the subsequent police report and stated: 'There may be differences between the police report and the video'. The other half of the participants did not receive a warning (no warning condition).

Misinformation condition

Approximately half of the sample was randomly assigned to the multiple misinformation items condition (*n* = 123) in which their post-event narrative contained all four misinformation items. The other half of the sample was in the single misinformation item condition (*n* = 116) in which their post-event narrative contained just one of the misinformation items. Participants in the single misinformation item condition were counterbalanced so that approximately even numbers of participants were assigned to receive each of the four misinformation items (item 1: *n* = 31, item 2: *n* = 28, item 3: *n* = 29, item 4: *n* = 28). All nonmisinformation statements were neutral sentences, which did not include any additional details about the item

TABLE 1 Misinformation sentences and neutral sentences presented during the post-event narrative, as well as the corresponding correct detail from the video

Item	Video depiction	Neutral sentence	Misinformation sentence
Item 1	The suspect got his tool belt and drill kit out of the van, then went to the front door and retrieved the key that was left for him *under the flowerpot*	The suspect got his tool belt and drill kit out of the van, then went to the front door and retrieved the key that was left for him	The suspect got his tool belt and drill kit out of the van, then went to the front door and retrieved the key that was left for him *under the doormat*
Item 2	The suspect tried on a *black* cap and checked his reflection in the mirror	The suspect tried on a cap and checked his reflection in the mirror	The suspect tried on a *red* cap and checked his reflection in the mirror
Item 3	After approximately 20 min, the suspect checked the time *on a wall clock*	After approximately 20 min, the suspect checked the time	After approximately 20 min, the suspect checked the time *on his watch*
Item 4	The suspect shut and locked the French doors and then stopped to look at a picture of *the Leaning Tower of Pisa* on the wall	The suspect shut and locked the French doors and then stopped to look at a picture of a landmark on the wall	The suspect shut and locked the French doors and then stopped to look at a picture of *the Eiffel Tower* on the wall

presented. Thus, participants in the single misinformation item condition received 36 neutral sentences and one misinformation sentence, and participants in the multiple misinformation item condition received 33 neutral sentences and four misinformation sentences.

2.3.3 | Recognition questionnaire

Participants were presented with 40 randomized multiple-choice memory questions about the video. The questions corresponded with each sentence of the police report, with some questions asking about more than one detail from the same sentence. There were three response options for each memory question and the ordering for each option was also randomized. One response option was always correct in that it reflected a detail from the video, and two options were always incorrect. The four potential misinformation items from the post-event narrative were included as incorrect response options. We refer to these response options as 'misinformation responses', though selecting this response option only qualified as evidence that the participant was misinformed if they actually received that misinformation item in the post-event narrative (i.e., if they received all four misinformation items or if that was the single item of misinformation they received). For example, one question asked participants to indicate the correct missing word in the sentence, 'The suspect retrieved the key from under the ___'. The possible answer choices were: the flowerpot (correct response); the doormat (incorrect response); and the rock (incorrect response). Some participants had been misinformed that the key was under the doormat in the post-event narrative. If these participants selected the first answer choice, they were coded as correct, if they selected the second, they were coded as misinformed, and if they selected the third, they were coded as incorrect. Participants who did not receive this misinformation item were coded as incorrect if they selected the second or third option. After each recognition question, participants were asked a source monitoring question where they indicated if they remembered their answer from the video, the police report, both, or neither.

2.4 | Procedure

After participants signed up for a scheduled time slot, they reported to a computer lab on campus and a Research Assistant administered the study in the form of a Qualtrics survey, an online survey platform. So as not to alert participants that the study involved misinformation, the survey was titled 'Memory for a Crime Video'. Participants who agreed to participate provided informed consent and then were presented with the video and the following instruction: 'The video below is a re-enactment of a crime used for the purpose of training incoming police officers and for continuing training of senior officers'. After watching the video, participants completed a 10-minute filler task consisting of trivia questions to establish a short delay between the video and the post-event narrative. Afterward, all participants received the following instruction: 'Please read the following police report about the video footage you just viewed. Sentences will be presented one at a time'. Those in the warning condition received the warning at the end of this instruction. Next, participants completed the recognition questionnaire and source monitoring questions. Finally, participants provided basic demographic information and were debriefed on the nature of the study and the fact that it contained misinformation.

3 | RESULTS

3.1 | Analysis plan

To establish that the misinformation negatively affected participants' memory, we first tested whether presenting misinformation increased the likelihood that participants selected the incorrect response option that aligned with the misinformation. Next, we examined the percentage of participants who were misinformed in the single and multiple misinformation items condition (Table 2). Then, we tested whether the warning and change-detection techniques increased resistance to misinformation independently and additively. Finally, we descriptively examined participants' responses to the change-detection statements

(change-detection condition only) and the responses to the source monitoring questions.

Inferential analyses were conducted using GLMM. GLMM analyses were performed in R using the lme4 package and the glmr function with the bobyqa, Nelder–Mead optimizers and Laplace approximations (Bates et al., 2015). GLMMs are preferred analyses over ANOVA models because they have the ability to analyze binary response distributions and have fewer assumptions. They can also maximize power and simultaneously estimate between-subject variance, while incorporating the random effects (participant's multiple responses, misinformation item) typically included in linear mixed models. Finally, they can account for nonnormal data included in generalized linear models (Bates et al., 2015; Bolker et al., 2009; Pinheiro & Bates, 2000).

Our dependent variable in all models was a dichotomous variable indicating whether participants selected the response corresponding to post-event misinformation they received (i.e., were misinformed). Fixed effects included warning and change-detection condition assignment. All models included two random effects: one for individual participants to account for the number of misinformation questions posed to each participant (one vs. four) and one for item to account for the four possible misinformation items presented to participants. Models were first validated to ensure that main effects and interaction effects were included only when the variables increased model fit based on AIC values. Below we report the converged models alongside the unstandardized fixed effect estimates (β), standard errors of the estimates (*SE*), and estimates of significance (*Z* and *p* values). Only significant findings ($p < .05$) are reported and are included in Tables 3 and 4.

3.2 | Acceptance of misinformation

To assess whether the misinformation paradigm was successfully implemented, we conducted a GLMM to examine if participants were more likely to select the misinformation response on the recognition questionnaire for the misinformation item(s) that they received. The independent variable was whether the recognition question asked about a misinformation item that was presented to participants (yes or no). As expected, when participants were presented with misinformation, they were more likely to select the misinformation option than when they were presented with a neutral sentence that did not contain misinformation ($B = 0.67$, $SE = 0.16$, $Z = 4.09$, $p < .001$). For example, when presented with the recognition question, 'The suspect tried on a _____ cap', participants who received 'red cap' as misinformation in the post-event narrative were more likely to select 'red' as their response relative to participants who received the neutral version of this item in the post-event narrative ('The suspect tried on a cap'). Thus, the misinformation paradigm implementation was effective.

TABLE 2 Percentage of participants misinformed by each item in the single and multiple misinformation item conditions

Item	Single misinformation item	Multiple misinformation items
Item 1 (Doormat)	19.4	26.8
Item 2 (Red Cap)	32.1	26.8
Item 3 (Watch)	71.4	65.9
Item 4 (Eiffel Tower)	37.9	39.8
Average	40.2	39.8

TABLE 3 Results of GLMM analyses exploring effects of misinformation on misinformed responses

Fixed effect	*B*	*SE*	*z*	*p*
(Intercept)	−1.13	0.25	−4.48	<.001
Misinformation	0.67	0.16	4.09	<.001
Random effects			**Variance**	***SD***
Participant			0.33	0.57
Item			0.17	0.42

Note: Base level: not misinformed.

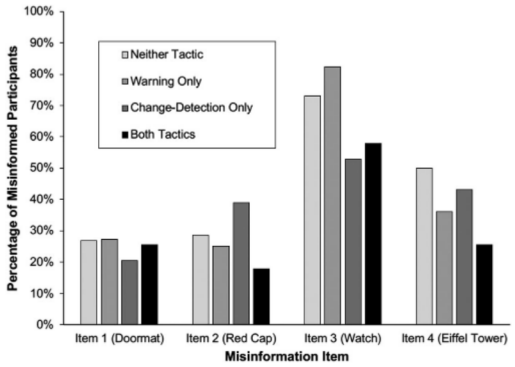

FIGURE 1 Percentage of participants misinformed by each item based on misinformation resistance tactic received

TABLE 4 Results of GLMM analyses exploring effects of change-detection and warning on misinformed responses

Fixed effect	*B*	*SE*	*z*	*p*
(Intercept)	−0.12	0.43	−0.28	.778
Change-detection	−0.50	0.22	−2.29	.022
Warning	−0.27	0.22	−1.23	.219
Random effects			**Variance**	***SD***
Participant			0.57	0.76
Item			0.61	0.78

Note: Base level: not misinformed.

As is evident in Table 2, participants were equally likely to be misinformed by any given misinformation item regardless of whether it was the only misinformation item they received or whether it was one of four misinformation items presented in the post-event narrative. However, some items elicited greater misinformation acceptance than others, which we accounted for by including a random effect for misinformation item in the models. Subsequently, we collapsed across the two misinformation conditions and examined rates of misinformation acceptance for participants who received just the warning, just the change-detection prompts, both, or neither.

TABLE 5 Accuracy of participants' responses to change-detection statements in the post-event narrative

Item	Accuracy	%
Item 1 (Doormat)	Correct	48.5
	Misinformed	51.6
Item 2 (Red Cap)	Correct	90.4
	Misinformed	9.6
Item 3 (Watch)	Correct	83.3
	Misinformed	16.7
Item 4 (Eiffel Tower)	Correct	60.4
	Misinformed	39.7
Average	Correct	70.6
	Misinformed	29.4

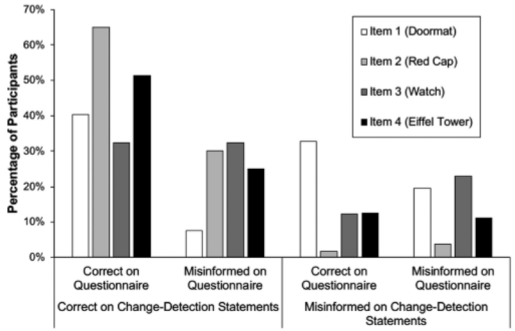

FIGURE 2 Consistency of responses between the change-detection statements and recognition questionnaire for each item for participants in the change-detection condition

As is depicted in Figure 1, on average, participants who received no misinformation resistance instructions were the most likely to be misinformed (44.65%), 42.7% of participants in the warning condition were misinformed, 38.85% of participants in the change-detection condition were misinformed, and 31.75% of participants who received both misinformation tactics were misinformed. A series of GLMMs revealed that participants who were in the change-detection condition were less likely to be misinformed than those in the non-change-detection condition ($B = -0.50$, $SE = 0.22$, $Z = -2.29$, $p = .022$), and the warning did not significantly affect the likelihood of being misinformed. Including the interaction term did not significantly improve model fit. We conducted sensitivity analyses in R using the simr function to run Monte Carlo simulations (Green & MacLeod, 2016). To avoid relying on observed power (Hoenig & Heisey, 2001), we specified our main model to detect an effect size half the size of the fixed effect found for change. The power curve revealed adequate power (80.30%, CI: [77.70, 82.72]) with 185 participants.

In order to gain a better understanding of how change-detection is related to misinformation susceptibility in the current study, we examined the responses of participants in the change-detection condition to the change-detection statements in the post-event narrative. Examining across all items and collapsing the low and high misinformation conditions, participants failed to indicate change 29.4% of the time (Table 5). We then examined the accuracy of participants' responses to both the change-detection statements and the recognition questionnaire (Figure 2). Participants varied in the consistency of their responses, with just under half the participants correct on both the change-detection statements and the recognition questionnaire (47.3%) and 14.3% of participants misinformed on both the change-detection statements and the recognition questionnaire. More participants were initially correct on the change-detection statements and then misinformed on the recognition questionnaire (23.8%) relative to participants who were misinformed on

TABLE 6 Participant responses to source monitoring questions

Item	Accuracy	Video (%)	Police report (%)	Both (%)	Neither (%)
Item 1 (Doormat)	Correct	63	15	13	10
	Misinformed	58	24	5	13
Item 2 (Red Cap)	Correct	69	8	9	14
	Misinformed	66	17	10	7
Item 3 (Watch)	Correct	73	4	14	8
	Misinformed	73	9	9	9
Item 4 (Eiffel Tower)	Correct	75	11	8	6
	Misinformed	64	19	10	7
Total	Correct	70	9	11	9
	Misinformed	65	17	9	9

the change-detection statements and then correct on the recognition questionnaire (14.7%).

Finally, we examined participants' responses to the source monitoring questions presented after each recognition question. In line with previous research (Pena et al., 2017), participants most often reported the video as the source of their memory for the misinformation item(s), regardless of their accuracy on the recognition questionnaire (Table 6). There were no condition differences in source attributions.

4 | DISCUSSION

The present study tested promising buffers against varying amounts of misinformation. This study is the first to our knowledge to examine the unique and combined effects of both a warning and change-detection in increasing resistance to misinformation. It is also the first to manipulate realistic, ecologically valid quantities of misinformation and to use GLMM analyses to examine binary response distributions within the misinformation paradigm. Participants who were asked to report changes between a post-event narrative and to-be-remembered video were more resistant to misinformation than participants who could not report changes. Previous research has shown that change-detection is effective in improving memory accuracy when the amount of misinformation that participants received was not manipulated (Butler & Loftus, 2018; Putnam et al., 2017). Our study confirms these findings and extends beyond currently published work by using a more refined type of analysis to show that change-detection is effective against two different quantities of misinformation.

Contrary to our hypothesis, we did not find a main effect of warning on misinformation resistance. We opted for a general warning in order to attempt to parallel a more realistic scenario, in which eyewitnesses to crimes are rarely explicitly informed that they have been exposed to misinformation. Specifically, participants were told, 'There may be differences between the police report and the video'. As previously mentioned, evidence is mixed regarding how specific a warning should be in order to induce misinformation resistance. On one hand, Blank and Launay (2014) specify that warnings, even at their most subtle, must mention the possible existence of misinformation. However, Karanian et al. (2020) did not mention the presence of misinformation and instead warned participants that the experimenters were 'unable to verify the accuracy of the [post-event] narrative', and still found this general warning was effective in reducing the misinformation effect. Additionally, the warning may not have been effective in the current study because it is possible that participants did not read the warning message carefully. We were not able to ascertain whether participants actually read and processed the warning with the current design. Future research should include an assessment of participants' comprehension of the warning message.

The present findings emphasize the utility of change-detection in increasing resistance to misinformation. Though both change-detection and warnings should theoretically heighten attention to misinformation, change-detection may better serve this purpose by providing constant reminders to be vigilant when monitoring post-event information. In fact, change-detection mechanisms may function as subtle, repeated warnings that draw attention to differences between the event and post-event information, and the effectiveness of these mechanisms indicates that their timing and frequency may be important factors to consider when attempting to increase resistance to misinformation. Furthermore, even with the benefits of change-detection, participants are still vulnerable to misinformation. Almost a quarter of participants in the change-detection condition initially resisted the misinformation on the narrative and then selected the misinformation response on the recognition questionnaire. This may be due to the peripheral nature of our misinformation items, as changes to more memorable details are more likely to be detected (Putnam et al., 2017).

Understanding the effectiveness of misinformation resistance tactics is also important given that exposure to even one piece of misinformation can alter memory accuracy. While participants in the current study who were exposed to multiple misinformation items incorporated more misinformation overall, receiving one versus multiple misinformation items did not appear to impact accuracy on any given item. Pena et al. (2017) found that participants who received large amounts of misinformation (i.e., 80% of the post-event narrative contained misinformation) accepted a higher percentage of misinformation items compared with the group that received the lowest amount of misinformation (20%). However, in Pena et al.'s study, the ratio of misinformation to neutral information in the post-event narrative was quite high and unlikely to occur in an applied context, which is why we selected more ecologically valid quantities of misinformation. Conversely, in the current study, the proportion of misinformation to neutral items was low, particularly in the single misinformation item condition. It is possible that participants in this condition simply were not paying attention to the one misinformation item, thereby resulting in similar accuracy rates between the single and multiple misinformation conditions. Future research should examine whether there is a threshold at which the number of misinformation items presented begins to increase the likelihood that a given misinformation item will be accepted.

A limitation of this study relates to the recognition questionnaire instruction, 'You have now finished the police report. Please answer the following questions'. It is possible that participants were answering the memory questions based on their memory of the post-event narrative, rather than their memory of the video as intended. Though they were told earlier in the study session that their memory for the video would be tested, the instruction immediately preceding the test did not explicitly tell them which source to refer to when recalling their answers. The majority of participants indicated the video as the source of their memory on the source memory question that came after each recognition question, and there was no clear pattern to suggest that individuals who were misinformed and selected the post-event narrative were different from those who were correct and indicated the video, or both, or neither. We examined across all responses and found that incidences of participants indicating that the misinformed response came from the post-event narrative occurred at a low rate

(6% of all responses), and at a rate very similar to that found in previous work with more explicit instructions to answer the memory questions based on memory for the to-be-remembered video (Pena et al., 2017). However, it is still possible that participants might have performed differently on the recognition questionnaire if they had been explicitly instructed to base their answers on their memory of the video.

This study provides insight into the use of change-detection mechanisms to improve memory accuracy in situations where misinformation is presented. Future research should examine change-detection used in a live scenario in order to examine whether it aids people in resisting misinformation that is presented verbally. For example, in a legal setting, change-detection could reduce the chance that an eyewitness to a crime is misinformed by information introduced during police questioning, as the presentation of false evidence during police interrogations has been shown to contribute to false memories and confessions (Kassin, 2007). Though it would disrupt the flow of the interview if an investigator asked a witness to think back to their original memory after each question, the investigator could remind the witness at various points throughout the interview to focus on any discrepancies between the investigator's questions and the witness' original memory in order to encourage change-detection. However, implementing change-detection in a legal setting would need to be done carefully so as not to undermine people's confidence in the justice system. Constant reminders to be mindful of inaccuracies or procedural errors on the part of the justice system could cause people to assume the system is fraught with mistakes. The legal system would need to strike a balance between encouraging eyewitnesses to be on the lookout for misinformation, while not overburdening them with this task. Future research should also examine whether change-detection improves precision for detecting misinformation specifically or if it simply leads to increased skepticism toward all information.

5 | CONCLUDING REMARKS

By applying a novel methodological and statistical approach to the misinformation paradigm, the results of this study provide support for change-detection as a tactic to increase resistance to varying amounts of misinformation. The findings of this study have practical implications for the legal field and provide a deeper understanding of how misinformation resistance can be influenced by a mechanism for reporting change during the encoding process.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ENDNOTE

[1] These conditions were later collapsed; see results for more information.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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