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Once (but not twice) upon a time: Narrative inoculation against conjunction errors indirectly reduces conspiracy beliefs and improves truth discernment

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Abstract

Psychological inoculation has proven effective at reducing susceptibility to misinformation. We present a novel storytelling approach to inoculation against susceptibility to the conjunction fallacy ($d_{\text{meta-analysis}} = 0.82$), a known cognitive predictor of conspiracy beliefs. In Study 1 (Pilot; $N = 161$), a narrative inoculation (vs. control) reduced susceptibility to conjunction errors, and in turn, conspiracy beliefs regarding government malfeasance. In Study 2 (main experiment; $N = 141$; pre-registered), two separate narrative inoculations (vs. control) directly reduced susceptibility to conjunction errors, and indirectly reduced conspiracy beliefs regarding extra-terrestrial cover-ups. In addition, the inoculation messages improved detection of both real and fake news ('truth discernment'). We discuss theoretical and practical implications, including the use of inoculation to induce critical thinking styles, and tailoring inoculations that may suit storytelling mediums.

KEYWORDS
conspiracy theories, conjunction fallacy, inoculation, misinformation

> 'Those who tell the stories rule the world' (Proverb, unknown origin)

1 | INTRODUCTION

Psychological inoculation – a classic attitudinal intervention used to induce psychological resistance against persuasion (McGuire, 1964) – is a promising strategy for reducing susceptibility to misinformation (see Compton et al., 2021; Lewandowsky & van der Linden, 2021; Traberg et al., 2022). For example, several gamified interventions have employed weakened doses of a variety of common disinformation tactics, such as spreading conspiracy theories and emotional manipulation, in order to confer psychological resistance against these tactics when players encounter them in the future (e.g., Basol et al., 2020; Roozenbeek & van der Linden, 2019a, 2019b). However, despite budding interest in the cognitive factors that play a role in misinformation susceptibility (e.g., Roozenbeek, Maertens, et al., 2022), research has yet to investigate whether inoculation can be used to confer psychological resistance against cognitive *biases* that make individuals vulnerable to conspiracist reasoning. This is important, because misinformation can exploit such biases, for example, by appealing to negatively valenced information and conspiratorial reasoning (Carrasco-Farré, 2022). Furthermore, exploring alternative avenues to existing inoculation techniques would provide researchers and policymakers with more options to tailor misinformation interventions to different contexts. Therefore, in the current research, we develop a storytelling approach to inoculation that we call *narrative inoculation* (see Compton & Mason, 2020), which we use to reduce susceptibility to the conjunction fallacy, a well-established predictor of conspiratorial

reasoning (Brotherton & French, 2014; Dagnall et al., 2017; Enders & Smallpage, 2019; Moulding et al., 2016; Šrol, 2022; Wabnegger et al., 2021).

1.1 | Inoculation against misinformation and conspiracy beliefs

Inoculation theory was originally developed in the 1960s and follows the biomedical process of immunisation: just as exposing people to a severely weakened strain of a virus ('the vaccine') triggers the production of antibodies to help confer resistance against future infection, the same can be achieved with attitudinal manipulation by pre-emptively exposing people to severely weakened doses of the kind of persuasive challenges that they might encounter in the future (McGuire, 1964). Recent work has demonstrated the efficacy of cognitive inoculation interventions in the domain of misinformation (see Compton et al., 2021; Lewandowsky & van der Linden, 2021; Traberg et al., 2022) and conspiracy theories (Banas & Miller, 2013; Jolley & Douglas, 2017; Roozenbeek & van der Linden, 2019a, 2019b). Inoculation typically includes two main synergistic components: (1) motivated resistance to psychological change which leads to some recognition of vulnerability (e.g., 'watch out for fake news!'), and (2) a pre-emptive refutation of how this attempted change might occur (e.g., '*merchants of doubt* may rely on conspiracy theories to manipulate your opinion') along with counter-arguments on how to spot and resist such persuasion attempts. Meta-analyses have found inoculation strategies to be effective (e.g., Banas & Rains, 2010).

1.1.1 | Methods of inoculation

Over the years, inoculation has been administered in a number of different ways. Most commonly, researchers use text manipulations to passively present the relevant information to participants (e.g., Cook et al., 2017; Maertens et al., 2020). Other contemporary methods include inoculation games, where players are rewarded with badges for actively engaging with weakened doses of the manipulation techniques that could be used against them (Roozenbeek & van der Linden, 2019a, 2019b). Still other, more scalable approaches have been developed in the form of short videos (see Lewandowsky & Yesilada, 2021; Nabi, 2003). For example, Roozenbeek, van der Linden, et al. (2022) developed inoculation scripts that were included as narration over 30- to 90-second animated videos. In an era dominated by short, digestible online information, this issue of scalability in fighting misinformation is an important one (Pennycook & Rand, 2021). Therefore, development of new techniques that address issues related to the need to capture sustained interest and attention are paramount in cognitive intervention research. Notably, while some methods of inoculation have been demonstrated to be more efficacious than others (e.g., active generation of counter arguments over passive reception of refutations; Basol et al., 2021; McGuire & Papageorgis, 1961), our intention is less concerned with comparative efficacy and more focused on developing a new technique that suits specific psychological processes and distribution contexts.

1.1.2 | Narrative inoculation

In a recent paper, van Prooijen et al. (2022) showed that conspiracy theories were rated as more believable when they were perceived as more entertaining. The authors concluded that conspiracy theories are endorsed at least in part due to their entertainment value, akin to the use of narratives in storytelling (see also Sternisko et al., 2020). Narratives are 'a representation of connected events and characters that have an identifiable structure' (Kreuter et al., 2007, p. 222). If a primary allure of conspiracy narratives to individuals is the entertainment value they appear to offer, it stands to reason that providing alternative sources of entertainment that act as counter measures to these narratives may be a promising way to capture the very audience that would benefit most from such intervention strategies.

A wealth of literature has suggested that narratives are effective vehicles of persuasion because of their mental 'transportation' power (see Dal Cin et al., 2004; Green & Brock, 2002). Furthermore, narrative inoculation was the focus of Compton and Mason's (2020) review, positing that more research needs to uncover the nature and parameters of the use of narratives in the administration of inoculation. Although research has explored inoculation and narrative as separate strategies (see Niederdeppe et al., 2015), there is much potential in combining the two approaches. In fact, Pfau's early work demonstrating the improved efficacy of inoculation at conferring attitudinal resistance with the integration of affective messaging often incorporated elements of narrative scenarios (e.g., Pfau et al., 2001). In a similar vein, Cook's recent *Cranky Uncle* comics use cartoon analogies and characters to aide in the communication of inoculation messages (see Winkler & Cook, 2022). To take this previous usage of narrative in inoculation research one step further, we sought to invent narratives that involved short entertaining stories with event structures intended to be analogous to mainstream films.

Indeed, despite the apparent efficacy of cognitive inoculation against misinformation (Traberg et al., 2022), some contextual factors may influence people's responses to this strategy. For example, McGuire and Papageorgis (1961) originally argued that inoculation that requires more effortful cognitive processes – such as active inoculation, compelling participants to generate their own refutations – should confer stronger resistance than more passive approaches (e.g., passively explaining counter-arguments in text format). This is analogous to Mayer and Moreno's (2003) active learning assumption, suggesting that engagement in more active cognitive processes improves meaningful learning. We posit that storytelling may be a

promising route through which we can ensure strong engagement with inoculation interventions.

For example, Emde et al. (2015) used a storytelling (vs. traditional) approach to present news to adolescents, discovering that information processing was enhanced in the storytelling condition among those displaying low initial knowledge about the issues discussed. Indeed, meta-analyses have found that stories are better recalled and easier to understand than standard essays (Mar et al., 2021) – which have been the norm in traditional inoculation research (McGuire & Papageorgis, 1961). We draw on this body of work to develop a narrative approach to psychological inoculation. Alongside greater cognitive engagement, and thus greater comprehension, this method could also serve as an alternative entertainment source to those that would otherwise be lured in by the entertainment value of conspiracy theories.

1.2 | Conspiracy beliefs and the conjunction fallacy

In a recent meta-analysis, Biddlestone et al. (2022) synthesised the relationships between various psychological motives and conspiracy beliefs. Among other links, they found that a reliance on automatic thinking styles – captured by a tendency to engage in intuitive thinking, as well as susceptibility to various cognitive biases – had a significant relationship with conspiracy beliefs. Among the cognitive biases analysed were measures of susceptibility to the *conjunction fallacy*. A conjunction error occurs when the likelihood of two independent events occurring together is incorrectly assumed to be higher than the likelihood of the events occurring alone (see Tversky & Kahneman, 1981). Statistically, the probability of two independent events occurring together is, in actuality, always lower than or equal to the probability of independent events, given the rules of probability where $P(A \text{ and } B) = P(A) * P(B)$. A canonical illustration of the conjunction fallacy is the 'Linda problem', where Linda is described as an outspoken individual who, as a student, was active in social justice issues. When asked, participants incorrectly assume that the probability of Linda being a bank teller *and* a feminist is more likely than the chance of her *only* being a bank teller (Tversky & Kahneman, 1981).

Brotherton and French (2014) found that such conjunction errors were associated with stronger beliefs in conspiracy theories. They argued that this may be due to conspiracy believers' tendency to underestimate the role of random occurrences (cf. Sternisko et al., 2022), and rely excessively on causal inferences (see also Dagnall et al., 2017; Enders & Smallpage, 2019; Moulding et al., 2016; Šrol, 2022; Wabnegger et al., 2021). This relationship offers an important opportunity to extend the use of inoculation to foster contextually relevant critical thinking (Cook et al., 2017). Thus, inoculation against the conjunction fallacy should confer psychological resistance against conjunction errors, and in turn, reduce conspiracy beliefs.

Here, we test the following hypotheses:

1. Narrative inoculation against the conjunction fallacy reduces susceptibility to conjunction errors, relative to a control condition.
2. Conjunction errors are positively related to conspiracy beliefs.
3. Narrative inoculation against the conjunction fallacy indirectly reduces conspiracy beliefs through fewer conjunction errors, relative to a control condition.

1.3 | Overview of the current studies

In one pilot (Study 1) and one pre-registered main experiment (Study 2), we aimed to test the mediation hypothesis that a narrative inoculation relying on storytelling (vs. control) can reduce susceptibility to conjunction errors, and in turn, reduce conspiracy beliefs. In the pilot study, we developed a narrative inoculation outlining how an FBI agent failed to effectively investigate a bomb attack because he made a conjunction error. We included an adapted measure of conspiratorial and neutral conjunction errors to analyse the number of conjunction errors made. Furthermore, we included a measure of general belief in conspiracies to investigate the indirect effect of our intervention on conspiracy beliefs.

In light of recent research showing that actively open-minded thinking (AOT; Baron, 2019) style is a particularly robust predictor of susceptibility to misinformation (Roozenbeek, Maertens, et al., 2022), we included this variable as a control and moderator to determine whether the efficacy of our intervention was conditional on this thinking style. While AOT – capturing a willingness to accept evidence in conflict with one's established beliefs – is a robust predictor of improved truth discernment (Pennycook, Cheyne, et al., 2020; Roozenbeek, Maertens, et al., 2022), it may also be associated with an increased willingness to accept the inoculation. In other words, those open to having their opinions changed should be most responsive to interventions that aim to do just that. Furthermore, we included conspiracy mentality as a control and moderator variable to investigate whether the efficacy of our intervention was conditional on a low baseline tendency to perceive the world in conspiratorial terms.

In the main experiment (Study 2), we included the narrative inoculation that we used in the pilot study (Study 1), creating an additional narrative inoculation to determine whether the type of conspiracy beliefs that are indirectly reduced depend on the target of the inoculation (i.e., refutational *same* vs. refutational *different*). We included the same moderators as the pilot study, adding the Misinformation Susceptibility Test (MIST; Maertens et al., 2022; Roozenbeek, Maertens, et al., 2022) as an exploratory dependent variable. In both studies, we controlled for related demographics (age, gender, education, religiosity) and political orientation (self-placed conservative ideology, social conservatism, economic conservatism). For versions of the models that did not include control variables, please see the Supplement. The Supplement, full data files and analysis code can be found at https://osf.io/n2v5r/?view_only=2566ad17d9884c04b2bca29920ac7514.

2 | STUDY 1: PILOT

2.1 | Methods

2.1.1 | Participants

A total of 615 responses were collected through adverts posted on various subreddits on the forum website *Reddit*. Despite reported issues with regards to skewed demographics on *Reddit* (i.e., predominantly younger men in the US; see Clement, 2022), previous work has used this data collection approach to corroborate established findings in the psychological literature (e.g., Biddlestone et al., 2020; Green et al., 2021), supporting it as an inexpensive source of high-quality data (Jamnik & Lane, 2017). Once participants were removed for suspecting that they may have taken part in one of our previous studies, failing one of the possible attention checks, failing to provide at least one of the conjunction error scale responses, or not holding nationality from a US territory, the final sample consisted of 161 participants, 79 men, 77 women ($M_{age} = 36.19$, $SD_{age} = 11.07$).[1] A sensitivity power analysis (two-tailed) revealed that we achieved a power of .80 to detect a minimum effect size of $d = 0.45$.

2.1.2 | Design and procedure

After providing their consent, participants were randomly allocated to either the narrative inoculation or control condition. Participants were then presented with the conjunction errors and conspiracy beliefs scales in randomised order, before completing the moderator variable scales in randomised order, and subsequently the control variables. Finally, participants were fully debriefed and given the opportunity to enter their email address into a $30 Amazon voucher raffle.

2.1.3 | Ethics

This study received ethical approval from the University of Cambridge Psychology Research Ethics Committee (Application number: PRE.2022.005).

2.1.4 | Materials

Experimental manipulation

In the narrative inoculation condition, participants were presented with three short texts intended to inoculate them against susceptibility to conjunction errors with the use of a short story (see Supplement, Section 4 for full experimental manipulation texts). The first text described a scenario wherein an FBI agent is tasked with uncovering who was responsible for a bomb attack on a government building. Based on the available evidence, the agent suspects that (1) the bomb used was a pipe bomb, and therefore (2) that a terrorist group known to the FBI that had previously used pipe bombs was responsible. The agent directs resources for 2 months to finding evidence that *The Freedom Frontier* group were responsible for the blast, finding no leads. At this time, the agent learns of another foiled pipe bomb attack on a different government building, immediately assuming it must have also been carried out by *The Freedom Frontier*. However, the attack was actually carried out by someone looking to hurt their ex-partner, who in fact survived the first blast. In the second text, the FBI agent has a meeting with their boss, who explains that their mistake may have been due to a *conjunction error*. That is, the agent incorrectly assumed that the two scenarios of a pipe bomb being used and *The Freedom Frontier* being responsible were more likely than these explanations being true independently. This constituted the 'weakened dose' and 'refutational preemption' part of the inoculation treatment (i.e., prebunking the conjunction fallacy). In the third and final text, participants were presented with a forewarning explaining people how they should remain on the lookout for attempts to manipulate their attitudes through exploitation of the conjunction fallacy (motivating resistance to psychological change). In the control condition, participants were simply told to begin the study by clicking the button on the bottom right. All participants were subsequently exposed to the 'full dose', that is, a series of potential conjunction fallacies (see Measures below).

Measures

Conjunction errors ($\alpha = .74$; $M = 1.52$, $SD = 1.91$) were measured using an adapted version of Wabnegger et al.' (2021) conjunction fallacy scale. Specifically, we included four of the COVID-19 conspiracy items (e.g., 'The US and China are debating the origin of the coronavirus. Which is most likely? [The virus was developed in a laboratory]/[The virus was developed in a laboratory and originates from China]') and five of the neutral items (e.g., 'Anton is an elected public officer and likes to spend his free time at the shooting range. Which is most likely? [Anton is a politician]/[Anton is a politician and is against the tightening of gun licensing laws]'), excluding all of the religious items (see Supplement, Section 4 for full scale used). Participants were asked to estimate the likelihood of the two possible scenarios presented in each case on scales from *not at all likely* (0) to *extremely likely* (100). A conjunction error was made when the second (conjunction) option was estimated to be more likely than the first (independent) option.

Conspiracy beliefs were measured with Brotherton et al.'s (2013) 15-item Generic Conspiracist Beliefs Scale (GCBS), using a response scale from *definitely not true* (1) to *definitely true* (5). The GCBS includes sub-scales measuring conspiracy beliefs regarding government malfeasance (e.g., 'The government is involved in the murder of innocent citizens and/or well-known public figures, and keeps this a secret'; $\alpha = .82$; $M = 2.73$, $SD = 1.07$), malevolent global conspiracies (e.g., 'The power held by heads of state is second to that of small unknown groups who really control world politics'; $\alpha = .85$; $M = 2.06$, $SD = 1.03$), extra-terrestrial cover-ups (e.g., 'Secret organizations communicate with extraterrestrials, but keep this fact from the public'; $\alpha = .88$; $M = 2.12$, $SD = 1.03$), personal wellbeing ('Experiments involving new drugs or technologies are routinely carried out on the

public without their knowledge or consent'; $\alpha = .78$; $M = 2.07$, SD = 0.97), and the control of information (e.g., 'A lot of important information is deliberately concealed from the public out of self-interest'; $\alpha = .61$; $M = 2.96$, SD = 0.91).

Conspiracy mentality ($\alpha = .80$; $M = 5.91$, SD = 1.92) was measured with Bruder et al.' (2013) five-item Conspiracy Mentality Questionnaire (CMQ; e.g., '[I think that…] …many very important things happen in the world, which the public is never informed about'), using a response scale from *certainly not* (1) to *certain* (11).

Actively open-minded thinking was measured with Svedholm-Häkkinen and Lindeman's (2017) 17-item Actively Open-Minded Thinking scale (AOT17), using a response scale from *strongly disagree* (1) to *strongly agree* (7). The AOT17 includes sub-scales measuring low dogmatism (e.g., 'I think there are many wrong ways, but only one right way, to almost anything', reverse-coded; $\alpha = .82$; $M = 5.50$, SD = 1.17), low resistance to belief change (e.g., 'One should disregard evidence that conflicts with your established beliefs', reverse-coded; $\alpha = .80$; $M = 5.73$, SD = 1.09), liberalism (e.g., 'A person should always consider new possibilities'; $\alpha = .48$; $M = 5.68$, SD = 0.84), and low belief personification (e.g., 'I tend to classify people as either for me or against me', reverse-coded; $\alpha = .51$; $M = 3.89$, SD = 1.18).

Control variables. Participants' year of birth, gender, highest level of completed education, religiosity (from *not at all religious* (1) to *very religious* (7)), nationality, and political orientation (general, social, and economic; from *extremely liberal* (1) to *extremely conservative* (9)) were measured as control variables.[2]

2.2 | Results

Pearson's *r* correlation coefficients between the main variables can be found in the Supplement (Section 1.1.1). The demographic variables of age, education, religiosity, and political orientation (general, social, and economic) significantly correlated with some of the main variables (certain conspiracy beliefs, conspiracy mentality, low dogmatism, low resistance to persuasion), and were thus controlled for in all subsequent regression analyses.

2.2.1 | Confirmatory factor analyses

Since a number of the scales we used included sub-scales, we performed confirmatory factor analyses (CFAs) to determine whether model fit was better when these scales were measured as a single factor or when distinguishing between their sub-scales as multiple factors. This revealed that model fit for the conjunction fallacy scale was no different when distinguishing between conspiracy and neutral conjunction errors, so we included this measure as a single factor (see Supplement, Section 1.1.2.1). In contrast, model fit was significantly better when distinguishing between sub-scales for both the GCBS and AOT17, so we decided to analyse these variables by distinguishing between their different sub-factors. Due to issues with low internal reliability, non-significant item loadings, and cross-loadings for the liberalism and low belief personification sub-scales, these AOT17 sub-factors were removed from all subsequent analyses (see Supplement, Section 1.1.2.3).

2.2.2 | Main effect of the narrative inoculation on conjunction errors

An independent samples *t*-test revealed that participants in the narrative inoculation condition made significantly fewer conjunction errors than those in the control condition, $t(158.91) = 4.04$, $p < .001$ (see Figure 1). This effect was medium-to-large, $d = 0.63$. The narrative inoculation did not significantly alter any of the conspiracy beliefs sub-factors relative to the control condition (all *p* values >.05, see Supplement, Section 1.1.3).

2.2.3 | Indirect effect of the narrative inoculation on conspiracy beliefs

To analyse our main model, we constructed a bias-corrected bootstrap (1000 re-samples) structural equation model (SEM) with the narrative inoculation (vs. control) as the independent variable, conjunction errors (mean-centred) as the mediator, and all types of conspiracy beliefs as the simultaneous dependent variables using the *lavaan* package in R. We additionally controlled for relevant demographics, political orientation, the two AOT17 sub-scales (mean-centred), conspiracy mentality (mean-centred), and interaction terms for both the narrative inoculation (vs. control) and conjunction errors with both conspiracy mentality and the two AOT17 sub-scales on all paths. This model revealed that the direct and total effects of the narrative inoculation (vs. control) on these types of conspiracy beliefs were non-significant (see Figure 2). However, our key hypothesis was about the *indirect* effect.[3] Consistent with our hypothesis, the narrative inoculation (vs. control) indirectly reduced conspiracy beliefs regarding government malfeasance through fewer conjunction errors, standardised indirect effect $\beta = -.07$, 95% CI [−.12, −.02].

2.2.4 | Exploratory analyses

Moderation analyses of the significant interactions in the main model revealed that the direct effect of the narrative inoculation (vs. control) on certain types of conspiracy beliefs was actually positive among those displaying high levels of dogmatism and low levels of conspiracy mentality (Supplement, Section 1.1.4). However, these exploratory analyses should be treated with caution due to sample sizes that were likely too small to sufficiently detect these interaction effects with a power of .80.

Exploratory SEMs that were similar to the main model including different variations of control variables revealed that the narrative inoculation (vs. control) also indirectly reduced other types of

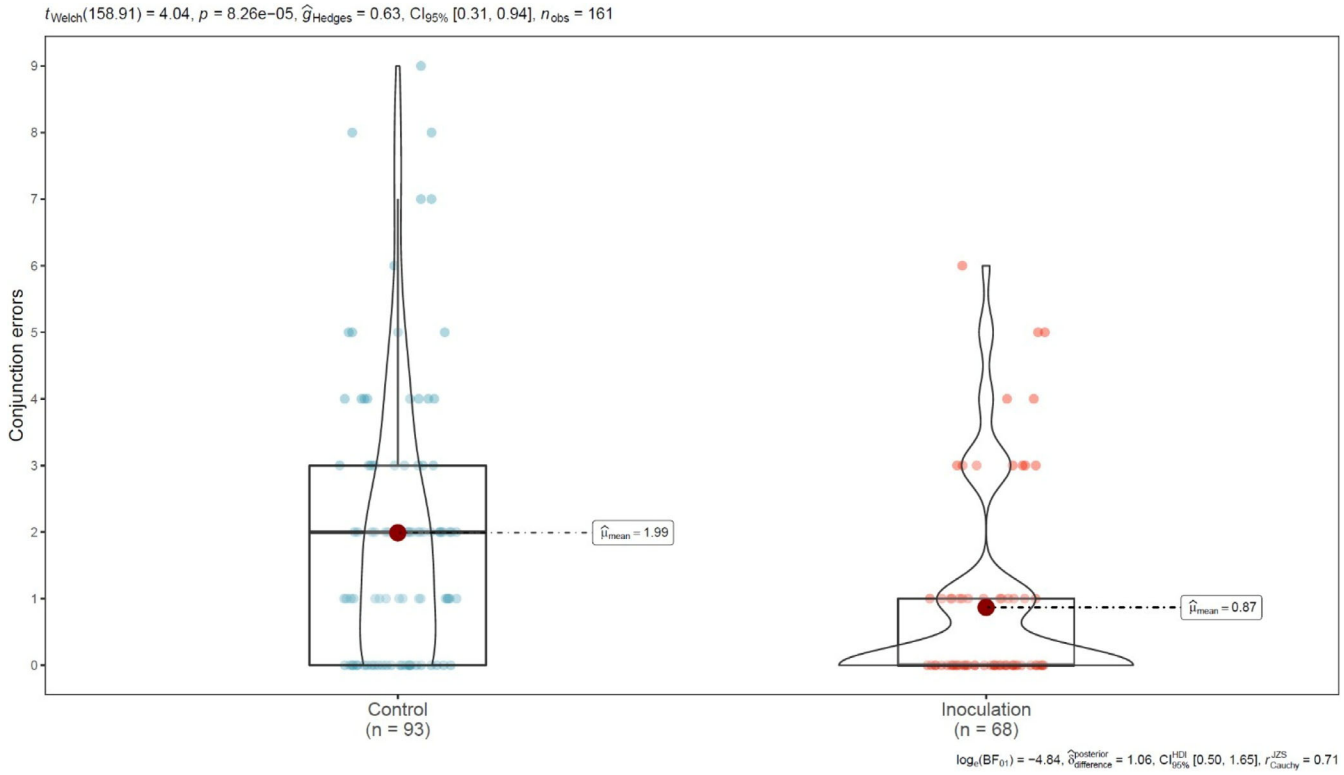

FIGURE 1 Violin plot with boxplots and data jitter for the mean difference in conjunction errors between the narrative inoculation and control conditions (Study 1).

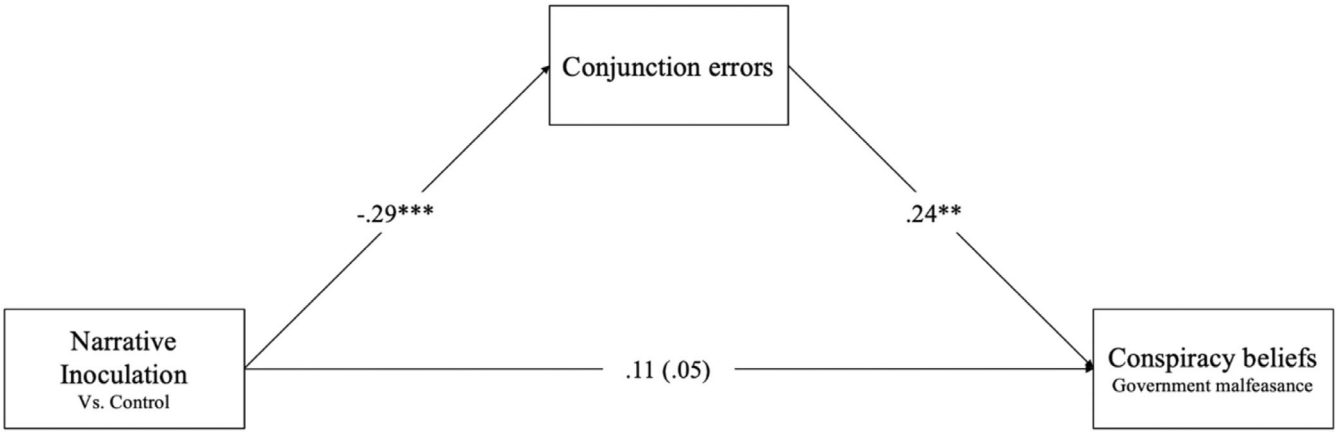

FIGURE 2 Indirect path model for the effect of the narrative inoculation (vs. control) on conspiracy beliefs regarding government malfeasance through conjunction errors, controlling for all other variables and interaction terms (Study 1). $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. Direct effects are presented outside parentheses, total effect is presented within parentheses

conspiracy beliefs when demographics, political orientation, and moderators (AOT and conspiracy mentality) were systematically excluded from the model (see Supplement, Section 1.1.5). Furthermore, other model variations also revealed that the narrative inoculation (vs. control) indirectly reduced mean scores on the GCBS when it was treated as a single factor (Supplement, Section 1.1.7; see Table S4 for breakdown of indirect effects for each model). Overall, these exploratory analyses thus further bolster the findings of our pre-registered main model that the narrative inoculation indirectly reduces endorsement of conspiracy beliefs through fewer conjunction errors.

2.3 | Discussion

Overall, our pilot study demonstrated that the experimental manipulation of narrative inoculation against conjunction errors reduced

susceptibility to conjunction errors relative to the control condition, and in turn, reduced conspiracy beliefs regarding government malfeasance. Despite some preliminary evidence for moderating effects of conspiracy mentality and dogmatism, we ultimately had insufficient power to reliably detect these interactions. Interestingly, our exploratory models indicated some variation in exactly which conspiracy beliefs were indirectly reduced by the narrative inoculation, suggesting that socio-demographic and other individual difference factors may account for some of the variance in responses to the intervention.

While in some cases inoculation has been shown to confer psychological resistance to psychological change in contexts different from those outlined in the intervention (refutational-*different*), the findings from our pilot study suggest that the narrative inoculation may have only indirectly reduced belief in conspiracies regarding government malfeasance because the protagonist was an FBI agent investigating a terrorist attack (refutational-*same*). This is also in line with previous research showing that the source of narratives is an important factor in determining the efficacy of interventions (Russell et al., 2020). In fact, the government malfeasance GCBS sub-scale includes an item stating that 'The government permits or perpetrates acts of terrorism on its own soil, disguising its involvement'. Despite the difference in perpetrators between this item and our narrative inoculation, the close resemblance may have played a role in this isolated effect. Furthermore, the backfire effects we observed with regards to two of the other GCBS sub-scales may have been due to a priming effect of exposure to a narrative outlining how government agents are fallible, potentially reducing faith in public officials. Thus, the contextual parameters of our intervention are unclear, warranting further investigation into its conditional effects.

3 | STUDY 2

In Study 2, we sought to corroborate our findings from Study 1, including an additional condition to determine whether narrative inoculation is most effective at reducing conspiracy beliefs in broadly the same context as the narrative (i.e., refutational-same). Therefore, we developed another narrative inoculation to address the conjunction fallacy in the domain of the most believable GCBS sub-scale in the pilot study: the control of information. Moreover, in line with recent psychometric research (Janssen et al., 2020), we discovered psychometric issues with the AOT17 in the pilot study. Specifically, we found low internal reliability, non-signficant loadings, and crossloadings between the items in the liberalism and low belief personification sub-scales (see Supplement, Section 1.1.2.3), reflecting Janssen et al.'s (2020) concerns over the absence of a reliable higher-order factor. Therefore, we decided to use a more recent, psychometrically validated single-factor measure of AOT (Baron et al., 2022), previously shown to be a uniquely consistent predictor of misinformation susceptibility (Roozenbeek, Maertens, et al., 2022).

Conjunction errors are also related to other epistemically questionable beliefs, such as paranormal beliefs (Rogers et al., 2009). Furthermore, the causal inferences presumed to link susceptibility to conjunction errors with conspiracy beliefs (Brotherton & French, 2014) are also related to general misinformation susceptibility (e.g., Saltor et al., 2022). Saltor et al. (2022) suggest that this is likely because many fake news stories rely on unwarranted causal relationships (e.g., 'The Government Is Knowingly Spreading Disease Through the Airwaves and Food Supply'; see Maertens et al., 2022). Therefore, we included a measure of general misinformation susceptibility (Maertens et al., 2022) to explore whether our narrative inoculations may directly or indirectly reduce misinformation susceptibility through fewer conjunction errors, elaborating on the established link between conjunction errors and conspiracy beliefs. The moderator variable of conspiracy mentality and control variables included in the pilot study remained the same.

All hypotheses and analyses were fully pre-registered: https://aspredicted.org/TW9_DR9.

3.1 | Methods

3.1.1 | Sample size justification

According to Fritz and MacKinnon (2007), in order to detect a mediation effect with small-to-medium coefficients ($\beta = .26$) on both paths and a power of .80, a minimum sample size of 148 is required. Furthermore, a priori power analysis using G*Power indicated that in order to detect an effect size of $d = .64$ between three groups with a power of .80, a minimum sample size of 99 is required.

3.1.2 | Participants

A total of 176 responses were collected from the US through *Prolific Academic*, of which 35 failed at least one of the attention checks, leaving a final sample of 141, 72 men, 67 women ($M_{age} = 39.91$, $SD_{age} = 14.31$). Sensitivity analysis using G*Power indicated that this final sample size enabled us to detect a minimum effect size of $d = 0.53$ with a power of .80 between the three groups. Despite our pre-registered attention check failure exclusions, 31 of these failures were in the earthquake narrative inoculation condition, so we decided to perform comparative analyses including the attention check failures to determine whether the results differed notably with appropriate power to detect the mediation effect (see Supplement, Section 2.1.8).

3.1.3 | Design and procedure

The design was much the same as the pilot study, with participants randomly allocated to one of the two narrative inoculation conditions or the control group. Next, the conjunction fallacy scale was presented, before the GCBS and misinformation susceptibility test in randomised order. Finally, participants were presented with the two

moderator variables in randomised order, before completing the control variables and finally being fully debriefed.

3.1.4 | Ethics

Full ethical approval was received from the University of Cambridge Research Ethics committee (Application number: PRE.2022.005).

3.1.5 | Materials

Experimental manipulations

The FBI agent narrative inoculation and control condition texts were identical to the pilot study. In the new control of information narrative inoculation, participants were presented with three separate texts, similar to the FBI narrative inoculation. The first text outlined a scenario wherein a seismologist was tasked with finding out what went wrong after an earthquake in a populated city. The scientist is relatively certain that public officials' access to privileged means of travel (e.g., air transport) contributed to their early escape, but also suspects that privileged information about the earthquake was withheld from the public to free up their own travel routes. They launch an inquiry, which does not uncover any leads for 2 months. Then, the scientist speaks to a family member of a public official at the time, who debunks the theory that privileged information was withheld by providing video evidence of the public officials carrying out their usual business in parliament when the earthquake struck. In the second text, the scientist's funding boss explains how they believe their mistake was due to a conjunction error, much the same as the conversation included in the second text of the FBI narrative inoculation. That is, the scientist incorrectly assumed that the likelihood of the public officials having access to both privileged means of transport *and* privileged information that was withheld from the public was more likely than these circumstances occurring independently. The third (final) text was identical to the one from the FBI narrative inoculation, generally reminding participants of how and why they should be on the lookout for those attempting to exploit the conjunction fallacy (see Supplement, Section 4 for full texts).

Measures

Conjunction errors ($\alpha = .70$; $M = 1.65$, SD = 1.87), *conspiracy beliefs*, and *conspiracy mentality* ($\alpha = .88$; $M = 6.80$, SD = 2.18) were measured as in the pilot study.

Actively open-minded thinking ($\alpha = .80$; $M = 4.25$, SD = 0.49) was measured with Baron et al.' (2022) 10-item AOT scale (e.g., 'Willingness to be convinced by opposing arguments is a sign of good character'), using a response scale from *completely disagree* (1) to *completely agree* (5).

Misinformation susceptibility was measured with Maertens et al. (2022) eight-item misinformation susceptibility test (MIST-8), providing distinct measures of veracity discernment ($M = 6.27$, SD = 1.63), real news detection ($M = 3.28$, SD = 0.99), fake news detection ($M = 2.99$, SD = 1.05), distrust ($M = 3.72$, SD = 1.22), and naïveté ($M = 4.28$, SD = 1.22) depending on the way scores are calculated. Respondents are presented with four real (e.g., 'Attitudes Toward EU Are Largely Positive, Both Within Europe and Outside It') and four fake (e.g., 'Certain Vaccines Are Loaded with Dangerous Chemicals and Toxins') news headlines, and must decide using a binary scale whether they are *fake* or *real* (see also Roozenbeek, Maertens, et al., 2022, for further details).

Control variables were collected as in the pilot study, this time excluding nationality due to the ability to pre-screen participants when collecting data from *Prolific*.

3.2 | Results

Pearson's *r* correlation coefficients between the main variables can be found in the Supplement (Section 2.1.1). The demographic variables of age, education, gender, and political orientation (general, social, and economic) significantly correlated with some of the main variables, and were thus controlled for in all subsequent regression analyses, in line with our pre-registered analyses.

3.2.1 | Confirmatory factor analyses

The CFAs revealed that model fit for the conjunction fallacy scale was no different when distinguishing between conspiracy and neutral conjunction errors, so we included this measure as a single factor (see Supplement, Section 2.1.2.1). In contrast, model fit was once again significantly better when distinguishing between the GCBS sub-scales of government malfeasance, $\alpha = .88$; $M = 2.88$, SD = 1.21, malevolent global conspiracies, $\alpha = .94$; $M = 2.56$, SD = 1.24, extra-terrestrial cover-ups, $\alpha = .87$; $M = 2.22$, SD = 1.06, personal well-being, $\alpha = .85$; $M = 2.34$, SD = 1.10, and the control of information, $\alpha = .77$; $M = 3.07$, SD = 1.10, so we decided to analyse this variable by distinguishing between its sub-factors.

3.2.2 | Main effect of the narrative inoculations on conjunction errors

A one-way ANOVA revealed a significant difference in conjunction errors between the experimental conditions, $F(2, 138) = 21.78$, $p < .001$, $\eta^2 = .24$. Post-hoc analyses with a Tukey correction for multiple comparisons revealed that significantly fewer conjunction errors were made in the FBI narrative inoculation, $M_{FBI} = 0.87$, $SD_{FBI} = 1.44$, $p < .001$, and earthquake narrative inoculation condition, $M_{Earthquake} = 0.90$, $SD_{Earthquake} = 1.35$, $p < .001$, compared to the control condition, $M_{Control} = 2.73$, $SD_{Control} = 1.92$ (see Figure 3). The effects for both the FBI narrative inoculation ($d = 1.09$) and earthquake narrative inoculation ($d = 1.05$) were large. Neither of the narrative inoculations significantly altered any of the conspiracy beliefs sub-factors or real and fake news detection (as measured by the MIST-8) relative to the control condition (all *p* values >.05, see Supplement, Section 2.1.3).[4]

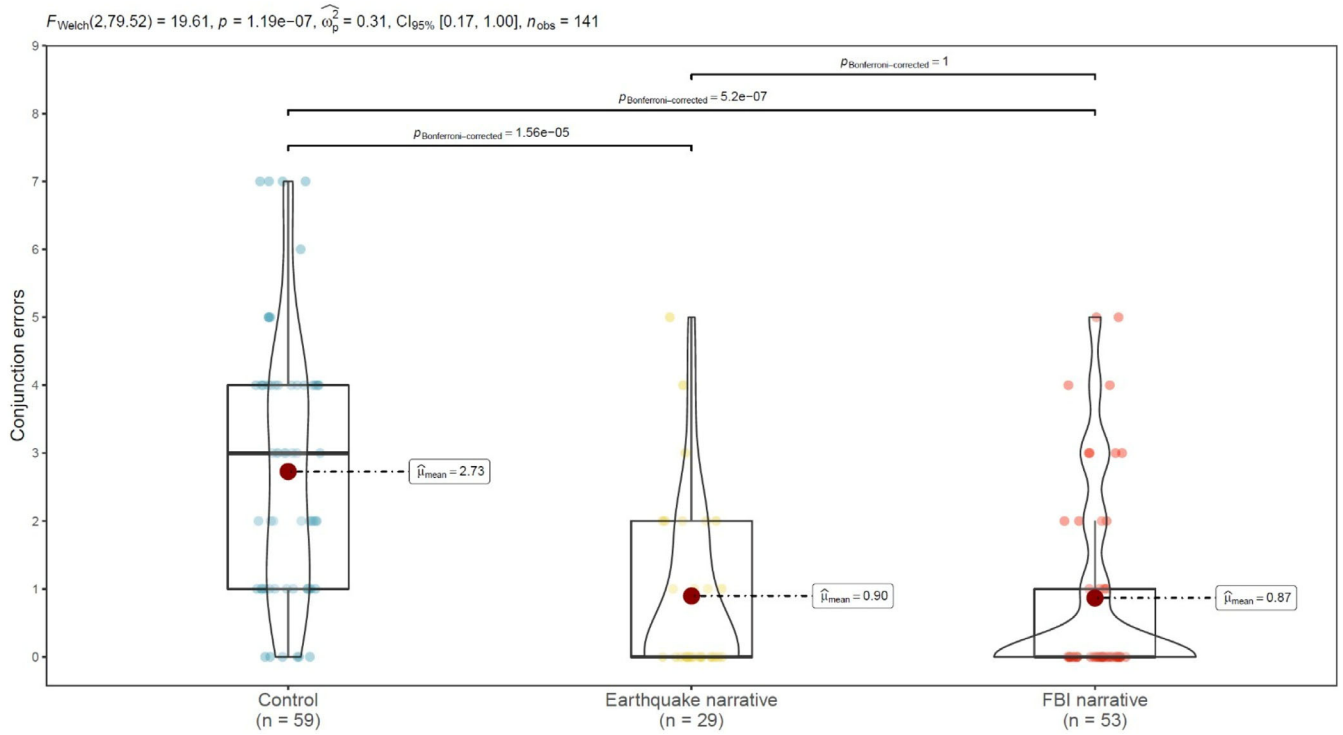

FIGURE 3 Violin plot with boxplots and data jitter for the mean difference in conjunction errors between the FBI narrative inoculation, earthquake narrative inoculation, and control conditions (Study 2).

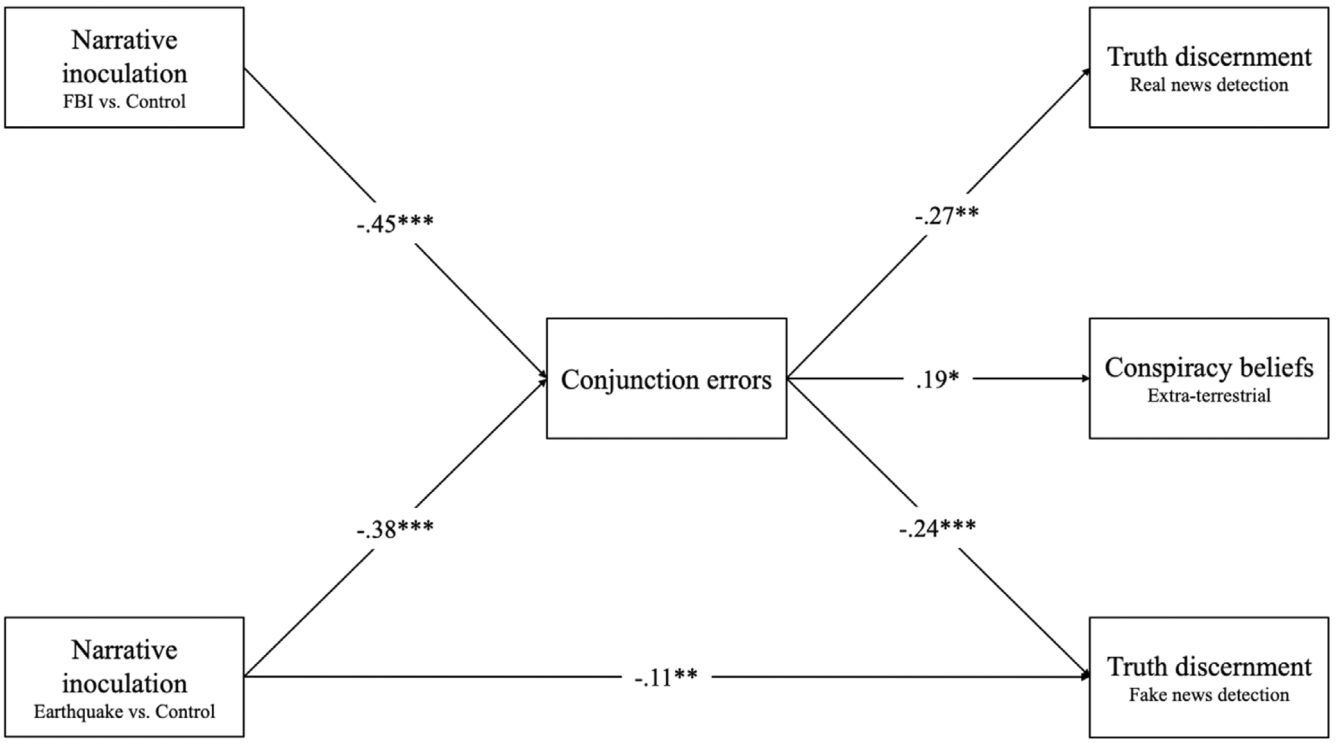

FIGURE 4 Indirect path model for the effect of the narrative inoculations (vs. control) on MIST-8 real and fake news detection, as well as conspiracy beliefs regarding extra-terrestrial cover-ups, through conjunction errors (Study 2). Negative direct effects denote less accurate detection of real and fake news, as well as lower conspiracy beliefs.

3.2.3 | Indirect effect of the narrative inoculations on conspiracy beliefs

In line with our main pre-registered analysis, we constructed a bias-corrected bootstrap (1000 re-samples) SEM with both of the narrative inoculations (vs. control) as the independent variables, conjunction errors (mean-centred) as the mediator, and both real and fake news detection and all types of conspiracy beliefs as the simultaneous dependent variables using the *lavaan* package in R. Furthermore, we additionally controlled for relevant demographics, political orientation, AOT (mean-centred), conspiracy mentality (mean-centred), and interaction terms for the narrative inoculations (vs. control) and conjunction errors with both conspiracy mentality and AOT on all paths.

This model revealed that both the FBI narrative inoculation (vs. control), standardised indirect effect $\beta = -.09$, 95% CI [−.16, −.01], and earthquake narrative inoculation (vs. control), standardised indirect effect $\beta = -.07$, 95% CI [−.14, −.01], indirectly reduced belief in extra-terrestrial cover-up (but not other types of) conspiracies through fewer conjunction errors (see Figure 4). Furthermore, the FBI narrative inoculation (vs. control) indirectly increased both real news detection, standardised indirect effect = .12, 95% CI [.04, .20], and fake news detection, standardised indirect effect = .11, 95% CI [.04, .18], and the earthquake narrative inoculation (vs. control) indirectly increased both real news detection, standardised indirect effect = .10, 95% CI [.03, .17], and fake news detection, standardised indirect effect = .09, 95% CI [.03, .15], as measured by the MIST-8, through fewer conjunction errors. Importantly, MIST-8 distrust and naïveté were not altered directly or indirectly by the narrative inoculations (both *p* values >.05, see Supplement, Section 2.1.9).

However, despite a non-significant total effect, the direct effect of the earthquake narrative inoculation (vs. control) on fake news detection was negative. Similarly, despite non-significant direct effects, the total effects of the earthquake narrative inoculation (vs. control) on conspiracy beliefs regarding both personal wellbeing, $\beta = .46$, $p = .018$, and the control of information, $\beta = .44$, $p = .026$, were positive.

3.2.4 | Exploratory analyses

Pre-registered moderation analysis of the significant interaction effects in the main model revealed that the direct relationship between conjunction errors and fake news detection was only negative and significant when conspiracy mentality was moderate and high, but not when conspiracy mentality was low (Supplement, Section 2.1.4). However, once again, these findings should be treated with caution due to insufficient power to detect interaction effects.

Exploratory SEMs similar to the main model revealed that both narrative inoculations (vs. control) indirectly reduced other types of conspiracy beliefs when the relevant demographics, political orientation, and moderators (AOT and conspiracy mentality) were systematically excluded from the model (Supplement, Section 2.1.5). Furthermore, both narrative inoculations (vs. control) indirectly reduced mean scores on the GCBS treated as a single factor when relevant demographics, political orientation, and moderators were excluded, but not when these control variables were included (Supplement, Section 2.1.8; see Table S8 for breakdown of indirect effects for each model).

3.3 | Discussion

The results from Study 2 largely corroborated the findings in the pilot study, showing that both narrative inoculations indirectly reduced conspiracy beliefs through fewer conjunction errors relative to the control group. These indirect effects were once again only found for certain conspiracy beliefs (when covariate controls were included), this time, for those regarding extra-terrestrial cover-ups. This is in contrast with the pilot study, which only showed an indirect decrease in conspiracy beliefs regarding government malfeasance. While the earthquake narrative inoculation was developed to address the possibility that these interventions may only reduce conspiracy beliefs that relate to their content (i.e., in the case of the earthquake inoculation, the control of information), this finding instead suggests that our narrative inoculations may reduce conspiracy beliefs in different domains depending on extraneous factors. Nevertheless, exploratory analyses revealed some evidence that both inoculations also indirectly reduced the single-factor measure of conspiracy beliefs.

Both narrative inoculations also indirectly improved detection of real and fake news, suggesting that inoculation against conjunction errors can reduce misinformation susceptibility without inducing a generally suspicious or gullible worldview. Considering the significant negative link between conjunction errors and the accurate detection of real and fake news, it appears that susceptibility to this logical fallacy may play a role in general misinformation susceptibility, even when controlling for the overlap in variance with AOT. Furthermore, the motivated defence induced by our narrative inoculations may have conferred psychological resistance against false information regardless of the manipulation technique being used.

Moderation analyses revealed that when conjunction errors and high conspiracy mentality are combined, this can have particularly detrimental consequences on people's ability to detect fake news. In contrast, conjunction errors did not relate to fake news detection among those displaying a low conspiracy mentality. Therefore, it appears that conspiracy mentality may direct the context under which conjunction errors hinder our ability to discern true from false information. We also report somewhat concerning results with regards to the effects that did not run through conjunction errors indirectly, at times worsening fake news detection and increasing certain conspiracy beliefs. Considering that these effects did not persist when excluding the moderator variables from the model, this may have been an artefact of individual difference responses to our intervention based on conspiracy mentality. Furthermore, there may have been some imperfections with regards to our experimental manipulations, perhaps demonstrated by the particularly high number of participants failing the earthquake narrative inoculation attention check. However,

comparative analyses confirmed similar effects when these attention check failures were included to achieve appropriate power (see Supplement, Section 2.1.9).

4 | INTERNAL META-ANALYSIS

To explore the collective evidence so far, we performed meta-analyses on the direct effects of our narrative inoculations on (1) conjunction errors and (2) conspiracy beliefs (see Supplement, Section 3 for details). The meta-analytic effect of narrative inoculation on conjunction errors was large, $d = 0.82$, with the Bayes Factor substantially favouring the directional hypothesis over the null, $BF_{10} = 3.76$. In contrast, the direct meta-analytic effect of narrative inoculation on conspiracy beliefs was small, $d = 0.14$, with the Bayes Factor indicating a need to collect more data, $BF_{10} = 2.56$.

5 | GENERAL DISCUSSION

In one pilot study and one main experiment, we demonstrated that a storytelling approach to inoculating participants against the conjunction fallacy can indirectly reduce conspiracy beliefs. In the pilot study, a narrative inoculation centred around an FBI agent failing to solve a bomb attack due to a conjunction error reduced participants' susceptibility to conjunction errors, and in turn, reduced conspiracy beliefs regarding government malfeasance. In the main experiment, we included an additional narrative inoculation centred around a seismologist incorrectly suspecting that public officials escaped an earthquake through withholding information from the public due to a conjunction error. In this case, both narrative inoculations indirectly reduced conspiracy beliefs, but this time only those regarding extra-terrestrial cover-ups. Exploratory evidence that our narrative inoculations can indirectly improve real and fake news detection was also provided in the main experiment.

Typically, researchers confer psychological inoculation by focusing on technique-based interventions that outline exactly *how* certain types of misinformation may manipulate one's opinion. For example, the *Bad News* game asks participants to roleplay as a disinformation producer using a number of misinformation techniques – such as spreading conspiracy theories or impersonation (see Roozenbeek & van der Linden, 2019a, 2019b). However, other approaches involve inoculating participants against the logical fallacies that may increase the likelihood of falling prey to false claims, regardless of the misinformation in question. For example, Cook et al. (2017) showed that explaining flawed argumentation techniques protected participants against climate change misinformation. In the current article, we provide a similar approach, demonstrating that inoculation against certain logical fallacies known to increase susceptibility to conspiracy beliefs – in this case, the conjunction fallacy – can provide protection against certain epistemically questionable beliefs.

While conspiracy beliefs have been linked to a number of different cognitive biases (see Biddlestone et al., 2022), some may be more complex in nature than others to effectively convey in an intervention. For example, accuracy nudges simply encourage people to reflect on whether the information they intend to share online is accurate (see Pennycook, McPhetres, et al., 2020). Research suggests that this may induce cognitive reflection, potentially involving components of AOT. However, conveying the complexities of the conjunction fallacy to participants includes a number of complicated components, such as numerical and probabilistic factors, as well as awareness of one's motivated reasoning. Therefore, the approach we employed in the current article may provide a more digestible way for interventions to convey complex ideas to participants, in turn, providing them with the general tools to judge the credibility of information regardless of its context. Alongside this, research has confirmed that some of the appeal of conspiracy theories comes from their entertainment value (van Prooijen et al., 2022), suggesting that our narrative storytelling technique may be particularly effective for those that would otherwise be vulnerable to conspiracy beliefs and misinformation.

Regarding the importance of scalability when implementing interventions against the spread of misinformation (see Pennycook & Rand, 2021), the technique outlined here has pros and cons. Participants were presented with three short texts, but these texts contained a fairly large amount of information. For example, not only were participants presented with a story, but also a mathematical demonstration of the conjunction fallacy, as well as more general inoculation content. Therefore, while effective, this technique may be hard to implement in, for example, a social media setting that favours short and concise information over complex and detailed information. However, the storytelling component to narrative inoculation may suit other mediums through which this intervention could be implemented, such as short internet videos (see also Roozenbeek, van der Linden, et al., 2022) or as sub-text in television shows and adverts. This raises the important notion of context when discussing scalability. In short, some interventions may be more or less scalable depending on the domain in which they are implemented.

5.1 | Limitations

Lastly, the current findings were not without their ambiguities and limitations. First, while the narrative inoculations indirectly reduced conspiracy beliefs in both studies, the type of conspiracy belief was different between studies. This raises the question of whether this intervention only reduced conspiracy beliefs relevant to the story presented, or whether there were other extraneous factors at play. Considering the different context of the two narratives presented in the main experiment, coupled with the same type of conspiracy beliefs that they both indirectly reduced (i.e., extra-terrestrial cover-ups), it appears most likely that the baseline ideologies, individual differences, and conspiracy beliefs of participants were influential factors. In fact, exploratory models in both studies analysing conspiracy beliefs as a single-factor revealed that both narrative inoculations indirectly reduced conspiracy beliefs overall, but these did not remain when controlling for demographics and political orientation in Study

2. Future research would benefit from unpacking this element further, perhaps through investigations involving many different measures of conspiracy beliefs.

Second, despite the apparent protective effects that reduced conjunction errors can have against epistemically questionable beliefs, there was some indication of higher misinformation susceptibility as a direct result of the interventions when conjunction errors were not reduced beforehand. It may be the case that the content of the stories involving suspicious and secretive circumstances primed participants into conspiracist suspicions when conjunction errors were not altered. Future research should thus explore how the content included in these narrative inoculations may have differing implications based on whether the stories are more or less conspiratorial in nature. Third, a disproportionately large number of participants failed the attention check in one condition,[5] warranting further investigations into how important the storytelling elements of narrative inoculations may be, considering the similarity in findings when attention check failures were included or excluded.

Third, we did not explicitly measure traditional or motivational threat in response to the inoculation treatment. Despite recent questions surrounding the value in measuring perceived threat as a determinant of whether certain inoculation strategies motivate a suitable level of resistance against malicious persuasion (see Banas & Rains, 2010 for a meta-analysis; see Compton, 2021 for a review), future scholars may benefit from including manipulation checks of perceived threat to further understand the nature of the intervention developed here. In a similar vein, while Banas and Rains (2010) found no meta-analytic effect of improved efficacy due to a delay between administering the inoculation and participants receiving the 'attack' (or 'viral load'), future studies could investigate possible temporal parameters to the intervention presented here. Finally, there remain ambiguities surrounding the potential influence of demand characteristics in our studies. Adopting a similar design to Stall and Petrocelli (2022), participants in our studies were either presented with corrective information about conjunction errors or no information. Further addressing Stall and Petrocelli's call to study whether interventions against conjunction errors can reduce susceptibility to well-established culturally relevant conspiracy narratives – rather than exclusively novel conspiracy theories – participants were presented with items reflecting the general components of common conspiracy narratives. Therefore, it may be the case that participants were aware of the nature of the materials being presented to them. Yet, we note that recent empirical research finds that survey experiments are relatively robust to demand characteristics, even when the intention of the experimenter is revealed (Mummolo & Peterson, 2019). Moreover, considering the decades of research demonstrating the efficacy of inoculation as an intervention strategy against epistemically questionable beliefs (Compton et al., 2021) – whether novel or otherwise – we suspect that our implementation of inoculation was qualitatively different from Stall and Petrocelli's training intervention. Nevertheless, future research would benefit from investigating the potential influence of demand characteristics in this intervention, as well as comparing the efficacy of our approach alongside other similar interventions.

5.2 | Future recommendations

As previously noted, our intention was to provide a proof-of-concept for the use of narrative storytelling to aide in the implementation of inoculation against conjunction errors, rather than developing a more efficacious strategy than existing inoculation intervention per se. Nevertheless, to extend and elaborate on the relevance of the technique presented here, we recommend that future researchers compare the efficacy of narrative inoculation against established inoculation strategies to determine when and how it may be appropriately administered. Future avenues could also focus on inducing other cognitive factors that are known to protect against epistemically questionable beliefs. In fact, in the main experiment, AOT was positively associated with detection of real news, corroborating past research (Roozenbeek, Maertens, et al., 2022). Thus, narrative inoculations bolstering AOT may be another fruitful avenue through which individuals could be helped to judge the veracity of information more critically.

Furthermore, some of the current findings revealed varying effects based on different levels of conspiracy mentality. For example, the narrative inoculation appeared to induce backfire effects on certain conspiracy beliefs for those low in conspiracy mentality (Study 1), and conjunction errors were only related to impaired detection of fake news when conspiracy mentality was high (Study 2). Therefore, future research could focus on tailoring these interventions based on how they may appeal to those with differing inclinations to perceive the world in conspiracist terms.

5.3 | Conclusion

Research is increasingly demonstrating the efficacy of psychological inoculation as an intervention against misinformation susceptibility. In the current article, we used a narrative approach to inoculation aimed at protecting individuals against the conjunction fallacy. Across two studies, this approach proved promising as an intervention to reduce certain conspiracy beliefs, alongside improvements in real and fake news detection. While previous research has used gamified versions of inoculation to this same end (see Roozenbeek & van der Linden, 2019a, 2019b), our approach provides additional avenues through which to enhance the scalability of inoculation by tailoring the information presented to suit certain storytelling mediums. In light of this proof of concept, we encourage others to extend these findings to protect against other relevant logical fallacies, alongside exploring different framings to effectively appeal to individuals particularly vulnerable to conspiracy beliefs.

CONFLICT OF INTEREST

There are no conflicts of interest to disclose. This work was reviewed and approved by the University of Cambridge Psychology Research Ethics Committee (Application number: PRE.2022.005).

DATA AVAILABILITY STATEMENT

All data have been made publicly available on the OSF with the following link: https://osf.io/n2v5r/?view_only=2566ad17d9884c04b2bca29920ac7514.

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ENDNOTES

[1] An additional 89 responses were collected in another condition intended for use in a separate analysis. Inclusion of these participants did not notably alter the results (see Supplement, Section 1.1.9).

[2] Additional control variables measuring participants' frequency of interactions with internet memes and internet meme awareness were included for use in a separate analysis (see Supplement, Section 6).

[3] It is often recommended to examine hypothesised and theoretically relevant indirect effects even in the absence of significant total effects (for an overview see Rucker et al., 2011).

[4] These effects remained largely similar when including the failed attention checks in the analysis, with an effect size for the earthquake narrative inoculation near identical to that of the experimental effect in the pilot study, $d = 0.64$ (see Supplement, Section 2.1.8).

[5] It is possible that the attention check included after the earthquake narrative incolation texts was particularly difficult as it drew heavily on how much participants fully comprehended the content (see Supplement, Section 4). Nevertheless, this disproportionate lack of comprehension compared to the FBI narrative condition did not appear to alter the intended experimental effect sizes.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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