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Hope over fear: The interplay between threat information and hope appeal corrections in debunking early COVID-19 misinformation

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ABSTRACT

The spreading of COVID-19 misinformation paralleled increasing fear towards the pandemic reported worldwide in its early stages. Yet research on the emotional basis for misinformation susceptibility and how emotional appeals may help reduce COVID-19 related misperceptions remains limited. To address this gap, we conducted a 2 (threat from COVID-19: yes vs. no) × 4 (correction conditions: none vs. factual correction vs. factual correction + words of optimistic outlook & individual efficacy vs. factual correction + words of optimistic outlook & collective efficacy) between-participant factorial experiment among an online sample of Chinese residents (N = 836) in June 2020. Misinformation about COVID-19 treatments and mitigation was presented in all conditions. Across five misinformation topics, threat information induced more misperceptions while all three types of corrections mitigated threat information's deleterious impact and improved belief accuracy. Importantly, corrections incorporating hope appeals showed enhanced effectiveness in improving belief accuracy when threat information was present whereas factual corrections absent hope appeals did not show similar sensitivity towards threat information. For hope appeal corrections, their indirect effects on desirable downstream behavioral intentions through corrected beliefs were stronger with than without preceding threat information. Our study thus demonstrated the potential of deploying hope appeals to fight the COVID-19 infodemic in China and beyond when threat information is prevalent, while highlighting the importance of studying the roles of emotional appeals in health misperception formation and correction.

The surging infodemic of COVID-19 related misinformation (Brennen et al., 2020; WHO, 2020a)—such as unproven treatments (e.g., the Miracle Mineral Solution), conspiracy theories about the origin of the virus (e.g., COVID-19 as a bioweapon), and baseless claims about how the virus spreads (e.g., 5G network spreading the virus)—threatens to undermine the public's compliance with public health guidelines (Roozenbeek et al., 2020). As the counts of COVID-19 cases and deaths rapidly grew in the early stages of the pandemic, more and more people around the globe experienced anxiety and fear. Previous research has devoted extensive attention to the cognitive aspect of misperception formation and correction (Kahan, 2012; Lewandowsky et al., 2012; Pennycook and Rand, 2019); for example, "accuracy nudges" that encourage people to think more deliberately were found to increase truth discernment and decrease intentions to like or share misinformation on social media, including in the context of COVID-19 (Effron and Raj, 2020; Pennycook et al., 2020). In contrast, despite preliminary research suggesting how discrete emotions, such as anxiety and anger, could exacerbate susceptibility to political misinformation (Martel et al., 2020; Weeks, 2015), the emotional basis of misperception formation is largely understudied in health contexts, let alone the potential to deploy emotional appeals as correction strategies in environments of high fear, such as the COVID-19 pandemic.

To address this gap, in the current study we first examined the emotional basis for misinformation susceptibility. We follow previous work and define misinformation as information that runs counter to the best available evidence and expert consensus (Nyhan and Reifler, 2010; Vraga and Bode, 2020). Specifically, the current study focuses on misinformation that promotes unproven medicines and treatments for

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COVID-19 (e.g., using vinegar, smoking cigarettes), given their potential in distracting the public from following recommended health practices (e.g., social distancing, vaccination). Drawing from the extended parallel process model (EPPM, Witte, 1992, 1996) and its extension—the extension of the extended parallel process model (E-EPPM, So, 2013; So et al., 2019), we argue that in times of a global health crisis, high levels of perceived threat may motivate individuals to evaluate and seek out efficacy information to cope with the threat and regain a sense of control, even when such efficacy information lacks evidence base. Our results show that fear-inducing information emphasizing the threat from the pandemic may increase acceptance of misinformation.

Furthermore, we present novel experimental data testing the effectiveness of deploying hope appeals (Chadwick, 2015; Nabi and Prestin, 2016) within correction messages to counteract potential deleterious impact of threat information. Emerging evidence has showcased the effectiveness of hope in advocating attitude and behavioral changes (Chadwick, 2015; Nabi and Myrick, 2019). This study follows this line of research and tests whether hope-inducing messages can be crafted to correct misinformation and encourage advocacy behaviors in the context of COVID-19.

Importantly, we identified the boundary condition of the effectiveness of hope appeal corrections and demonstrated the nuanced interplay between threat and hope in misperception formation and correction. The problem of misinformation is by no means unique to the COVID-19 pandemic (Lazer et al., 2018; Vosoughi et al., 2018). The literature on misinformation correction demonstrates that corrections are overall effective in improving belief accuracy, though modest in effect sizes and substantial in effect heterogeneity (Walter et al., 2019). To identify the conditions where correction messages deploying hope appeals would show stronger versus weaker effectiveness, we adopted a factorial design crossing the presence of threat information with correction messages varying in the use of hope appeals to clarify how they might interact with each other. This design makes it possible to specify when hope appeal corrections are particularly effective in debunking misperceptions as well as producing downstream behavioral intentions aligned with public health recommendations. Lastly, we addressed collective efficacy as a promising hope appeal component and recruited a Chinese sample to inform the theoretical understanding of the roles of emotional appeals in misperception formation and correction in a non-Western collective culture, which provide insights to inform the global fight against the COVID-19 infodemic.

1. Emotional basis of misinformation susceptibility

A burgeoning line of research has begun to examine the roles of discrete emotions in susceptibility to misinformation. Emotional experiences serve as important heuristics in the processing of misinformation and alter the belief outcomes in distinct ways (Landrum et al., 2021). For example, anger can sometimes increase reliance on one's prior identity and thus promote beliefs in political misinformation in line with one's partisanship, while anxiety increases reliance on the information environment and makes partisanship-incongruent misinformation more believable (Weeks, 2015). During the COVID-19 pandemic, feelings of depression were found to be associated with beliefs in misinformation and conspiracy theories (De Coninck et al., 2021). Anger can also make one susceptible to anger-inducing rumors, such as hospitals' mismanagement of a pandemic (Na et al., 2018).

However, we know much less about how *fear-inducing threat messages* may affect misinformation susceptibility, especially in a high-*threat* and low-*control* context, such as during the COVID-19 outbreak. While anxiety and fear are both threat-related and may co-occur, they have distinct key eliciting factors and focus on different aspects of the threat (Lazarus, 1991). Based on appraisal theories of emotion, the hallmark of anxiety is the appraisal of the uncertainty of a given situation, whereas fear is elicited when the situation is perceived to be threatening, high in severity, and out of one's control (Frijda, 1987; Lazarus, 1991). In this study, we focus on fear, and draw from the extended parallel process model (EPPM, Witte, 1992, 1996) and cognitive appraisal theory of emotion (Lazarus, 1991) to explain the role of fear in susceptibility to COVID-19 misinformation. The experience of fear was widespread during the early phase of the pandemic, when news coverage about the COVID-19 outbreak during January–June 2020 expresses negative sentiments, with fear standing out as the most prominent category (Aslam et al., 2020). Concomitantly, public opinion polls across different countries show that people experience high levels of negative emotions including fear (Chao et al., 2020; Keeter, 2020).

According to the cognitive appraisal theory of emotion (Lazarus, 1991), fear generates the tendency to alleviate or avoid the appraised threat, such as by taking preventative measures when perceived efficacy is high. In line with this literature, EPPM (Witte, 1992, 1996) also posits that the fear aroused by threat appraisals can motivate people to evaluate and appraise their efficacy in coping with the threat. And when people do not feel efficacious in averting the threat in this appraisal process, they tend to seek out more information to increase their coping-related efficacy perceptions (e.g., So, 2013; So et al., 2019). Therefore, fear, as induced by the threat of the COVID-19 outbreak, coupled with heightened uncertainty, may motivate individuals to seek *efficacy* information, regardless of whether it is supported by science or falsehoods, to alleviate perceived threat and regain a sense of control (Brashers, 2001; Seeger et al., 2003). The infodemic of COVID-19 brought a considerable amount of false or unsubstantiated claims about COVID-19 treatments to the public information environment, especially online (Brennen et al., 2020). Since misinformation about unwarranted preventive strategies can generate a false sense of efficacy and control, information highlighting threats is likely to make people more vulnerable to falling prey to such misinformation. Supporting this line of reasoning, research suggests that chronic fear can lead to less careful information processing in general (e.g., Jepson and Chaiken, 1990).

The context of the early COVID-19 outbreak in China is suitable to test our theoretical argument on threat, fear, and misinformation. A survey in 2020 among Chinese adults showed that 85% of respondents expressed a strong fear of infections for themselves and their families (Gao et al., 2020). Moreover, research categorizing COVID-19 misinformation in China has confirmed that unwarranted "preventative strategies" was one of the most prominent types of misinformation circulating online (Zhang et al., 2021). These misleading preventative strategies range from ineffective but harmless behaviors, thus likely to distract people from science-based preventative strategies (e.g., Vitamin C can treat COVID-19), to ones that can create serious health problems (e.g., smoking cigarettes). Therefore, we expect information highlighting the threat of COVID-19 to increase susceptibility to such misinformation, promoting baseless preventative strategies.

H1. When people are exposed to threat information, they are more likely to believe in misinformation about misguided actions to prevent COVID-19, compared to those who did not see threat information.

2. Emotion and misinformation correction

If threat-induced fear could amplify one's susceptibility to misinformation promoting ungrounded COVID-19 treatments, would it be possible to leverage emotional appeals to reduce misperceptions? We seek to bridge the research on emotional persuasion and theories about biased information processing (Kunda, 1990; Taber and Lodge, 2006) by (a) examining the potential effects of emotional appeals, such as hope appeals, for mitigating misinformation that has been amplified by threat information and (b) identifying conditions where such effects are stronger versus weaker.

Lodge and Taber (2000) and the John Q. Public model (2015) viewed emotion as an essential part of biased information processing: when individuals assess a piece of new information, they use a "how-do-I-feel"

heuristic that relies on the emotion heuristic as a primary basis in making judgments. Therefore, message features that elicit and impact the emotional heuristics most people rely on in their snap reactions are crucial to how a message is processed. Such an anchoring role of emotion heuristics in one's reasoning processes points to the potential of leveraging emotion in facilitating the acceptance of corrective messages.

However, scholars have only begun to understand the role of emotions in misinformation correction, and the empirical evidence so far has been scarce and inconclusive (Weeks and Gil de Zúñiga, 2019). A pioneering study by Weeks (2015) found that individuals' emotional states (anger and anxiety) did not influence their acceptance of corrective messages. However, Sangalang et al. (2019) found that narrative corrections with an emotional ending (anger and fear) were more effective in reducing misinformed beliefs, pro-tobacco attitudes, and intentions to use organic tobacco when compared with the misinformation-only control, although the superiority of the emotional enhancement over the non-emotional correction was only documented for attitudes. Noticeably, these pioneering studies have not systematically tested the effectiveness of emotion-based corrections (e.g., hope) *while* varying the presence of susceptibility-amplifying emotions (e.g., fear). Therefore, it remains to be seen whether the effectiveness of corrections deploying emotional appeals, such as hope appeals, would be moderated by exogenously manipulated threat information and fear, as both are prevalent during a pandemic.

3. Leveraging hope appeals to correct COVID-19 misinformation

3.1. Hope and hope appeal messages

Given that fear might increase one's susceptibility to health misinformation, we examine the potential effectiveness of hope appeals in correcting misinformation. A burgeoning line of research advocates studying more on the persuasion potential of messages that appeal to positive emotions, such as feelings of hope and compassion (e.g., Chadwick, 2015; Myrick and Oliver, 2015). Hope appeals emerged as one of the promising strategies to facilitate belief, intention and behavioral changes (e.g., Chadwick, 2015; Nabi and Myrick, 2019). In addition, hope was found to be an important coping strategy when facing adversities, as hope is positively associated with individual resilience, psychological well-being, as well as decreased depression and distress (Marciano et al., 2022; Snyder, 2002). Thus, hope and hope-inducing messages are of high relevance to cope with the COVID-19 pandemic as well as the accompanied infodemic. This study thus tests if hope-inducing messages can be crafted to correct misinformation in the context of COVID-19, and if so, identifies the boundary conditions for the effectiveness of hope appeals corrections.

Some characterize hope as a way of thinking that generates perceptions about one's own capacity and pathways to initiate and achieve desirable goals (Snyder, 2002). Alternatively, hope was defined as a feeling of "fearing the worst but yearning for better," which is associated with the desire to achieve an important, positive, yet uncertain future outcome in the face of adversity (Lazarus, 1991). Both perspectives agree upon the motivational function of hope. Hope is not only a coping strategy for reducing stress, anxiety, and the deleterious psychological effects of adversity, but can also serve as a pivotal resource to facilitate goal-directed actions (Lazarus, 1991; Snyder, 2002), including broadening one's openness to different perspectives and thus persuasion (Fredrickson, 2013). Therefore, in the wake of the COVID-19 pandemic and its ensuing infodemic, evoking hope has potential to reduce stress, motivate people for science-based healthy behaviors, and promote acceptance of correction messages.

However, few studies have systematically investigated how to create messages that can effectively evoke hope (i.e., hope appeals). Various hopeful stimuli have been utilized, ranging from narratives emphasizing underdog experiences worth empathy (Prestin, 2013) to efficacy-promoting messages (Nabi and Prestin, 2016). Existing research suggests that hope appeals consist of several appraisal components: a) *importance*, b) *goal congruence,* c) *positive future expectation,* and d) *possibility appraisal* (Chadwick, 2015). A hope appeal message should emphasize an opportunity to achieve a desirable future outcome that is important, possible, and consistent with the message-receiver's goals. Additionally, hope appeal messages should present pathways to achieve that desired outcome. In the case of the COVID-19 pandemic, *importance* and *goal-congruence* are high, especially in the Chinese context during the early months of the pandemic: public opinion polls showed widespread consensus among the Chinese people that controlling the pandemic was an important and desirable future outcome (Gao et al., 2020; Qian et al., 2021). In this study, we thus focus on positive *future expectation* and *possibility appraisal* of the future outcome when developing hope appeal corrections.

3.2. Hope appeal components: individual efficacy and words of optimistic outlook

An important factor that influences the *possibility appraisal* of a future outcome is efficacy perception, which captures the perceived situation control and the feasibility of using certain pathways to reach desired goals. To elicit hope, emphases on the agency (goal-directed energy) and feasible pathways (available routes to pursuit goals) can reinforce each other throughout the goal pursuit process because these self-referential efficacy perceptions (Snyder, 2002) can help focus individuals' attention to pathways and strategies promising in achieving the goal while enhancing their motivation to overcome impediments (Snyder, 2002). In EPPM, individual efficacy perceptions, including both response efficacy (i.e., perceived effectiveness of the recommended response to mitigate threat) and self-efficacy (i.e., perceived individual ability to perform a recommended action), follow fear arousal and, in turn, activate protection motivation that eventually prompts actions to mitigate the fear-inducing threat (Witte, 1992, 1996). The construct of efficacy perceptions thus connects the literature on hope appeals and EPPM, although prior research has not yet clarified its implications for misperception formation and correction. As discussed earlier, we argue that EPPM and E-EPPM provide the theoretical reason why misinformation about COVID-19 treatments is particularly powerful and deceitful because these allegedly efficacious treatments, though scientifically untrue, nevertheless provide a bogus sense of efficacy. Such bogus sense of efficacy brought by misinformation can potentially alleviate the experienced fear and may even generate a false sense of hope (e.g., van der Meer and Jin, 2020). A hope appeal correction message can be effective in discrediting such unsubstantiated efficacy information because its efficacy component, when supported by science, can replace bogus efficacy information with evidence-based strategies to address the need to regain control.

Besides science-based efficacy information that can enhance possibility appraisal, *future expectation* should also be featured in a hope appeal correction message. *Future expectation* can potentially be activated by hopeful expressions that portray a rosy future, even without specifying the concrete routes and actions needed to reach that future. We call such future-looking while efficacy-lacking rhetoric *words of optimistic outlook*. Research found that presenting a future different from the undesirable current state can induce hope and motivate behavior change (Cohen-Chen et al., 2017). Similarly, viewing underdog narratives depicting the characters' sought-after dreamed future, despite unfavorable odds at present, evoked hope and subsequent goal-directed motivations (Prestin, 2013). Such results imply that describing a future where the COVID-19 pandemic is under control can induce hope, and by extension, promote correction acceptance.

Combining individual efficacy information and optimistic future depiction will address both the *possibility appraisal* and the *future expectation* components, yielding a stronger hope appeal message and more effective misinformation correction. Supporting this idea, recent research done by Nabi and Prestin (2016) showcased that emotionally

consistent stimuli (versus inconsistent messages), where the general hope-framed message was combined with high efficacy information, led to better persuasion success, including higher trust in health news and more intention to carry out desirable behaviors. Thus, we aim to test the benefits of hope appeal corrections featuring both words of optimistic outlook and individual efficacy information in terms of debunking misinformation. We first seek to establish whether such hope appeal corrections can correct misperceptions without backfiring.

H2. Compared to misinformation-only conditions, simple factual corrections will decrease misperceptions.

H3. Compared to misinformation-only conditions, hope appeals combining words of optimistic outlook and individual efficacy information will decrease misperceptions

3.3. Collective-efficacy as an alternative message feature

Previous research on hope-inducing efficacy information typically assumes the source of agency is confined to the individual (e.g., Snyder, 2002). However, in addition to internal factors, external factors can also influence hoped-for future events. For example, restoring optimism and individual well-being after a flood disaster also depends on external factors like support from communities (Ntontis et al., 2021). Perceptions of such external factors can influence evaluation related to the possibility of achieving the desirable outcome, thus influencing the degree of hope induced (Roth and Hammelstein, 2007). Following this logic, this study explores if one specific type of external factor beyond oneself, perceived collective efficacy, can also serve as a source of agency to evoke hope.

Bandura (2000) defined collective efficacy as people's shared beliefs in their collective power to produce desired results. Perceived collective efficacy may be fostered through social interactions and identification with social groups. Such perceptions about how larger social groups beyond oneself engage in goal-directed activities, such as community mobilization and governmental support, may contribute to experienced hope. For example, expected social support from communities increases perceived collective efficacy, which also contributes to restoring individual's optimism after flooding disasters (Ntontis et al., 2021). Individuals experienced higher levels of optimism when other people were striving for shared future outcomes (Carver and Scheier, 2001). After the 911 terrorist attack, hearing that community members were helping each other restored hope (Aspinwall and Leaf, 2002). Research on social coping also suggests that when groups experience a shared stressor, such as COVID-19, collaborative communal coping can increase individuals' efficacy perceptions and alleviate distress (Afifi et al., 2020).

Therefore, we argue that appraisals of nationalistic collective capacity in achieving the desired goal can evoke hope, especially in collectivist cultures such as China. Perceived collective efficacy regarding the performance of one's own country in dealing with COVID-19 was associated with reduced risk perceptions (Dryhurst et al., 2020), implying that higher collective efficacy may lead to more optimistic perceptions with regard to ending the pandemic. Although still understudied, a growing line of research has begun to examine the roles of collective efficacy in evoking hope and motivating collective actions (Cohen-Chen and Van Zomeren, 2018). We follow this line of research and test the contribution of hope appeal based on collective efficacy in debunking misinformation. Testing collective efficacy in a collective culture can thus provide theoretical insights to inform the global combat against misinformation beyond individualistic cultures and western countries, where most research on health misinformation correction has been conducted.

H4. Compared to misinformation-only conditions, hope appeal corrections combining words of optimistic outlook and collective efficacy information will decrease misperceptions.

3.4. How threat information moderates the effects of hope appeal corrections

As argued above, people may turn to misinformation for alleged "magic cures" to regain a sense of control. If threat and fear could exacerbate the power of such misinformation to mislead people, corrections leveraging hope appeals hold the potential to counteract the amplification effects of threat information. When fear-inducing threat information is present, hope appeal corrections can promote efficacy perceptions, either by promoting preventative measures grounded in science or by increasing perceived collective ability to cope with the pandemic. This is to satisfy the desire for a positive outlook, since this desire is likely to have been made even stronger by salient threat; in contrast, when the threat ebbs, the desire for a positive future would appear less urgent and important, leading to a reduced need for hope. Empirically, this reasoning amounts to an interaction hypothesis where the effectiveness of hope appeal in correcting misinformation will be stronger when a threat is made salient (vs. not salient).

Although previous research has not yet manipulated hope appeal and threat information simultaneously in the context of misinformation correction, a line of inquiry (e.g., Dillard et al., 2017; Nabi and Myrick, 2019) studying the joint impacts of fear and hope reveals stronger persuasive effects when messages designed to invoke these two emotions converged towards the same persuasive goal. That said, prior research has not yet examined the situation where they diverge in persuasive goals. Our study aims to fill this gap: whereas we expect hope appeal corrections' effectiveness to be stronger with threat present than absent, we do not expect similar interaction patterns for factual corrections. This test of the interaction effect between threat information and hope appeals will help identify the boundary conditions to specify when hope appeals would be particularly useful in facilitating misinformation correction.

H5. When people are exposed to threat information, the debunking effects of hope appeal corrections combining words of optimistic outlook with either individual efficacy (H5a) or collective efficacy (H5b) will be stronger than when there is no threat information.

3.5. Impacts of hope appeal corrections extended to downstream behaviors

Finally, we examine whether the effects of correction messages, varying in the incorporation of hope appeal features and the accompany of threat information, would extend to improve behavioral changes beyond belief changes. The self-efficacy components of hope appeals contain information on science-based behavioral recommendations, which have the potential to motivate intentions to adopt behaviors consistent with public health guidelines. Such behavioral effects following corrected misbeliefs are grounded in the Theory of Planned Behaviors (Ajzen, 1985; Fishbein and Ajzen, 1975)as well as previous evidence supporting the belief-behavior link in tobacco use and indoor tanning after misperception correction (Sangalang et al., 2019; Tan et al., 2015). The connotation of positive future expectation in the hope appeals based on collective efficacy can also increase behavioral confidence and a sense of control which can, in turn, influence behavioral change (Frijda, 1987; Lazarus, 1991). With that said, for issues deeply seated in one's predispositions such as vaccination, corrected misbeliefs do not necessarily translate into respondents' updated behavior intentions (Nyhan and Reifler, 2010). We follow our previous expectation for the interaction effects between threat information and hope appeal corrections and hypothesize a moderated mediation effect: we expect the indirect effects of hope appeal corrections through corrected misperceptions on behavioral intentions will be more pronounced when threat information is present rather than absent. The reasoning behind these moderated mediation hypotheses is consistent with the

hypothesized interaction effects on belief accuracy while extending the pattern to downstream behavioral consequences.

H6. Regarding the behavioral effects of hope appeal corrections combining words of optimistic outlook with either individual efficacy information (H6a) or collective efficacy information (H6b), the indirect effects through corrected beliefs will be stronger when threat information is present than absent.

4. Method

Replication data files, *R* codes, treatment message stimuli, and referenced appendices that support the findings of this study are openly available on the Open Science Framework (OSF) at https://osf.io/w3rgm/?view_only=8c8185737201435a9e0ba9fd63e25e95.

4.1. Sample

The analytical sample reported here consisted of 836 Chinese citizens living in mainland China recruited by Qualtrics in June 2020. Participants were all adults ranging from 18 to 85 years old ($M = 39.58$, $SD = 12.53$). More than half of the sample (60.77%) had at least a Bachelor's degree, and most participants (92.34%) were urbanites. To ensure data quality, the sample excluded participants who dropped out before ($n = 244$) or during randomization ($n = 32$) and who spent longer than 1.5 interquartile range above the third quartile in survey completion time ($n = 58$, no significance differences across conditions). This research is approved by the University of Wisconsin-Madison Institutional Review Board.

4.2. Procedure and design

This study used a 2 (with threat vs. no threat) × 4 (misinformation only vs. factual correction vs. factual correction + words of optimistic outlook & individual efficacy vs. factual correction + words of optimistic outlook & collective efficacy) between-participants design. Misinformation was present in all conditions yet varying in topic. We used G*Power (Faul et al., 2009) to conduct a power analysis. Given the 2×4 design and $N = 836$, we can detect small effects size ($f = 0.11$) with $\alpha = 0.05$ and power = .80.

Reported data were from a larger between-participants experiment where factual correction plus individual hope appeal components were included in addition to the combined versions. The main goals of this report are to present evidence testing whether hope appeal corrections, when constructed to maximize their hope-inducing potency by incorporating both hope-evoking words of optimistic outlook and the efficacy component (individual or collective) (e.g., Chadwick, 2015; Nabi and Myrick, 2019), can correct misinformation; and more importantly, we aim to show the emotional linkage between misperception *formation* and *correction* by testing the interaction between threat information and hope appeal corrections. Therefore, we did not present data on individual hope appeal components in the main report as they are suboptimal in inducing hope and other persuasion outcomes (e.g., Musschenga, 2019; Nabi and Prestin, 2016; Snyder, 2002). Interested readers can find additional details in Online Appendix 8.

Participants first answered a set of screening questions to assess their eligibility, including their current place of residence, nationality, and whether or not they could read and write Simplified Chinese. Only Chinese who lived in Mainland China and could read and write Chinese natively were eligible for participation. After the screening questions, participants reported their risk perceptions of COVID-19, general concerns about health, emotion regulation ability, and levels of information exhaustion regarding COVID-19. All these covariates were measured prior to message exposure. In the threat treatment condition, participants were exposed to textual and visual information about the high risk of COVID-19 transmission and the severity of the symptoms (see Online Appendix 2 for details). In the no-threat condition, participants did not receive such information.

After the threat manipulation, participants were first told they would see an online story about COVID-19 and were shown a short social media post promoting misinformation on unwarranted preventive strategies (see the Stimuli section below for details). The topic of misinformation was randomly assigned to be drinking water, eating garlic, using vinegar, consuming Vitamin C, or smoking, which were identified as popular misinformation in China based on public opinion polls (see Online Appendix 1). Each participant only viewed one topic.

After misinformation exposure, participants in the misinformation-only control conditions proceeded directly to respond to outcome measures. Participants in the three correction conditions proceeded to read a correction message randomly selected from one of the three conditions varying in the presence of hope appeal components (*words of optimistic outlook, individual efficacy information, collective efficacy information*). The baseline factual correction was included across the three correction conditions. Details about condition-specific stimuli are provided below. Finally, participants answered questions on manipulation checks, beliefs, and behavior intentions associated with misinformation, and demographic information, and were debriefed.

4.3. Stimuli (see examples in online Appendix 2)

Threat stimuli. The threat stimuli were designed to evoke fear with threat information, emphasizing two components — the likelihood and the severity of the threat from the COVID-19 pandemic (Witte, 1992, 1996). The textual part of the stimuli details the high probability of COVID-19 transmission and the severity of the COVID-19 symptoms. The visual part of the stimuli illustrates infected lungs as well as a suffering hospitalized patient.

Misinformation stimuli. Messages presenting misinformation were designed to resemble popular misleading posts on Chinese social media platforms such as WeChat. These messages were similar in style and length but varied in topic — they claimed that either drinking water, eating garlic, using vinegar, consuming Vitamin C, or smoking was an effective preventive strategy against COVID-19.

Correction stimuli. To identify effective message components for correction messages, we adopted an "additive structure" in designing the corrections. Table 1 summarizes the content of each correction message. We started by laying down the basis of each correction—factual information that debunked the corresponding misinformation and remained constant across the three correction conditions for a given topic. Participants in the *factual correction condition* only read the debunking information and did not read any words of optimistic outlook or efficacy information.

For the two hope appeal correction conditions, we varied different components of hope appeals to address *future expectation* and *possibility*

Table 1
Message components of experimental conditions.

Message components	Misinformation condition	Factual correction condition	Words of optimistic outlook & individual efficacy condition	Words of optimistic outlook & collective efficacy condition
Misinformation	✓	✓	✓	✓
Debunking information		✓	✓	✓
Words of optimistic outlook			✓	✓
Individual efficacy			✓	
Collective efficacy				✓

appraisal, which were added to the factual correction. To address future expectation, we used words of optimistic outlook, which depicted a better future outcome without specifying concrete and actionable items that could influence the possibility of realizing that outcome. To manipulate possibility appraisal, we used two types of goal-congruent efficacy information. *Individual efficacy information* focused on how one can take actions to prevent COVID-19 on themselves in addition to factual debunking; *collective efficacy information stressed* how the society as a whole can take action to fight the pandemic. Participants in the *words of optimistic outlook & individual efficacy condition* received both words of optimistic outlook and individual efficacy information in addition to the baseline factual correction, whereas participants in the *words of optimistic outlook & collective efficacy condition* received both words of optimistic outlook and collective efficacy information in addition to the baseline factual correction. Noticeably, all hope appeal components (words of optimistic outlook, individual efficacy, and collective efficacy) were randomly drawn from a stimuli pool, where five different wordings of each component were created to increase generalizability and address case-category confounding. See Appendix 2B for the exact wording.

4.4. Manipulation checks

After participants were exposed to all experimental stimuli, their self-reported hopeful and fearful feelings were measured as manipulation checks. Participants were asked to rate to what extent a list of adjectives described their feelings after reading the messages (1 = *strongly disagree*, 5 = *strongly agree*). Feelings of fearful, afraid, scared, and anxious were averaged into a *fear* scale (*alpha* = .91, $M = 2.72$, $SD = 1.02$). Feelings of hopeful, optimistic and encouraged were averaged into a *hope* scale (*alpha* = .87, $M = 3.60$, $SD = 0.92$).

Regarding the threat manipulation, a two-tailed *t*-test showed that compared to the no-threat condition, participants in the threat condition experienced higher levels of fear ($t(832) = -2.16$, $p = 0.031$), collapsing all misinformation and correction conditions. Regarding the hope appeal manipulations, OLS regression showed that compared to the *factual correction condition*, both *words of optimistic outlook & individual efficacy condition* ($b = 0.18$, 95% *CI* [0.01, 0.34], $p = 0.033$, partial *eta-squared* = 0.01) and *words of optimistic outlook & collective efficacy condition* ($b = 0.39$, 95% *CI* [0.23, 0.55], $p < 0.001$, partial *eta-squared* = 0.03) induced higher levels of hopeful feelings, collapsing all no-threat and threat conditions. Additionally, testing these hope appeal conditions against the *misinformation control condition* generated identical patterns (see Appendix 3 for full models).

4.5. Measures

Misinformation belief. Participants answered the degree to which they agreed or disagreed with a list of false statements about COVID-19 preventive actions (1 = *strongly disagree* to 7 = *strongly agree*, $M = 3.25$, $SD = 1.77$). For each misinformation topic (drinking water, eating garlic, using vinegar, consuming vitamin C, and smoking), two statements about whether the topic-specific action can prevent COVID-19 were averaged to create an index for participants who were assigned to that topic (Pearson's *r* ranging from 0.73 to 0.85). For example, for a participant who read misinformation about drinking water, the average of their beliefs in "Drinking a large amount of water can prevent COVID-19" and "Drinking a large amount of water can reduce the chance of COVID-19 infection" were treated as their misinformation belief.

Misinformed behavior intention. Participants answered how likely they were to engage in the falsely recommended actions (drinking water, eating garlic, using vinegar, consuming vitamin C, and smoking) to prevent COVID-19 (1 = *very unlikely* to 4 = *very likely*, $M = 2.56$, $SD = 1.03$). The item corresponding to the misinformation topic assigned to each participant was coded as the *misinformed behavior intention*. For example, participants who read misinformation about drinking water were asked: "If the COVID-19 outbreak comes back again in the next month, how likely are you to do each of the following to prevent the virus: drinking a large amount of water." And their response was coded as their misinformed behavior intention.

Covariates. A set of participants' pre-existing values and perceptions were assessed and included as covariates, including perceived likelihood (4-point scale, $M = 1.94$, $SD = 0.99$) and severity (4-point scale, $M = 3.28$, $SD = 0.75$) of COVID-19 infection, general concern about health (5-point scale, *alpha* = .87, $M = 3.64$, $SD = 0.74$), information exhaustion (5-point scale, *alpha* = .91, $M = 2.95$, $SD = 1.11$), emotion regulation ability (5-point scale, *alpha* = 0.66, $M = 4.05$, $SD = 0.54$), news literacy (7-point scale, *alpha* = 0.86, $M = 5.45$, $SD = 0.74$) (see details of covariates in Appendix 4). Demographics, and misinformation topics were also included as covariates.

4.6. Analysis

For H1, a two-tailed *t*-test was used to test the difference in beliefs among those who saw threat information versus those who did not see threat information within the misinformation control condition. To test H2-H4, OLS regression was used to compare each of the correction conditions with the misinformation control condition in predicting beliefs. Interaction terms between dummy variables indicating assignment to correction conditions (vs. misinformation control) and the threat manipulation were added to the OLS regression to test H5. Covariates likely to impact the outcome variables were also included in these models to improve estimation accuracy. To test the moderated mediation path model of H6 (Fig. 1), we conducted structural equation modeling using the *lavaan* package in *R*, with *bootstrap* = 10,000. We provide detailed model specification, parameter definition and model fit information (saturated) in Appendix 6.

5. Results

Our findings supported H1 such that, when exposed to threat information, people were more likely to adopt misinformed beliefs about COVID-19 prevention. In the misinformation control condition, those who saw threat information before misinformation were more likely to adopt misinformed beliefs than those who did not see threat information by 0.84 points on a 7-point scale ($t(187) = -3.44$, $p < 0.001$, Cohen's d = 0.49). Fig. 2 depicts the differences between groups.

Next, we turned to the effectiveness of corrections in decreasing misinformed beliefs. All types of corrections decreased misinformed beliefs compared to the misinformation condition, when adjusting for the effects of covariates (H2-H4; Table 2, Model 2). We did not find significant differences in fact-check efficacy when comparing the

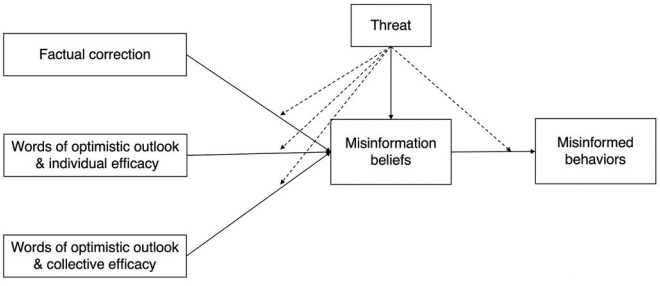

Fig. 1. Conceptual model on the moderated mediation mechanism representing the effect of corrections and threat on misinformed behaviors through the indirect effect of misinformation beliefs
Notes: Covariates were also added to predict the mediator and the outcome, respectively. The covariate-mediator and the covariate-outcome paths were allowed to be moderated by the binary threat condition. See Online Appendix 6 for the list of covariates as well as the full model specification.

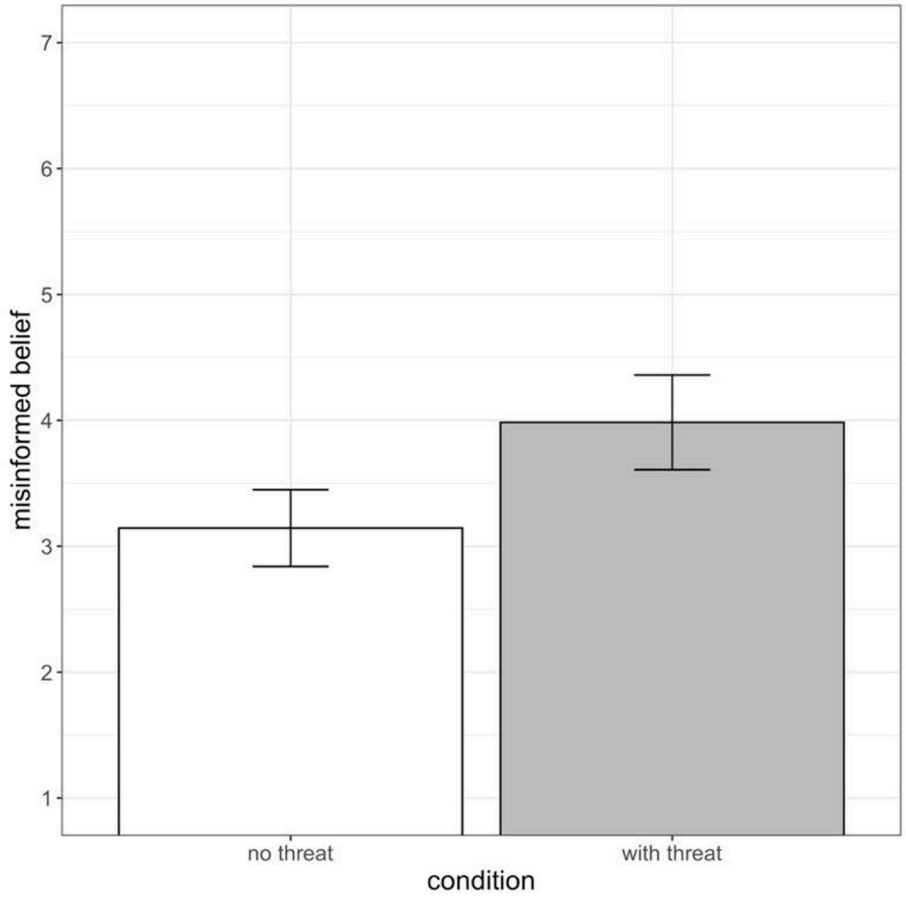

Fig. 2. Effects of threat information on misperceptions. *Note*: Error bars represent 95% CIs.

factual-only correction and hope appeal corrections. Similarly, no discernible difference in effectiveness was detected between the two types of hope appeal corrections (Online Appendix 5). However, our findings revealed notable interaction effects between threat information and the two tested hope appeal corrections. The interaction tests (Table 2, Model 3) suggested that hope appeal corrections were more effective in correcting misinformation when a threat was present rather than absent: a) *words of optimistic outlook & individual efficacy* correction, $b = -0.77$, 95% *CI* [−1.44, −0.10], $p = 0.023$, partial *eta-squared* = 0.01; and b) *words of optimistic outlook & collective efficacy* correction, $b = -0.88$, 95% *CI* [−1.54, −0.21], $p = 0.010$, partial *eta-squared* = 0.01. H5 was supported. In contrast, the factual correction did not significantly interact with threat. This contrast in how corrections interacted with threat information was further illustrated in Fig. 3. Whereas the effectiveness of factual corrections did not significantly differ with versus without the threat (illustrated by overlapping *CI*s), the correction effects of both types of hope appeals were more prominent when a threat was present than absent. This contrast in conditional effects illustrates that while both factual correction and hope appeal corrections "get the job done," hope appeal corrections were more sensitive to the presence of threat in the environment.

Finally, our findings supported H6, such that in a threatening context, corrections featuring hope appeals were effective in decreasing misinformed behavior intentions through corrected beliefs. Table 3 summarizes the indirect effects of the moderated mediation path model (see Appendix 6 for details of model specification, parameter definition and model fit). Indirect effects were estimated as the product of the effect of each correction on misinformed beliefs ("*a*" path) and the subsequent effect of beliefs on behavior intentions ("*b*" path). The degree to which threat information moderated the indirect effects via misinformation beliefs (moderated mediation) was assessed by taking the *difference* between the indirect effects of a correction when threat is present versus absent. Our findings showed that the indirect effects of the two corrections featuring hope appeals—*words of optimistic outlook & individual efficacy* correction and *words of optimistic outlook & collective efficacy* correction—were more salient in a threatening context compared to a non-threatening context.

6. Discussion

Scholars have made important progress so far in identifying cognitive and motivational mechanisms to explain misperception formation and to guide misbelief correction (Kahan, 2012; Lewandowsky et al., 2012; Pennycook and Rand, 2019; Taber and Lodge, 2006). Yet despite that the theoretical importance of affective processes has been acknowledged (Lodge and Taber, 2000), the empirical base is rather thin. More importantly, existing research tends to focus on how emotions might either increase susceptibility to misinformation (Martel et al., 2020; Weeks, 2015) or strengthen corrections (Sangalang et al., 2019), but not their joint impacts or nuanced interactions. In the context of COVID-19 misinformation, we demonstrated the added value in conceptualizing and testing the dual roles of emotional appeals in misperception formation and correction *jointly*, in the case of the fear-hope pair: while threat information fostered misperception formation, hope appeal corrections—but not factual corrections—were found to be more effective in reducing misperceptions when fear was exogenously made salient.

Our data also support the main effects of all tested correction messages, including the simple factual correction and enhanced versions with variants of hope appeals, that successfully reduced misconceptions.

Table 2
Effects of corrections and threat information on misinformed beliefs.

	Model 1	Model 2	Model 3
Threat information	0.24 *		0.84 ***
	[0.00, 0.47]		[0.36, 1.31]
Factual correction		−0.45 **	−0.16
		[-0.78, −0.12]	[-0.62, 0.31]
Words of optimistic outlook & individual efficacy		−0.46 **	−0.10
		[-0.79, −0.13]	[-0.57, 0.37]
Words of optimistic outlook & collective efficacy		−0.34 *	0.08
		[-0.67, −0.00]	[-0.39, 0.54]
Factual correction × Threat			−0.65
			[-1.32, 0.02]
Words of optimistic outlook & individual efficacy × Threat			−0.77 *
			[-1.44, −0.10]
Words of optimistic outlook & collective efficacy × Threat			−0.88 **
			[-1.54, −0.21]
Age	0.00	0.00	0.00
	[-0.01, 0.01]	[-0.01, 0.01]	[-0.01, 0.01]
Education	−0.12	−0.14	−0.13
	[-0.26, 0.03]	[-0.28, 0.01]	[-0.27, 0.02]
Income	0.05 *	0.06 *	0.06 *
	[0.00, 0.10]	[0.01, 0.11]	[0.01, 0.11]
Perceived likelihood of COVID-19 infection	−0.02	−0.01	0.00
	[-0.15, 0.11]	[-0.14, 0.12]	[-0.13, 0.13]
Perceived severity of COVID-19 infection	−0.02	−0.01	−0.02
	[-0.18, 0.15]	[-0.17, 0.16]	[-0.18, 0.15]
General concern about health	0.15	0.16	0.16
	[-0.05, 0.34]	[-0.04, 0.35]	[-0.04, 0.35]
News literacy	−0.09	−0.10	−0.10
	[-0.28, 0.10]	[-0.29, 0.09]	[-0.29, 0.09]
Information exhaustion	0.42 ***	0.41 ***	0.41 ***
	[0.29, 0.54]	[0.29, 0.54]	[0.28, 0.53]
Emotion regulation ability	0.12	0.12	0.11
	[-0.13, 0.37]	[-0.14, 0.37]	[-0.15, 0.36]
Topic: Garlic	−0.69 ***	−0.67 ***	−0.71 ***
	[-1.05, −0.32]	[-1.03, −0.30]	[-1.08, −0.34]
Topic: Vinegar	−0.71 ***	−0.70 ***	−0.68 ***
	[-1.08, −0.34]	[-1.07, −0.33]	[-1.05, −0.31]
Topic: Vitamin C	−0.26	−0.27	−0.27
	[-0.63, 0.12]	[-0.64, 0.11]	[-0.64, 0.10]
Topic: Smoking	−0.87 ***	−0.86 ***	−0.87 ***
	[-1.24, −0.50]	[-1.23, −0.49]	[-1.24, −0.50]
(Intercept)	3.63 ***	4.06 ***	3.68 ***
	[3.34, 3.92]	[3.73, 4.40]	[3.28, 4.08]
R^2	0.13	0.14	0.15
F	8.71 ***	8.00 ***	7.10 ***

Note: Comparison baseline is misinformation condition. Data represent unstandardized B and 95% CI. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

Noticeably, during the early phase, the COVID-19 pandemic induced widespread fear in China. Therefore, the experimental condition that more faithfully represents this situation is the high-threat condition. There, based on simple main effects analyses (Online Appendix 5), both the factual correction and the hope appeal corrections were able to decrease misbeliefs, largely to a similar degree. Our data thus do not support the notion that hope appeals can necessarily enhance factual corrections.

That said, the formal interaction tests showed that hope appeal corrections were particularly sensitive to the presence of threats. In contrast, the effectiveness of factual corrections did not significantly differ with versus without the threat. Given that hope appeal corrections were constructed to subsume the simple factual rebuttal, this sensitivity to fear-provoking threat information suggests the conditional nature of hope appeal corrections as a package beyond their factual baseline. Coupled with the finding that hope appeals corrections induced more hopeful feelings than simple factual rebuttals, these findings suggest the unique operation of emotional processes and particularly the interplay between fear and hope in amplifying versus correcting misinformation.

Taken together, while hope appeal corrections featuring both words of optimistic outlook and efficacy-boosting information were no more superior than factual corrections in terms of overall main effects, they were more likely to respond to threat information and become more efficacious in correction accordingly. These results highlight that in the context of misinformation correction, it is important to examine the joint impacts of emotional appeals and to specify how one emotional appeal may amplify or weaken the effects of another. It is worth mentioning that, in the moderated mediation analyses, hope appeal corrections' indirect effects on improved downstream behavioral intentions also became stronger with the presence of threat information. That said, this indirect pathway for factual corrections showed a similar pattern, suggesting that the contrast between hope appeals and factual corrections' behavioral consequences in response to threat information was less clearcut than their effects on correcting misbeliefs.

We advanced the existing research on hope appeals by specifying the contribution of different components of hope appeals to misinformation correction, making it possible to inform the design of effective hope appeal correction messages. We showed that the two tested versions of

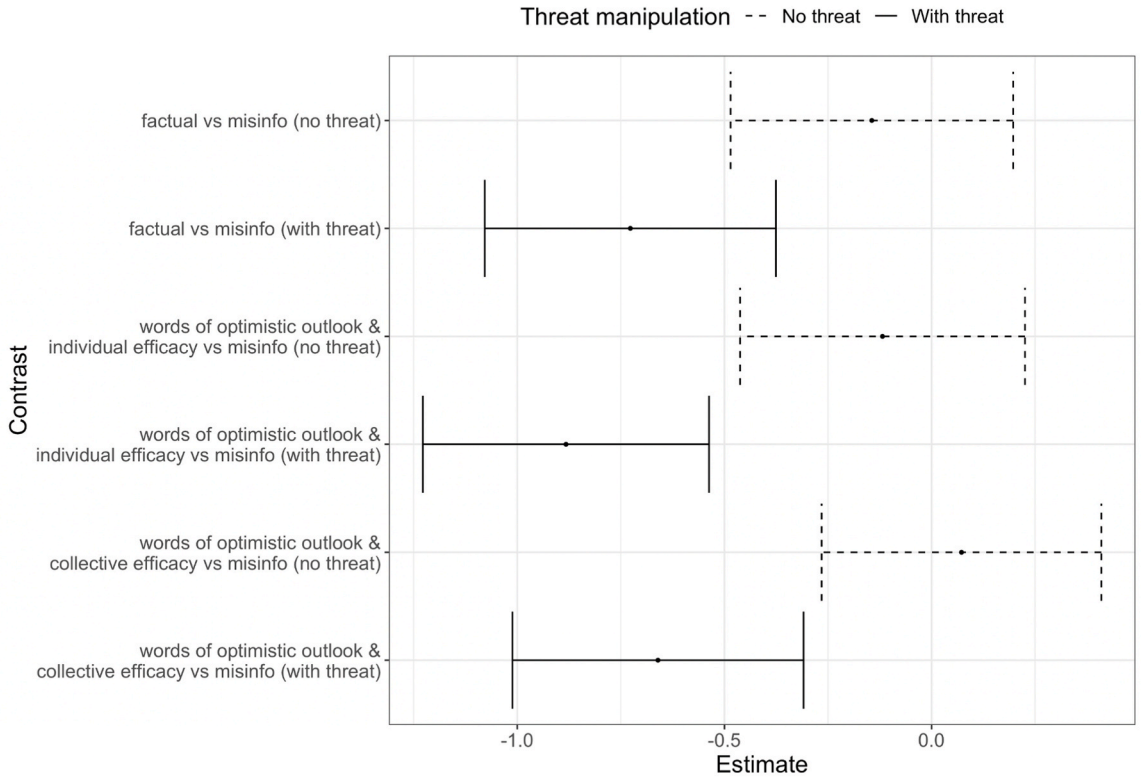

Fig. 3. Effects of threat information and corrections on misperceptions. ***Note***: Error bars represent 84% CIs for visual clarity of comparing between groups (see Maghsoodloo and Huang, 2010).

Table 3
Indirect effects of corrections and threat information on misinformed behavior intentions through misinformed beliefs.

Indirect effects (condition → belief → behavior intention)	Estimate	95% CI
Factual correction *w/*threat	−0.18	[-0.31, −0.07]
Factual correction *w/o* threat	−0.03	[-0.13, 0.06]
Moderated mediation effect for factual correction condition	−0.15	[-0.31, −0.01]
Words of optimistic outlook & individual efficacy *w/* threat	−0.19	[-0.32, −0.08]
Words of optimistic outlook & individual efficacy *w/o* threat	−0.02	[-0.11, 0.07]
Moderated mediation effect for words of optimistic outlook & individual efficacy	−0.17	[-0.33, −0.03]
Words of optimistic outlook & collective efficacy *w/* threat	−0.18	[-0.31, −0.06]
Words of optimistic outlook & collective efficacy *w/o* threat	0.01	[-0.08, 0.11]
Moderated mediation effect for words of optimistic outlook & collective efficacy	−0.19	[-0.35, −0.05]

Notes: Details of model specification, parameter definition, and model fit (saturated) in Online Appendix 6. Comparison baseline is misinformation condition. 95% CIs were constructed through bootstrapping (resamples = 10,000).

hope appeals, one that presents scientifically valid preventative measures and the other that encourages communal coping and social support, were both able to generate significantly more hopeful feelings, compared to the factual baseline. Regarding misinformation correction, we demonstrated that hope appeals incorporating words of optimistic outlook and both types of efficacy information, individual and collective efficacy, have the potential to correct misinformation. Importantly, our results supported the role of collective efficacy as a promising hope appeal component. Challenging the prevailing focus on self-referential efficacy perceptions (i.e., individual efficacy), we demonstrated that perceived collective efficacy could also serve as a source of agency to evoke hope. Our findings on the effects of the perceived collective power of society have broader implications for future research on perceptions of collective agency and efficacy, such as religious beliefs and information on community mobilization and mutual support in the aftermath of public health crises, violent unrest, or natural disasters.

Furthermore, our findings show that the sensitivity of hope appeal corrections to threat information is not reducible to the efficacy component alone. Given the recommendation from prior research (Chadwick, 2015; Nabi and Myrick, 2019), this report focused on the combined version of hope appeal corrections that incorporates both words of optimistic outlook and efficacy information. This choice allows us to test the effectiveness of hope appeal corrections in their stronger form. In Online Appendix 8 (Table A8.1), we reported additional details testing how the disaggregated versions of hope appeal corrections—each combining the simple factual rebuttal with one of the individual hope appeal components (i.e., words of optimistic outlook, individual efficacy, collective efficacy)—might respond to threat information. We did not find any interaction effects. Therefore, there seems to be an emerging property in the combined version of hope appeal corrections that has made it more likely to respond to threat information. Practically, this finding suggests that during public health crises, deploying the combined version of hope appeal corrections is more promising in counteracting misperception-inducing threats and fear than their individual components alone.

This study is limited in several ways. First, the timing of data collection, June 2020, restricted the magnitude of the effectiveness of hope appeal corrections we were able to find, as the COVID-19 outbreak was relatively under control in China by May 2020 (WHO, 2020b). One may find even stronger effects of hope appeal corrections when the threat from the pandemic grows larger elsewhere. Additionally, we focused on testing the roles of positive future expectation and possibility appraisal of future outcome in misinformation correction, given that

other hope appeal components—importance and goal-congruence—were high in the Chinese context during the early stage of the pandemic. This assumption might not hold true for those who show high levels of information overload and COVID-19 news fatigue. Future research may consider testing the roles of importance and goal-congruence in correction message design. Moreover, the stimuli messages of this study differed in terms of message length given the incremental approach for message design. For example, participants in the factual correction condition saw shorter messages (around 200 words), whereas participants in the hope appeal conditions read longer messages (around 400 words). Since message length is not a significant predictor of the efficacy of fact-checking (Walter et al., 2019) and is unlikely to affect hopeful feelings by itself alone, we have reasons to doubt it would have confounded our main results. Furthermore, the conditional effects of hope appeal corrections under threat versus no threat were small in effect size, though still worth reporting given their theoretical implications. Related to this, although we did not find significant interaction effects between threat and factual correction, we did see a similar pattern in that condition as in the two correction conditions. Thus, future research could be done to replicate the findings of this study. Moreover, future research is encouraged to examine the roles of emotional appeals in misinformation correction beyond China, especially among vulnerable populations in other countries, and during other public health crises beyond the COVID-19 pandemic. Lastly, this study only focuses on the effectiveness of hope appeal corrections in correcting misinformed beliefs and behaviors with and without threat. Future research could explore if hope appeal corrections can promote a broader range of science-based correct beliefs and behaviors.

7. Conclusion

The COVID-19 infodemic and the amount of fear experienced by the public stress the importance of studying the roles of emotional appeals in misinformation susceptibility and correction. We gathered experimental evidence in which exogenously manipulated, fear-inducing threat information increased misbeliefs in unwarranted preventative measures. Moreover, we found that hope appeals can help correct health misinformation. Unlike fact-only corrections, hope appeal corrections were more sensitive to the presence of threat information, indicating that they can be particularly effective when facing salient threats or adversities. Our findings thus bridge the research on health misinformation correction and persuasive hope appeals and highlight the importance of studying the joint impacts of discrete emotional appeals in misperception formation and correction.

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Credit author statement

Conceptualization: JL, RT, and SY; Methodology: JL, RT, LS, and SY; Formal analysis and investigation: JL and RT; Writing - original draft preparation: JL, RT, LS; Writing - review and editing: SY; Funding acquisition: SY; Resources: SY; Supervision: SY.

Declaration of competing interest

No potential conflict of interest was reported by the author(s).

Data availability

Replication in the Open Science Framework (OSF) project depository (link: https://osf.io/w3rgm/?view_only=8c8185737201435a9e0ba9fd63e25e95).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2023.116132.

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