Effect of Emphasizing the Climate Change Background to Cultivate Supporters and Information Engagers of Genetically Modified Crops

Abstract: This study investigates the effectiveness of the climate change-focused background strategy in the context of GM crops. A between-subjects online experiment revealed that integrating climate change background into a report about GM crops significantly increased perceptions of gene-editing scientists' benevolence and personal relevance, which in turn respectively and positively predicted attitudes toward GM crops and information engagement intention. Notably, the climate change background remained effective among individuals with initially low support for GM crops. These findings provide theoretical insights into how the background functions within science communication and offer a versatile, practical strategy for effectively reporting on GM crops.

Keywords: genetically modified organisms; benevolence; personal relevance; information engagement; climate change background

Introduction

The safety of genetically modified (GM) crops and foods, as well as their health, economic, and environmental benefits, has been increasingly supported by scientific evidence and practical outcomes (Klümper & Qaim, 2014; National Academies of Sciences, Engineering, and Medicine, 2016; Smyth et al., 2024; Voytas & Gao, 2014). However, some individuals still hold negative attitudes and behavioural intentions toward GM crops and foods. About 57% of Americans believe GM foods are unsafe to eat (Funk & Kennedy, 2016), and 47% say they would not knowingly eat GM crops (Runge et al., 2017). In China, public attitudes towards the research and consumption of GM crops are also at relatively low levels (Du et al., 2022; Huang, 2020; Mou & Lin, 2014), which hinders the participation of GM crops in addressing various societal (e.g., famine) and environmental issues (e.g., climate change). As a result, communication researchers have been working to develop information strategies to improve public attitudes toward GM crops (Dixon, 2016; Hasell et al., 2020; Lyons et al., 2019; Lyons et al., 2024; Yuan et al., 2019).

However, strategies that demonstrate short-term positive effects in experiments may not effectively improve public attitudes. On the one hand, the media are saturated with a wide range of scientific information. People may not be exposed to carefully crafted information related to GM crops. On the other hand, the persuasive effect of scientific information may be temporary. Existing evidence suggests that seeking and sharing relevant information can enhance the longevity of the effectiveness of attitude changes (Gong et al., 2023). Information seeking and sharing, as personal information engagement behaviours, also contribute to public engagement with science (Doxzen & Henderson, 2020; Wirz et al., 2020) and the broader dissemination of scientific information through interpersonal networks (Besley et al., 2008; Katz & Lazarsfeld, 1955), ultimately benefiting both the scientific community and society. Therefore, when aiming to improve public attitudes towards GM crops, we should not overlook the importance of encouraging information engagement.

Although it is reasonable to tailor strategies separately targeting attitudes towards GM crops and information engagement, information strategies that simultaneously achieve both goals should be prioritized. A background strategy, such as incorporating the climate change background into scientific reporting on GM crops, may be an ideal approach. Specifically, the climate change background could enhance perceptions of gene-editing scientists' benevolence and increase perceived personal relevance, which may respectively and positively predict attitudes towards GM crops and intention to engage with relevant information.

We conducted an online experiment to empirically test the effects of the background strategy and relevant mechanisms. In addition to the relationships proposed above, we also considered prior support for GM crops as a moderating factor to examine whether the effects of the background strategy would be influenced by motivated reasoning (Kunda, 1990), which has weakened the effect of many relevant information strategies (e.g., Dixon, 2016; Druckman & Bolsen, 2011; Yuan et al., 2019). The findings contribute to insights into the effectiveness of background in scientific reports and provide science communicators with a versatile information strategy when reporting on GM crops and foods.

Literature review

Background strategy and its application in science communication about GM crops

The background is one of the fundamental categories of news schema. In a news article or report, background is not a part of the main news events but provides general, historical, political, or social context or conditions surrounding these events (van Dijk, 1985). The background represents the concept of in-depth or explanatory reporting—uncovering relevant facts to analyse, interpret, deepen, and expand on the main facts. This approach helps to highlight the significance of the main facts, such as emphasizing their importance and revealing the underlying reasons for the characters' behaviour (Xie, 2005).

Although some early evidence suggests that audiences prefer news stories with background information (Fredin & Tabaczynski, 1993), the background is often viewed as a structural norm (van Dijk, 1985; 1988), rather than a strategy that could attract audiences or enhance persuasiveness. Background has not been systematically and empirically tested for its impact on audiences (Van Krieken & Sanders, 2021). Especially, in current communication practices, background seems to be insufficiently emphasized. Science news coverage often omits background information (Evans et al., 1990; Pellechia, 1997). Furthermore, in the new media environment, background is sometimes omitted or separated from the main content (Zeng, 2014).

It is worth revisiting the value of background and re-emphasizing the background strategy in science communication. Indeed, science communication researchers have long highlighted the importance of background. As Miller (2001, p. 119) noted, "more of what currently goes on backstage in the scientific community has to become more visible." According to Priest (2001), the key to science communication is not so much the accuracy of information but helping understand the social significance of the scientific endeavour and its contribution. Sturgis and Allum (2004) further emphasized that the public needs to understand the institutional embedding, patronage, organization, and control involved in addressing and solving societal issues, as this will serve to contextualize scientific knowledge when people evaluate the science under consideration.

This study aims to test the effectiveness of the background strategy in communicating about GM crops. One important background for the research and development of GM crops is climate change/global warming. GM crops are advantageous in addressing and mitigating climate change. Crops are genetically modified to possess greater stress tolerance (e.g., drought resistance, salt and alkali resistance, and pest resistance), enabling them to adapt to climate change and its various side effects (e.g., drought, land degradation, and pests; Raza, 2019). Moreover, GM crops support climate change mitigation. For example, some new crop varieties have been developed to capture and store excess atmospheric carbon dioxide (Zahed et al., 2021). Herbicide-resistant crops allow for reduced reliance on mechanical tillage for weed control, thereby decreasing carbon dioxide emissions (Smyth et al., 2024). Therefore, when reporting on GM crops, climate change information can be introduced as a background, highlighting one of the reasons for the research and development of GM crops.

The association between climate change background, perceived scientists' benevolence and attitudes towards GM crops

Public attitudes impact the development of science and technology and are closely related to the interests of stakeholders such as governments, businesses, and scientists (Hamstra, 2000). Existing research has extensively explored the antecedents of public attitudes (Besley et al., 2013; Miller, 2004). For example, the "deficit model" of public attitudes towards science posits that overall, people's knowledge, literacy, and understanding of science and technology form the basis of their attitudes (Allum et al., 2008). However, scientific issues are often complex and filled with uncertainties. For laypeople with limited scientific knowledge, it may be challenging to comprehend scientific issues and make relevant decisions based on logical coherence and cohesiveness. One approach to reducing the complexity of cognition and decision-making is to consider "whom to trust."

Although direct measures of trust perceptions (i.e., using a unidimensional or single-item measurement) have been fairly common in previous research, recent studies advocate for viewing trust perceptions as a multidimensional construct and conceptualizing specific dimensions (Besley et al., 2021; Besley & Tiffany, 2023). Existing evidence suggests that one aspect people consider when evaluating a trustee is the extent to which the trustee's motivations are benevolent (Hendriks et al., 2015; Besley et al., 2021). Benevolence is a perception or belief that individuals act with the interests of others or society at heart, instead of pursuing personal aims or benefits (Hautea et al., 2024; Hendriks et al., 2016).

Trust and benevolence perceptions of scientific institutions (e.g., scientists) may affect individuals' attitudes towards science and technologies. Proponents of this view often regard trust and benevolence as heuristic cues that enable people to support technologies involving risks, such as GM technologies, without detailed knowledge of the technical nature of the risks (Brossard & Nisbet, 2007; Kim et al., 2013; Priest, 2001). Empirical evidence indicates that trust in scientists predicts support for GM crops or foods (Priest, 2001; Siegrist et al., 2012; Zhu et al., 2022). In contrast, few studies have explored the unique impact of perceived benevolence. For instance, Besley and colleagues (2021) found that perceptions of American scientists' benevolence generally predicted support for GM research.

Considering the potential positive impact of perceived gene-editing scientists' benevolence on attitudes towards GM crops, a focus in strategy development could be how to convey scientists' benevolence. Attribution research in social psychology provides indirect evidence suggesting that providing a climate change background can increase perceived benevolence. The dual-processing model of attribution posits that attribution involves two stages: an initial characterization stage, where individuals automatically attribute others' behaviour to certain internal attributes, followed by a more controlled correction phase, where individuals use external cues to enhance or diminish the initial attribution (Fiske & Taylor, 2013).

According to this theory, when evaluating the motivations behind scientists' involvement in the research and development of GM crops, individuals often rely on stereotypical impressions of scientists, such as insufficient warmth and being driven by commercial interests (Fiske & Dupree, 2014; Johnson & Dieckmann, 2020). This automatic attribution results in a lower estimation of benevolence. When only the main facts about GM crops are presented and external cues are absent, attribution correction does not occur. However, providing background information allows the audience to consciously integrate scientists' behaviour with situational cues for attribution correction. Specifically, a climate change background suggests that scientists are acting to address and mitigate climate change, which benefits public interests and thus is perceived as more benevolent. Based on the above reasoning, we propose:

H1: Perceived scientists' benevolence mediates the relationship between climate change background and individuals' attitudes towards GM crops. More specifically, a report on GM crops with a climate change background will increase perceived scientists' benevolence and consequently positively affect attitudes towards GM crops.

The association between climate change background, perceived personal relevance and information engagement intention

Information seeking and information sharing are often considered two distinct information behaviours. However, recent research advocates conceptualizing them as a single construct: information engagement, as both reflect motivated engagement with interactions involving specific information (Gong et al., 2023; Su et al., 2021; Tian et al., 2022), which may enhance the persuasive impact and long-term sustainability of the information. Regarding information seeking, most definitions capture the core idea of "active efforts to obtain specific information in response to a relevant event" (Niederdeppe et al., 2007, p. 154). Generally, information seekers are motivated to go beyond heuristic information processing to engage in systematic processing (Griffin et al., 1999), such as cognitive elaboration, which can help individuals better understand and remember information (Eveland, 2001) and lead to more persistent attitude changes (Petty & Cacioppo, 1986).

The other side of information engagement—sharing, including both one-way and two-way (i.e., discussion) forms of person-to-person(s) communication (Jeong, 2018)—might also reinforce individual attitudes. Specifically, the initial act of information sharing signals that the sharers are supporters of a specific issue and reminds the sharers of this self-identity (Gong et al., 2023). Subsequently, to exhibit personal consistency (Lacasse, 2016), individuals may adjust their attitudes and behaviors to align with the initially presented self-image, as indicated by cognitive dissonance theory (Festinger, 1957; see Gong et al., 2023).

Therefore, it is worthwhile to explore how to encourage public information engagement to enhance and prolong the persuasive effects of scientific information. As initially mentioned, information engagement is driven by high levels of motivation. The motivations behind information seeking and information sharing are inherently different. However, they can both be enhanced by perceived personal relevance, which refers to the individual's interest in a topic or the perceived significance of a topic to one's personal situation (Rucinski, 2004). Information seeking reflects individuals' cognitive motivation. Information seekers aim to respond effectively and timely to specific events by gaining a better understanding through information (Niederdeppe et al., 2007). Many theories predicting information seeking identify perceived personal relevance as a crucial antecedent. High levels of perceived personal relevance can provide strong motivation for information seeking by increasing the perceived threat associated with the relevant issue (comprehensive model of information seeking; Johnson & Meischke, 1993), elevating the confidence individuals need to have in the validity of the message (heuristic-systematic model of information processing; Eagly & Chaiken, 1993), reducing perceived information sufficiency (risk information seeking and processing model; Griffin et al., 1999), among other factors.

Perceived personal relevance may also trigger information sharing, which is largely driven by social motives, such as self-construction (Ihm & Kim, 2018; 2024), defined as “matching one’s self-presentation to one’s own ideal self” (Baumeister & Hutton, 1987, p. 71). When individuals think scientific issues have a high degree of personal relevance, they may share relevant information to clarify and express their ideal image to their audience, that is, to present themselves as an attentive public (Miller & Pardo, 2000) for the issue. Existing empirical evidence supports this assertion, indicating that perceived personal relevance is positively associated with self-constructive motivated sharing (Ihm & Kim, 2024).

Based on the potential positive impact of perceived personal relevance on information engagement, another focus of our strategy development can be on how to make the audience recognize the relevance of GM crops to their own lives. Even if the public initially perceives high personal relevance due to concerns about the safety of GM crops, it remains beneficial to convey other values of GM crops, such as their benefits in addressing and mitigating climate change. Hasell et al. (2020) experimented comparing a non-narrative message about GM crops without climate change consensus to a narrative message about GM crops with climate change consensus and found that exposure to the latter led to lower levels of psychological resistance. This may be because audiences in the latter condition were more likely to perceive the significance of GM crops (Hasell et al., 2020), which indicates a higher level of perceived personal relevance. Although their study did not directly examine the impact of incorporating climate change-related information as an independent factor, it suggests that this strategy could be beneficial in enhancing the perceived relevance of GM crops to individuals. Thus, we propose:

H2: Perceived personal relevance mediates the association between climate change background and individuals’ GM crops-related information engagement intention. More specifically, a GM crops report with a climate change background will increase perceived personal relevance and consequently positively affect information engagement intention.

The potential moderating effect of prior support for GM crops

While the effectiveness of the climate change background has been assumed in the previous discussion, questions remain about how different audiences react to it. A generally effective information strategy may be less effective for specific groups, such as those with initially low support. Prior support or attitudes play a significant role in information processing, primarily related to motivated reasoning. Motivated reasoning is a cognitive and social response wherein motivation may influence how new information is perceived (Kunda, 1990). A typical motivation is avoiding cognitive dissonance (Festinger, 1957), which motivates individuals to use their reasoning abilities to defend their prior cognitions, such as support for or attitudes towards a particular issue (Kunda, 1990). Consequently, information that challenges prior support often has little effect on attitudes or may even lead to boomerang effects (Hart & Nisbet, 2012). Concerning GM crops and foods, studies have found that initially low support or negative attitudes can lead to negative cognitive outcomes (Druckman & Bolsen, 2011; Yuan et al., 2019) or diminish the persuasive effect of information (Dixon, 2016). Given this evidence, there is concern that the proposed background strategy may also have limited effectiveness for people with initially low support for GM crops.

However, it is also possible that the climate change-focused background strategy achieves universal effectiveness. Hasell et al. (2020) noted that many individuals with initially low support for GM crops are environmentalists. Therefore, leveraging environmentalists' concern for climate change to reduce biases against GM crops and associated scientists may be beneficial (Hasell et al., 2020). Precisely, the benefits of

GM crops for climate change may align with another value held by their opponents—environmentalism—thereby mitigating motivated reasoning.

It is important to note that research on the moderating role of prior support for GM crops provides contradictory evidence and does not directly examine perceived scientists' benevolence and perceived personal relevance as dependent variables, despite both being cognitions that motivated individuals hope to defend. Thus, we refrain from proposing specific hypotheses and instead pose the following research questions:

RQ1: Will prior support for GM crops moderate the effect of climate change background on perceived scientists' benevolence?

RQ2: Will prior support for GM crops moderate the effect of climate change background on perceived personal relevance?

The proposed model including all research hypotheses and questions is presented below (Figure 1):

[Insert Figure 1 about here]

Method

Participant

Since this study aims to develop a new strategy to enhance public perception of scientists' benevolence, and no prior research has examined the effect size of such a strategy, there is some uncertainty in setting an a priori effect size for computing the required sample size. To address this challenge, we followed empirical guidelines for determining sample size (e.g., recommendations of a minimum sample size of 100 or 200; Boomsma, 1985) and conducted a sensitivity analysis.

Participants were recruited through Credamo, an online survey panel provider in China, and took part in an online experiment between January 11th and 20th, 2024. Eligible participants were Chinese residents aged 18 years or older. The initial sample size was 317, with 35 participants being excluded due to failure in attention checks (e.g., "I have never used a smartphone") or manipulation checks (see the procedure section). As a result, 282 responses were included in the final analysis.

In total, 282 participants (62.4% women, N = 176) had a mean age of 31.34 (SD = 7.60) years and 90.4% of participants reported an individual monthly income of 2,000 CNY or above. Regarding educational attainment, 85.5% of participants held a bachelor’s degree.

With a final sample size of 282, we conducted a sensitivity analysis to determine the smallest detectable effect size. As detailed in the data analysis section, we used a latent moderated structural equation model to examine the effects of treatment conditions on perceived scientists' benevolence and perceived personal relevance. In the case of three predictors (including the latent interaction factor), a *G*Power* (Faul et al. 2009) analysis showed that our sample of 282 participants provided a power of .80 to detect a small effect size $f^2 = .039$ (Cohen, 2013). When considering two predictors (excluding the latent interaction factor), the smallest detectable effect size was $f^2 = .035$. These results indicate that our study design is highly sensitive and capable of detecting small effect sizes, which reduces the risk of Type II errors and ensures that even subtle effects of the strategy can be reliably identified.

Stimulus

The experiment compared the effects of two scientific reports about GM crops. The report without the climate change background explained four traits of GM crops (strong carbon fixation ability, herbicide resistance, drought tolerance and salinity resistance, and pest resistance) in a popular science style, along with brief technical principles (see Figure 2).

[Insert Figure 2 about here]

In the report with the climate change background, the climate change background was introduced before the four traits of GM crops, explaining the causes and impacts of climate change. Another distinction was that in the report with the background, the traits of GM crops were presented in conjunction with their contributions to addressing and mitigating climate change as contextual supplementation (see Figure 3).

[Insert Figure 3 about here]

The stimulus materials were designed as WeChat articles, one of the most common channels through which Chinese people encounter information about science and technology. It is noteworthy that, due to previous research findings indicating that "global warming" is more prevalent and engaging in Chinese society compared to "climate change" (see Ma et al., 2023), we used the Chinese translation of "global warming" in the articles.

Procedure

Upon agreeing to participate in the study, participants were randomly assigned to one of the two treatment conditions (without background: N = 141; with background: N = 141). After exposure to the message, participants were immediately asked whether the message introduced content related to global warming to verify their awareness of the climate change background. Participants in the no-background condition answered "No," while participants in the background condition answered "Yes," indicating successful manipulation. Following this, participants completed a survey, including the measures detailed in the next section and their demographic information.

Measurement

Two mediators, two outcome variables, and one moderating variable were assessed. For the mediators, we modified and adopted existing scales to measure *perceived scientists' benevolence* (Besley et al., 2021; Hendriks et al., 2015). *Perceived personal relevance* was measured using three items adapted from previous research (Gong et al., 2023) and tailored to our study context. Regarding the outcome variables, *attitudes towards GM crops* were measured with four items from Heddy et al. (2017), which comprehensively reflect perceptions, attitudes, and behavioral intentions towards GM crops. Based on an extensive literature review (Tian et al., 2022; Gong et al., 2023), we conceptualized *information engagement intention* as intention to seek, share, and discuss information, and accordingly used three corresponding items to measure it. Finally, *prior support for GM crops* was measured as a moderating variable using three items adopted from previous studies (Dixon, 2016). All measurement items are detailed in Table 1.

[Insert Table 1 about here]

Data Analysis

Before testing the hypotheses, we conducted a confirmatory factor analysis (CFA) to establish the validity of the measurement model using Mplus 8.3.

To test our research hypotheses, we employed latent moderated structural equations (LMS) modeling using a two-step evaluation method (Klein & Moosbrugger, 2000). In the first step, the model (referred to as Model 0) was estimated without the latent interaction term. The model fit was assessed based on cutoff criteria for fit indices (i.e., χ^2/df ratio, CFI, TLI, RMSEA, and SRMR; Hu & Bentler, 1999).

Once it was confirmed that Model 0 fit the data well, the second model (referred to as Model 1) including the interaction term was estimated. To evaluate the fit of

Model 1, a log-likelihood difference test was performed using the formula D = −2(log-likelihood value of Model 0 − log-likelihood value of Model 1), with the difference in degrees of freedom between the two models (∆df; Maslowsky et al., 2015). When the log-likelihood difference test was statistically significant, we could use and interpret the path coefficients of Model 1. Based on the path coefficients of the interaction term in Model 1, we were able to determine the moderating effects that prior support played in a hypothesized structural model.

In both Model 0 and Model 1, the treatment condition (without background vs. with background) was considered as an exogenous variable, and gender, age, education, and personal monthly income as covariates were included in the models.

Results

Measurement Model Validation

The results of the CFA showed a good model fit: χ^2 = 178.967, df = 109, χ^2/df = 1.642, CFI = .978, TLI = .973, RMSEA = .048, 90% CI: [.035, .060], and SRMR = .040. As shown in Table 1, the standardized factor loadings for each measurement scale were statistically significant and exceeded .5. The CR coefficients ranged from .736 to .948, and the AVE values were all above or close to .5[1]. Based on theoretical and statistical considerations (Fornell & Larcker, 1981; Hair et al., 2009), we confirmed convergent validity of the measures. To establish discriminant validity, we examined the intercorrelations among the latent variables. As shown in Table 2, the AVE values were higher than the square of correlation coefficients between the other variables. Consequently, we concluded that discriminant validity was also established (Fornell & Larcker, 1981; Kline, 2023).

[Insert Table 2 about here]

Hypothesis Testing

Based on the two-step evaluation method suggested by Klein and Moosbrugger (2000), we firstly estimated Model 0 excluding the latent interaction factor (treatment condition × prior support). The fit of the initial model was deemed acceptable: χ^2 = 449.466, df = 184, χ^2/df = 2.443, CFI = .919, TLI = .903, RMSEA = .072, 90% CI: [.063, .080], and SRMR = .111.

Modification indices (MI) indicated that the model fit could be improved by adding a path from prior support to attitudes towards GM crops (MI = 104.229). Clearly, it was reasonable to consider the impact of prior support on post-experiment attitudes. After this modification, the overall goodness-of-fit was good: χ^2 = 337.497, df = 183, χ^2/df = 1.844, CFI = .953, TLI = .943, RMSEA = .055, 90% CI: [.045, .064], and SRMR = .093. The slightly elevated SRMR was primarily due to a large portion of the variance in perceived scientists' benevolence (σ^2 = .748) and perceived personal relevance (σ^2 = .897) left unexplained by the experimental factor, which is commonly observed in previous experimental studies (e.g., Kim et al., 2023).

Therefore, we proceeded to the second step, where we estimated Model 1, including the latent interaction factor (treatment condition × prior support), and performed the log-likelihood ratio test between Models 0 and 1. The relative fit index of Model 1, $D = -2(-5558.980 - -5553.565) = 10.83 > 5.991$, $\Delta df = 2$, indicated that Model 1 statistically outperformed Model 0. Accordingly, we interpreted the path coefficients from Model 1 to test the hypotheses.

The results showed that perceived scientists' benevolence and perceived personal relevance respectively mediated the effects of the climate change background on attitudes towards GM crops and information engagement intention. More specifically, compared to participants who read the report about GM crops without the climate change background, those who read the report with the climate change background perceived higher levels of scientists' benevolence (β = .161, SE = .052, p = .002), which in turn predicted their attitudes towards GM crops (β = .492, SE = .052, p < .001). The mediation effect of perceived benevolence was significant and positive (unstandardized point estimate = .160, 95% CI [.066, .255]). Therefore, H1 was supported.

Similarly, compared to the report without the climate change background, the report with the climate change background increased perceived personal relevance (β = .186, SE = .062, p = .003), which was positively associated with information engagement intention (β = .650, SE = .086, p < .001). The positive indirect effect of the climate change background on information engagement intention through perceived personal relevance was significant (unstandardized point estimate = .151, 95% CI [.064, .239]). Hence, H2 was supported.

The path coefficients from the latent interaction factor to perceived scientists' benevolence and perceived personal relevance addressed the research question regarding the moderating roles of prior support for GM crops. Unexpectedly, prior support negatively moderated the effect of the climate change background on perceived scientists' benevolence (β = -.175, SE = .065, p = .007; see Figure 4). Specifically, the positive impact of the climate change background on perceived scientists' benevolence was stronger for those who reported lower levels of prior support compared to those with higher levels of prior support. However, prior support did not significantly moderate the effect of the climate change background on perceived personal relevance (β = .085, SE = .066, p = .202). All path coefficients are summarized in Figure 5.

[Insert Figure 4 about here]

[Insert Figure 5 about here]

Discussion

Despite numerous strategies that can improve public attitudes toward GM crops, it is crucial to recognize the complexities inherent in translating observed short-term effects into real-world, long-term attitudinal changes, particularly within the diverse landscape of scientific communication teeming with diverse issues (Hautea et al., 2024). One method to enhance and prolong the persuasive effects of scientific information is by encouraging public information engagement. Therefore, we set attitudes towards GM crops and information engagement about GM crops as two normative goals and developed a background strategy to achieve them. Our experiment demonstrated that applying the climate change-focused background strategy to scientific reporting on GM crops effectively enhanced perceived scientists' benevolence and perceived personal relevance, which in turn positively predicted attitudes towards GM crops and information engagement intention, respectively.

Importantly, we found that initially low support for GM crops did not diminish the positive impact of the climate change background. This seems to suggest that the climate change-focused background strategy is not subject to the effect of motivated reasoning, which has limited the effectiveness of many prior scientific and GM crop-related information strategies (e.g., Dixon, 2016; Druckman & Bolsen, 2011; Yuan et al., 2019). In fact, the background strategy was particularly effective in improving perceptions of scientists' benevolence among opponents of GM crops, who are often the target audience for persuasive information. A similar phenomenon can be observed in correcting misinformation about GM foods. For instance, Bode et al. (2021) found that while expert correction led to lower GM misperceptions, this effect was particularly powerful among those with higher initial misperceptions. In our study, the climate change background corrected negative attributions about scientists involved in GM crop research and development, leading to higher perceived benevolence. This correction was more pronounced among opponents of GM crops, as they initially tend to perceive these scientists as somewhat selfish and cold (Fiske & Dupree, 2014; Johnson & Dieckmann, 2020).

Although we emphasize the broad effectiveness of the climate change-focused background strategy across different groups, we do not wish to overstate its effectiveness. Based on the standardized path coefficients, effects of the background are limited in terms of improving perceived scientists' benevolence (β = .161) and perceived personal relevance (β = .186; Cohen, 2013), which may be partly due to the relatively high baseline levels of these two variables ($M_{benevolence}$ = 4.128 on a 5-point scale; $M_{relevance}$ = 5.388 on a 7-point scale). Furthermore, while we have identified perceived scientists' benevolence as the sole mediator explaining the relationship between the climate change background and attitudes toward GM crops, other mediating mechanisms might exist, such as reducing reactance (Hasell et al., 2020) or enhancing argument strength (Lyons et al., 2019).

Several theoretical implications of our study should be noted. Firstly, this study contributes to the literature on the trust of scientists by examining the importance and the information strategy of improving public perceptions of scientists' benevolence. Recent scholarship has emphasized the need to focus on benevolence as a crucial dimension of trust and to explore its role in various contexts (Besley et al., 2021; Besley & Tiffany, 2023). Our research provides evidence of the positive association between perceived scientists' benevolence and attitudes toward GM crops, suggesting that communicating scientists' benevolence is also essential in the Chinese context. Additionally, prior studies have proposed various strategies to convey benevolence (Beall et al., 2017; Hautea et al., 2024; Hendriks et al., 2016; Kim et al., 2024; Thon &

Jucks, 2017). Our study introduces the background strategy as a complementary approach and demonstrates its effectiveness in communicating about GM crops.

Secondly, this study expands the understanding of information behaviors and perceived personal relevance in the field of science and technology, and offers insights into how to promote them. Prior studies have primarily focused on either scientific information seeking or sharing (e.g., Su et al., 2021; Wang et al., 2024; Wen & Wei, 2018), with few examining these behaviors simultaneously, which limits the theoretical understanding of scientific information engagement. Therefore, this study highlights the significance of conceptualizing information seeking and sharing as components of information engagement and identifies perceived personal relevance as a critical antecedent. Furthermore, building on existing research that clarifies the predictors of perceived personal relevance, we propose how information strategies can proactively enhance the perception of personal relevance, which is essential for capturing public attention and interest in specific scientific issues to cultivate an attentive public.

Finally, this study reveals how to mitigate motivated reasoning in science communication. The information processing mechanism driven by the defense of prior cognitions has long been a significant challenge for strategic science communication. However, in this study, opponents of GM crops did not reject the idea that scientists engaged in the research and development of GM crops are benevolent, nor did they deny the relevance of GM crops to their personal lives. This phenomenon is conducive to mitigating differences in perceptions of scientists' benevolence and personal relevance, and further minimizing the gap between opponents and proponents of GM crops. We believe that it may be useful to identify facts that are acknowledged or even valued by opponents of GM crops (e.g., climate change) and use these facts as arguments (e.g., scientists are working to address and mitigate climate change), rather than directly asserting our own stance (e.g., scientists are benevolent). In this process, the role of background is to present those associated but important facts effectively.

This study provides an effective practical strategy for initiatives aimed at improving public attitudes towards GM crops and encouraging public engagement with science. It is worth noting that the background strategy is versatile for various communicators. Not only can individual communicators, such as scientists, emphasize the background of their involvement in the research and development of GM crops in their biographies and social media posts, but institutional media can also craft the background to enhance their reporting on GM crops news. However, unlike existing strategies that focus on how to report the main facts, the background strategy requires identifying and presenting associated facts. This grants communicators considerable creative freedom but poses challenges regarding their knowledge and capabilities.

Limitations

This study has several limitations that should be acknowledged. First, we may have underestimated the effects of the climate change background. In our experimental design, both stimuli mentioned four traits of GM crops, which suggested environmental benefits associated with them. Recent research has found that emphasizing the environmental benefits of GM crops helps increase perceptions of their environmental impact (Suldovsky & Akin, 2023), which could be related to perceptions of scientists' benevolence. In other words, the pro-environmental traits of GM crops may have acted as a confounding factor, reducing the differences between conditions.

Second, there is also the possibility that the effect of the climate change background may have been overestimated. We employed a sample of Chinese adults who generally acknowledge and are highly concerned about climate change (Shen &

Wang, 2023; Dai et al., 2015). Thus, the climate change-focused background strategy may be particularly effective among this group.

Third, the placement of the background in a report is flexible and may influence its effectiveness. However, this study only considered the background positioned before the main facts.

Finally, we examined the climate change-focused background strategy solely within the context of GM crops, despite the potential effectiveness of backgrounds consisting of other content. In other contexts, backgrounds would need to be operationalized in different ways.

Considering these limitations, it will be necessary for future studies to operationalize backgrounds using a wider range of content and formats and to examine their effects across different scientific issues and cultural contexts. Furthermore, future research could directly measure audience perceptions of the background to assess its value more accurately.

Notes

1. The AVE value of information engagement intention is 0.484, slightly below the recommended threshold of 0.5. This is largely due to the fact that information seeking, sharing, and discussing can be understood as distinct constructs. AVE is a relatively conservative measure, and some scholars recommend that the use of CR alone is sufficient to conclude convergent validity (Fornell & Larcker, 1981; Malhotra, 2010). It is important to recognize that the recommended statistical threshold for AVE is based on heuristic rules and does not necessarily indicate whether one's theory is supported by the data (Fornell & Larcker, 1981). However, it is reasonable to theoretically converge information seeking, sharing, and discussing into a single construct, as explained in our literature review. Therefore, based on theoretical and statistical considerations, we still affirm the convergent validity of information engagement intention.

Disclosure statement

The authors report there are no competing interests to declare.

References

Allum, N., Sturgis, P., Tabourazi, D., & Brunton-Smith, I. (2008). Science knowledge and attitudes across cultures: A meta-analysis. *Public understanding of science*, *17*(1), 35-54.

Baumeister, R. F., & Hutton, D. G. (1987). Self-presentation theory: Self-construction and audience pleasing. In *Theories of group behavior* (pp. 71-87). New York, NY: Springer New York.

Beall, L., Myers, T. A., Kotcher, J. E., Vraga, E. K., & Maibach, E. W. (2017). Controversy matters: Impacts of topic and solution controversy on the perceived credibility of a scientist who advocates. *PloS one*, *12*(11), e0187511.

Besley, J. C. (2013). The state of public opinion research on attitudes and understanding of science and technology. *Bulletin of Science, Technology & Society*, *33*(1-2), 12-20.

Besley, J. C., & Tiffany, L. A. (2023). What are you assessing when you measure "trust" in scientists with a direct measure?. *Public Understanding of Science*, *32*(6), 709-726.

Besley, J. C., Kramer, V. L., Yao, Q., & Toumey, C. (2008). Interpersonal discussion following citizen engagement about nanotechnology: What, if anything, do they say?. *Science Communication*, *30*(2), 209-235.

Besley, J. C., Lee, N. M., & Pressgrove, G. (2021). Reassessing the variables used to measure public perceptions of scientists. *Science Communication*, *43*(1), 3-32.

Bode, L., Vraga, E. K., & Tully, M. (2021). Correcting misperceptions about genetically modified food on social media: Examining the impact of experts, social media heuristics, and the gateway belief model. *Science Communication*, *43*(2), 225-251.

Boomsma, A. (1985). Nonconvergence, improper solutions, and starting values in LISREL maximum likelihood estimation. *Psychometrika,* 50, 229-242.

Brossard, D., & Nisbet, M. C. (2007). Deference to scientific authority among a low information public: Understanding US opinion on agricultural biotechnology. *International Journal of Public Opinion Research*, *19*(1), 24-52.

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. routledge.

Dai, J., Kesternich, M., Löschel, A., & Ziegler, A. (2015). Extreme weather experiences and climate change beliefs in China: An econometric analysis. *Ecological Economics*, *116*, 310-321.

Dixon, G. (2016). Applying the gateway belief model to genetically modified food perceptions: New insights and additional questions. *Journal of Communication*, *66*(6), 888-908.

Doxzen, K., & Henderson, H. (2020). Is this safe? Addressing societal concerns about CRISPR-edited foods without reinforcing GMO framing. *Environmental Communication*, *14*(7), 865-871.

Druckman, J. N., & Bolsen, T. (2011). Framing, motivated reasoning, and opinions about emergent technologies. *Journal of communication*, *61*(4), 659-688.

Du, Z., Xiao, Y., & Xu, J. (2022). How does information exposure affect public attitudes toward GMO in China? The mediating and moderating roles of conspiracy belief and knowledge. *Frontiers in Psychology*, *13*, 955541.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Harcourt brace Jovanovich college publishers.

Evans, W. A., Krippendorf, M., Jae, H. Y., Posluszny, P., & Thomas, S. (1990). Science in the prestige and national tabloid presses. *Social Science Quarterly*, *71*(1), 105.

Eveland Jr, W. P. (2001). The cognitive mediation model of learning from the news: Evidence from nonelection, off-year election, and presidential election contexts. *Communication research*, *28*(5), 571-601.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior research methods*, 41(4), 1149-1160.

Festinger L., (1957). *A theory of cognitive dissonance*. Stanford University Press.

Fiske, S. T., & Dupree, C. (2014). Gaining trust as well as respect in communicating to motivated audiences about science topics. *Proceedings of the National Academy of Sciences*, *111*(supplement_4), 13593-13597.

Fiske, S. T., & Taylor, S. E. (2013). *Social cognition: From brains to culture*. Sage.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research*, *18*(1), 39-50.

Fredin, E. S., & Tabaczynski, T. (1993). Media schemata, information-processing strategies, and audience assessment of the informational value of quotes and background in local news. *Journalism Quarterly*, *70*(4), 801-814.

Funk, C., & Kennedy, B. (2016). The new food fights: U.S. public divides over food science. Pew Research Center. http://www.pewinternet.org/2016/12/01/public-opinion-about-genetically-modified-foods-and-trust-in-scientists-connected-with-these-foods/

Gong, Y., Tian, J., Li, Y., Zhou, J., Pongpiachan, S., Chen, X., & Sun, Y. (2023). Mitigating perceived environment insignificance through Information engagement. *Science Communication*, *45*(4), 431-459.

Griffin, R. J., Dunwoody, S., & Neuwirth, K. (1999). Proposed model of the relationship of risk information seeking and processing to the development of preventive behaviors. *Environmental research*, *80*(2), S230-S245.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2009). *Multivariate data analysis* (7th ed.). Prentice-Hall.

Hamstra, A. (2000) “Studying Public Perception of Biotechnology: Helicopter or Microscope?” in M. Dierkes and C. von Grote (eds) Between Understanding and Trust: The Public, Science and Technology, pp. 124–140. Amsterdam: Harwood Academic Publishers.

Hart, P. S., & Nisbet, E. C. (2012). Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. *Communication research*, *39*(6), 701-723.

Hasell, A., Lyons, B. A., Tallapragada, M., & Jamieson, K. H. (2020). Improving GM consensus acceptance through reduced reactance and climate change-based message targeting. *Environmental Communication*, *14*(7), 987-1003.

Hautea, S., Besley, J. C., & Choung, H. (2024). Communicating trust and trustworthiness through scientists' biographies: Benevolence beliefs. *Public Understanding of Science*, 09636625241228733.

Heddy, B. C., Danielson, R. W., Sinatra, G. M., & Graham, J. (2017). Modifying knowledge, emotions, and attitudes regarding genetically modified foods. *The Journal of Experimental Education*, *85*(3), 513-533.

Hendriks, F., Kienhues, D., & Bromme, R. (2015). Measuring laypeople's trust in experts in a digital age: The Muenster Epistemic Trustworthiness Inventory (METI). *PloS one*, *10*(10), e0139309.

Hendriks, F., Kienhues, D., & Bromme, R. (2016). Evoking vigilance: Would you (dis) trust a scientist who discusses ethical implications of research in a science blog?. *Public Understanding of Science*, *25*(8), 992-1008.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal*, *6*(1), 1-55.

Huang, Q. (2020). Understanding public perceptions of genetically modified organisms in China: The role that heuristics play during digital media exposure. *Chinese Journal of Communication*, 13(3), 293-311.

Ihm, J., & Kim, E. M. (2018). The hidden side of news diffusion: Understanding online news sharing as an interpersonal behavior. *New Media & Society*, *20*(11), 4346-4365.

Ihm, J., & Kim, E. M. (2024). My news, your news, and our news: Self-presentational motivations and three levels of issue relevance in news sharing on social media. *New Media & Society*, 14614448241237487.

Jeong, M. (2018). Sharing tobacco and e-cigarette information: Predicting its occurrence and valence among youth and young adults. *Health communication*, *33*(9), 1114-1123.

Johnson, B. B., & Dieckmann, N. F. (2020). Americans' views of scientists' motivations for scientific work. *Public Understanding of Science*, *29*(1), 2-20.

Johnson, J. D., & Meischke, H. (1993). A comprehensive model of cancer-related information seeking applied to magazines. *Human Communication Research*, *19*(3), 343-367.

Katz, E., & Lazarsfeld, P. F. (1955). *Personal influence: The part played by people in the flow of mass communication*. Free Press.

Kim, N., Skurka, C., & Madden, S. (2024). The effects of self-disclosure and gender on a climate scientist's credibility and likability on social media. *Public Understanding of Science*, 09636625231225073.

Kim, S. H., Kim, J. N., & Besley, J. C. (2013). Pathways to support genetically modified (GM) foods in South Korea: Deliberate reasoning, information shortcuts, and the role of formal education. *Public Understanding of Science*, *22*(2), 169-184.

Kim, S., Monahan, J. L., & Do, Y. K. (2023). Communication-based strategies to curb the overuse of low-value cancer screening. *Journal of Communication*, *73*(5), 399-412.

Klein, A., & Moosbrugger, H. (2000). Maximum likelihood estimation of latent interaction effects with the LMS method. *Psychometrika*, *65*(4), 457-474.

Kline, R. B. (2023). *Principles and practice of structural equation modeling*. Guilford publications.

Klümper, W., & Qaim, M. (2014). A meta-analysis of the impacts of genetically modified crops. *PloS one*, *9*(11), e111629.

Kunda, Z. (1990). The case for motivated reasoning. *Psychological bulletin*, *108*(3), 480.

Lacasse, K. (2016). Don't be satisfied, identify! Strengthening positive spillover by connecting pro-environmental behaviors to an "environmentalist" label. *Journal of Environmental Psychology*, *48*, 149-158.

Lyons, B. A., Hasell, A., Tallapragada, M., & Jamieson, K. H. (2019). Conversion messages and attitude change: Strong arguments, not costly signals. *Public Understanding of Science*, *28*(3), 320-338.

Lyons, B. A., Mérola, V., Reifler, J., Spälti, A. K., Stedtnitz, C., & Stoeckel, F. (2024). When experts matter: Variations in consensus messaging for vaccine and genetically modified organism safety. *Public Understanding of Science*, *33*(2), 210-226.

Ma, X., Yang, Y., & Chen, L. (2023). Promoting Behaviors to Mitigate the Effects of Climate Change: Using the Extended Parallel Process Model at the Personal and Collective Level in China. *Environmental Communication*, 17(4), 353-369.

Malhotra, N. (2010). *Marketing Research: an applied orientation* (6th ed.). Prentice-Hall.

Maslowsky, J., Jager, J., & Hemken, D. (2015). Estimating and interpreting latent variable interactions: A tutorial for applying the latent moderated structural equations method. *International journal of behavioral development*, *39*(1), 87-96.

Miller, J. D. (2004). Public understanding of, and attitudes toward, scientific research: What we know and what we need to know. *Public understanding of science*, *13*(3), 273-294.

Miller, J.D. & Pardo, R. (2000) “Civic Scientific Literacy and Attitude to Science and Technology: a Comparative Analysis of the European Union, the United States, Japan and Canada,” in M. Dierkes and C. von Grote (eds) *Between Understanding and Trust: The Public, Science and Technology*, pp. 81–130. Amsterdam: Harwood Academic Publishers

Miller, S. (2001). Public understanding of science at the crossroads. *Public understanding of science*, *10*(1), 115-120.

Mou, Y., & Lin, C. A. (2014). Communicating food safety via the social media: The role of knowledge and emotions on risk perception and prevention. *Science Communication*, 36(5), 593-616.

National Academies of Sciences, Engineering, and Medicine. (2016). *Genetically engineered crops: Experiences and prospects*. The National Academies Press.

Niederdeppe, J., Hornik, R. C., Kelly, B. J., Frosch, D. L., Romantan, A., Stevens, R. S., ... & Schwartz, J. S. (2007). Examining the dimensions of cancer-related information seeking and scanning behavior. *Health communication*, *22*(2), 153-167.

Pellechia, M. G. (1997). Trends in science coverage: A content analysis of three US newspapers. *Public Understanding of Science*, *6*(1), 49.

Petty, R. E., & Cacioppo, J. T. （1986）. *Communication and persuasion: Central and peripheral routes to attitude change*. New York: Springer-Verlag.

Priest, S. H. (2001). Misplaced faith: Communication variables as predictors of encouragement for biotechnology development. *Science Communication*, *23*(2), 97-110.

Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., & Xu, J. (2019). Impact of climate change on crops adaptation and strategies to tackle its outcome: A review. *Plants*, *8*(2), 34.

Rucinski, D. (2004). Community boundedness, personal relevance, and the knowledge gap. *Communication Research*, *31*(4), 472-495.

Runge, K. K., Brossard, D., Scheufele, D. A., Rose, K. M., & Larson, B. J. (2017). Attitudes about food and food-related biotechnology. *Public Opinion Quarterly*, *81*(2), 577-596.

Shen, C., & Wang, Y. (2023). Concerned or Apathetic? Exploring online public opinions on climate change from 2008 to 2019: A Comparative study between China and other G20 countries. *Journal of Environmental Management*, *332*, 117376.

Siegrist, M., Connor, M., & Keller, C. (2012). Trust, confidence, procedural fairness, outcome fairness, moral conviction, and the acceptance of GM field experiments. *Risk Analysis: An International Journal*, *32*(8), 1394-1403.

Smyth, S. J., Phillips, P. W., & Castle, D. (2024). An assessment of the linkages between GM crop biotechnology and climate change mitigation. *GM Crops & Food*, *15*(1), 150-169.

Sturgis, P., & Allum, N. (2004). Science in society: Re-evaluating the deficit model of public attitudes. *Public understanding of science*, *13*(1), 55-74.

Su, L. Y. F., Scheufele, D. A., Brossard, D., & Xenos, M. A. (2021). Political and personality predispositions and topical contexts matter: Effects of uncivil comments on science news engagement intentions. *New Media & Society*, *23*(5), 894-919.

Suldovsky, B., & Akin, H. (2023). The role of trust in communicating scientific consensus and the environmental benefits of genetically engineered crops: Experimental evidence of a backfire effect. *Environmental Communication*, *17*(1), 101-118.

Thon, F. M., & Jucks, R. (2017). Believing in expertise: How authors' credentials and language use influence the credibility of online health information. *Health communication*, *32*(7), 828-836.

Tian, J., Sun, M., Gong, Y., Chen, X., & Sun, Y. (2022). Chinese residents' attitudes toward consumption-side climate policy: The role of climate change perception and environmental topic involvement. *Resources, Conservation and Recycling*, *182*, 106294.

Van Dijk, T. A. (1985). Structures of news in the press. *Discourse and communication: New approaches to the analysis of mass media discourse and communication*, *10*, 69-93.

Van Dijk, T. A. (1988). News as discourse. New Jersey: Lawrence Erlbaum Associates,Publishers.

Van Krieken, K., & Sanders, J. (2021). What is narrative journalism? A systematic review and an empirical agenda. *Journalism*, *22*(6), 1393-1412.

Voytas, D. F., & Gao, C. (2014). Precision genome engineering and agriculture: opportunities and regulatory challenges. *PLoS biology*, *12*(6), e1001877.

Wang, L., Gollust, S. E., Rothman, A. J., Vogel, R. I., Yzer, M. C., & Nagler, R. H. (2024). Effects of Exposure to Conflicting Health Information on Topic-Specific Information Sharing and Seeking Intentions. *Health communication*, 1-9.

Wen, N., & Wei, R. (2018). Examining effects of informational use of social media platforms and social capital on civic engagement regarding genetically modified foods in China. *International Journal of Communication*, *12*, 22.

Wirz, C. D., Scheufele, D. A., & Brossard, D. (2020). Societal debates about emerging genetic technologies: Toward a science of public engagement. *Environmental Communication*, *14*(7), 859-864.

Xie, C. Q. (2005). 论新闻背景在深度报道中的运用. *新闻界*, *(05)*, 144-145.

Yuan, S., Ma, W., & Besley, J. C. (2019). Should scientists talk about GMOs nicely? Exploring the effects of communication styles, source expertise, and preexisting attitude. *Science Communication*, *41*(3), 267-290.

Zahed, M. A., Movahed, E., Khodayari, A., Zanganeh, S., & Badamaki, M. (2021). Biotechnology for carbon capture and fixation: Critical review and future directions. *Journal of Environmental Management*, *293*, 112830.

Zeng, Q. X. (2014). 新媒体语境下的新闻叙事模式. *新闻与传播研究*, *(11)*, 48-59, 125-126.

Zhu, Y., He, G., & Gao, L. (2022). Complementarity or substitution? The interaction effects between knowledge and trust on public attitudes toward genetic modification. *International Journal of Public Opinion Research*, *34*(3), edac027.