

Original Research

The Effects of Gain-Loss Framing and Message Sidedness on GMO Acceptance: The Mediating Role of Psychological Reactance

Han Lin¹ and Yonghwan Kim²

¹ Department of Media and Communication, Dongguk University, Republic of Korea

² Department of Media and Communication, Dongguk University, Republic of Korea

Corresponding to
Yonghwan Kim

Department of Media and Communication, Dongguk University, 30 Pildong-ro 1-gil, Jung-gu, Seoul, 04520, Republic of Korea

Email: yhkim17@dongguk.edu

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ABSTRACT

Misinformation about GMOs (genetically modified organisms) circulated on social media has negatively impacted people's beliefs and behaviors. This study explores whether and how the information element of online news can improve public attitudes toward controversial issues such as GMOs. For this purpose, a 2 (gain vs. loss frames) x 2 (one-sided vs. two-sided messages) experimental design is adopted. The results of ANCOVA show that those exposed to two-sided messages showed greater levels of GMO acceptance compared with those exposed to one-sided messages. A significant interaction effect on GMO acceptance was also found, demonstrating that a two-sided message focusing on the gain frame showed the highest levels of GMO acceptance. In addition, the effects of message sidedness and gain-loss frames on GMO attitudes are mediated by psychological reactance. Specifically, two-sided messages, compared to one-sided messages, led to lower GMO risk perceptions and higher GMO acceptance by reducing psychological reactance. Furthermore, compared to loss-framed messages, gain-framed messages decreased GMO risk perceptions and increased GMO acceptance by lowering participants' psychological reactance. These results can provide a deeper understanding of the mechanism by which news messages might influence individuals' acceptance of scientific information through activating psychological reactance.

KEYWORDS

gain-loss framing, message sidedness, GMO, attitudes, psychological reactance

The online environment enables the widespread dissemination of messages. As a result, misinformation about health, politics, and science floods the Internet (Kim et al., 2021; Vraga & Bode, 2017) due to the absence of gatekeepers in vetting quality information as well as increased selective exposure. Scholars are paying more attention to the spread of misinformation in the online environment and how to correct it (Rojecki & Meraz, 2016; Spohr, 2017). The corrective function of online news is important because the public can be exposed to popular social issues through online news websites (Xu, 2013). For example, corrective

messages in online news can be spread via social media in order to limit misperceptions and change public views on emerging health issues (Appelman & Hettinga, 2020). However, little is known about how to reduce the public's misunderstanding through online news and improve the public attitude in the face of certain topics that are difficult to clearly refute and prove, such as information about GMOs and vaccines (Bode & Vraga, 2018; Chung et al., 2020).

A strategy to improve attitude certainty is to provide two-sided messages on controversial issues. A two-sided message is a persuasive communication that presents both supportive and opposing points of view and then presents arguments to counter the opposing view (Allen, 1991; Eisend, 2006). Two-sided messages are effective in reducing the harm of misinformation because they can reduce unknowability and increase the audience's ability to refute negative messages. Recent studies have indicated that two-sided messages significantly reduce misperceptions of vaccine dangers and are an effective way to combat misinformation (Featherstone & Zhang, 2020). However, two-sided messages may not work in all situations; their effectiveness can be restricted by factors such as source credibility (Eisend, 2010), involvement (Eisend, 2013), argument quality (Kao, 2012), and prior attitude (Xiao & Su, 2021). Hence, the circumstances under which two-sided messages play a greater role in correcting misunderstanding need to be studied further.

In addition to a more comprehensive view, scholars have emphasized the importance of providing future-oriented perspectives on controversial topics (Hermans & Gyldensted, 2019). The emphasis on gain or loss is a key issue in considering future orientation. Prospect theory (Kahneman & Tversky, 1979) provides the theoretical underpinning for the process of how to change the audience's attitude by emphasizing different dimensions (positive vs. negative) of the same message. Thus, this study integrates the two

message strategies, namely message sidedness and gain-loss framing, and explores how they interact and influence the audience's receptive attitude.

We also explore the mediating effects of psychological reactance in order to better account for the reasons and mechanisms by which different information strategies work. Psychological reactance is a psychological phenomenon in which individuals choose to resist external decision-making suggestions in order to restore their internal sense of security when they perceive that the attitudes or behaviors of others contradict their own views. In most studies, psychological reactance is proposed as an important psychological reason for the failure of persuasive messages (Dillard & Shen, 2005; Lee & Cameron, 2017; Quick & Kim, 2009).

In summary, we explore how message sidedness and gain-loss framing influence audience attitudes in terms of both cognitive and emotional/psychological mediating mechanisms. The results of this study may be of great significance for correcting the public misunderstanding of controversial topics, such as GMOs. The public is fearful due to the perceived risks of new technologies, so general persuasive messages rarely change attitudes and may even provoke a boomerang effect because the audience has a prior, negative perception or an unyielding attitude (Nyhan & Reifler, 2010). Along this line of research, this study attempts to give an answer to how the public attitude toward controversial events can be improved through the message design of online news.

GMOs and Public Misunderstanding

With the development of science and technology, the use of genetically modified organisms (GMOs) has gained the support of many scientists (Domingo & Bordonaba, 2011), but the topic is still controversial. Uncertainty about the technology, ineffective channels for releasing official information, and a lack of public trust

in the government and scientists have led to a large amount of misinformation and various rumors about GMOs circulating on the Internet, especially on social media (Jiang & Fang, 2019). This misinformation can impact attitudes about GMOs through several mechanisms, resulting in GMO food not being well accepted by the public and even causing large-scale demonstrations against GMOs (Cui & Shoemaker, 2018). The proliferation of misinformation makes it hard for the public to acquire scientific knowledge about GMOs and form a rational attitude toward them. Therefore, although the safety of GMO food cannot be definitively proven, how to correct misunderstood attitudes about controversial topics (such as GMOs) through online news is our concern.

Message Sidedness

Message sidedness refers to whether a controversial issue contains only supportive arguments (one-sided messages) or mentions the opposing viewpoint in addition to providing a supportive position (two-sided messages: Allen, 1991; Eisend, 2006). Many researchers argue that two-sided messages can improve the persuasive effect of the messages (Cornelis et al., 2014; Kao, 2012).

Jones and Brehm (1970) explained that one-sided persuasion, rooted in the one-sidedness and absoluteness of the statement, will cause greater pressure on recipients to adopt a particular point of view, and recipients are more likely to resist this point of view. Kamins and Assael (1987) applied the assimilation-contrast theory to explain that the addition of negative messages will narrow the gap with opposing viewpoints and increase the likelihood of entering the range of acceptance, while consumers are prone to be suspicious of one-sided messages that emphasize only positive characteristics and are therefore less likely to accept them. Inoculation theory (Banas & Rains, 2010; Ivanov, 2017) borrows the biological principle of vaccine-induced immunity to argue that message

perception can be enhanced by adding moderately opposing opinions and countering them. Thus, two-sided messages which contain both positive and negative views can be considered a type of inoculation as a way to increase the resistance of the audience to negative messages.

A large number of empirical studies have reported the positive effects of two-sided messages on attitude change (Featherstone & Zhang, 2020; Kim, 2020; Lyons et al., 2019). These results highlight the potential positive effects of two-sided messages in reducing uncertainty as well as in increasing the audience's ability to counter negative messages. For example, studies on how two-sided messages affect attitudes toward human papilloma virus (HPV) vaccination have suggested that two-sided messages exert a more positive persuasive effect in individuals with lower levels of misconceptions about HPV compared to one-sided messages (Xiao & Su, 2021). An experimental study demonstrated that two-sided messages further increased supportive attitudes toward the MMR (measles, mumps, and rubella) vaccine by reducing negative emotions (Featherstone & Zhang, 2020).

Based on these results, scholars have suggested that two-sided messages can be considered an effective information strategy in combating misinformation and misunderstanding (Featherstone & Zhang, 2020). According to the aforementioned studies, when a controversial topic is discussed, such as GMOs, the audience may not know much about GMOs or may have a negative impression of GMOs beforehand. Therefore, in order to increase the degree of trust in the messages and reduce the audience's tendency to refute them, two-sided messages ought to be able to narrow the distance from people with opposing views. We hypothesize that two-sided messages that include arguments both for and against GMOs and present arguments against opposing views are more effective in changing the audience's attitudes than one-sided messages that contain only the benefits of GMOs.

Thus, H1 is proposed as follows:

H1: Compared with one-sided messages, news information about GMOs delivered through two-sided messages, will reduce GMO food risk perception (H1a) and increase GMO acceptance (H1b).

However, many other studies have found that two-sided messages do not always work and need to be considered together with other factors, such as source credibility (Eisend, 2010), involvement (Eisend, 2013), argument quality (Kao, 2012), and prior attitude (Xiao & Su, 2021). In the negative political advertising context (Kim, 2020), the persuasive effect of a two-sided message is stronger only when participants see a negative ad targeting the party candidate they support (partisan matching condition). In addition, a study on sport shoe brands showed that two-sided messages lead to more favorable advertising attitudes only when the quality of the arguments is high (Kao, 2012). Therefore, while examining the main effect of two-sided messages, it is crucial to consider the conditions under which two-sided messages work.

Gain-Loss Framing

Framing theory suggests that how a message is presented influences how the audience processes that information; that is to say, even the same content can have different effects depending on the way it is conveyed (Goffman, 1974). One fruitful area of study on framing theory is prospect theory, proposed by Kahneman and Tversky (1979). It describes the effect of gain-loss frames on the result of choice; in other words, when choosing an action, individuals base their decisions on the outcome of their thinking in terms of the gain they will have if they act or the loss they will suffer if they do not act. Even the same messages can lead to completely different decisions depending on whether they are framed

as gain or loss. In general, individuals are more sensitive to the losses they suffer (Kim & Moon, 2017). This means that they tend to avoid the losses that result from not taking an action rather than pursue the gains of engaging in an action.

A series of meta-analyses on message frames have also demonstrated that, depending on the type of message, gain-loss frames may have different effects on attitudes, intentions, and behaviors (Gallagher & Updegraff, 2012). By emphasizing the potential gain from a particular action, some researchers argue that gain-framed messages are well suited to promote risk-averse behaviors or behaviors that can ensure a positive outcome. Given that preventive health behaviors are perceived as risk-averse (that is to say, they focus on actions that encourage people to maintain good health), researchers argue that gain framing is particularly effective in improving attitudes and promoting behavior relative to loss framing. There is a great deal of factual evidence for this concept in various contexts, such as disease prevention (Mathur et al., 2013), anti-smoking campaigns (Schneider et al., 2001), and so forth. For example, Schneider et al. (2001) found that gain-framed messages about the benefits of quitting smoking shifted smoking-related beliefs and attitudes toward avoidance and cessation more than loss-framed messages.

On the contrary, by emphasizing the potential risks that may arise from not taking an action, messages with loss framing are well suited to stimulate risk-taking behaviors as well as individuals' attitudes and perceptions of the related risk. Loss-framed messages can be more successful in encouraging disease detection (Meyerowitz & Chaiken, 1987; Nabi et al., 2020; Rothman & Salovey, 1997). For example, Cherubini et al. (2005) found that loss-framed messages (i.e., messages that emphasize the negative consequences of not doing examinations) had a significant positive effect on attitudes toward prostate screening compared to gain-framed messages. Furthermore, loss frames

influence individual health behaviors through the moderation of attitudes and intentions (Pakpour et al., 2014).

However, it is noteworthy that this conclusion cannot always be supported. Some studies have also found that the effectiveness of gain-loss frames may be compromised in situations where the action itself bears risks. For example, in a study designed to promote CT (computed tomography) scans, gain framing was more effective than loss framing (Lee, 2016). The reason for this contrary result can be attributed partially to the individual's perception of uncertainty about whether the action may contain risk or not. When there are hazards hidden in the actions, individuals will consider whether there are risks in addition to gains and losses (Bartels et al., 2010; Kahneman & Tversky, 1979; Shim et al., 2021). Chang (2007) asserts that because gain-framed messages contain reassuring or optimistic themes, they can be used to reduce the perceived risk in new product promotions. Considering the uncertainty factor implied by GMO-related topics, the public may have a high risk perception of GMOs. Given the potential strength of gain framing in reducing perceived risk, we propose the following hypothesis:

H2: Compared with loss-framed messages, news information about GMOs delivered through gain frames will reduce GMO food risk perception (H2a) and increase GMO acceptance (H2b).

Although the aforementioned studies prove that gain-loss frames are more or less effective relative to each other, a comprehensive analysis of gain framing reveals that the average effect of gain-loss frames in persuasive messages of different types is small (O'Keefe & Jensen, 2007, 2009). This finding means that neither frame type is inherently more effective than the other and implies that other factors or interaction

effects deserve consideration. Some studies also provide evidence of how gain-loss frames and other variables interact with each other to influence the audience's attitude. For example, when there is news coverage about nuclear energy development, news content focused on loss framing in environmental protection can enhance the public acceptance of nuclear energy compared with gain framing (Kim, 2017b).

Bartels et al. (2010) used news reports with gain-loss frames to observe subjects' attitudes toward the West Nile virus vaccine. They found that loss-framed information is more persuasive when subjects perceive the effect of the vaccine to be less stable (i.e., high perceived risk), while gain-framed information is more effective when subjects perceive the effect of the vaccine to be stable (i.e., low perceived risk). Similarly, in a study on HIV (human immunodeficiency virus) vaccines, Evangeli et al. (2013) found that when participants believed that the outcome is certain, that is, that they would not become infected with HIV through HIV vaccination, individuals exposed to gain-framed information show more positive attitudes toward participating in vaccine trials.

In the aforementioned studies, although gain-loss frames may have limited effects on the persuasive outcome, other factors associated with these messages may lead to different influence processes. Discovering these processes will be an important advance in understanding how these frames can persuade more generally. Thus, while stressing the main effect of two-sided messages, we also hope to understand how gain-loss frames can lead to different outcomes depending on message sidedness given that two-sided messages are effective in reducing the perceived risk and uncertainty about the subject. Based on prior studies (Bartels et al., 2010; Evangeli et al., 2013) and rationales of the proposed H1 and H2 above, two-sided messages with gain framing may have a greater persuasive effect on improving public attitudes toward GMOs compared to other

combinations of messages (e.g., loss framing with one-sided or two-sided messages and gain framing with one-sided messages). In other words, two-sided messages with gain framing would show the strongest effect in terms of decreasing perceived risk of GMO and increasing GMO acceptance. Therefore, H3 is proposed as follows:

H3: Message sidedness and gain-loss framing interact to affect GMO food risk perception and GMO acceptance; that is, two-sided messages with gain framing will show the lowest level of GMO food risk perception (H3a) and the highest level of GMO acceptance (H3b).

The Mediating Role of Psychological Reactance

Psychological reactance theory depicts the intrinsically motivated processes of resistance to social influences (Brehm, 1966). This theory asserts that once people perceive that their freedom is being threatened, they will reestablish their freedom to maintain their inner security (Brehm & Brehm, 1981). Any force on the individual that makes it more difficult to exercise their freedom constitutes a threat (Brehm & Brehm, 1981)¹. Thus, when an external stimulus (e.g., a persuasive message) is perceived to threaten, hinder, or eliminate their freedom of choice, psychological reactance is assumed to emerge. This threat to freedom usually depends on the way the message is delivered and whether the audience perceives the strong persuasive intent implied in the message (Shen, 2015). To some extent, all attempts at persuasion can be considered a threat to one's freedom

(Reynolds-Tylus, 2019). Psychological reactance is, therefore, an important reason for the ineffectiveness of persuasive messages (Dillard & Shen, 2005; Lee & Cameron, 2017; Quick & Kim, 2009).

Dillard and Shen (2005) divided psychological reactance into negative emotions and negative cognitions. Negative emotions are the feelings of hostility, anger, and other emotional states that individuals may experience after being exposed to particular persuasive messages. Negative cognitions are embodied as resistance to persuasive messages, rebuttal intention, disapproval, and so forth. These two concepts reflect the extent to which individuals respond when they suffer from psychological reactance. To better explain the framing effects of information in online news, it is important to understand that how a message is presented can effectively alleviate psychological reactance.

Researchers reveal that for diverse topics, including smoking (Erceg-Hurn & Steed, 2011), weight management (Lee & Cameron, 2017), organ transplantation (Reinhart et al., 2007), environmental protection (Kim & Kim, 2018), and nuclear power development (Kim, 2017b), persuasive messages may induce psychological reactance because messages about such topics could include some information that contradicts one's existing beliefs. This resistance can lead to negative attitudes and opposing actions on the topic. In related studies on the kinds of messages that can cause psychological reactance, coercive language of a commanding nature is generally considered to be an important factor (Shen, 2015). Coercive language has a strong persuasive intent, so it can easily trigger psychological reactance and lead to the failure of persuasion. In contrast, suggestive language, which does not

¹ It is important to note that freedom in psychological reactance theory is not freedom in general terms; it is "not an abstract consideration, but a concrete behavioral reality, including emotions, attitudes, and any other sensory state of the organism" (Brehm & Brehm, 1981, p. 12). In other words, even if one is merely exposed to information, if this information makes it difficult for the individual to make a preferred decision, it constitutes a threat to freedom (see Shen, 2015).

threaten the audience's freedom of action, can alleviate psychological reactance (Cho & Sands, 2011; Dillard & Shen, 2005; Kim & Kim, 2018).

In a similar context, some studies (Kim, 2014) have shown that when the audience perceives news to be overtly biased, they will consider this bias as an infringement on their freedom of choice, leading them to resist the news and reject the claims made in it. This dynamic can often be seen in controversial news reports (Chia & Cenite, 2012). This suggests that two-sided messages can be expected to reduce the audience's psychological reactance because they have less coercive language and more suggestive language in order to avoid the problem of bias.

Another reason why the message sidedness may be related to psychological reactance is that it influences the credibility of the message (De Veirman & Hudders, 2020). People may believe that messages presenting both negative and positive perspectives are more credible compared to one-sided messages that only emphasize a positive side because they offer more nuanced and diverse views of the arguments (Eisend, 2007). We expect that message sidedness may work in a similar way for the topic of GMOs, suggesting the mediating role of psychological reactance in the relationship between message sidedness and individuals' GMO food risk perception and GMO acceptance.

In particular, news articles with two-sided messages to correct the audience's bias against GMOs (i.e., negative consequences of GMOs) would be considered credible because the messages describe diverse perspectives including both the possible disadvantages and advantages of GMOs as well as counterarguments against the possible disadvantages of GMOs, which could reduce individuals' psychological reactance. Furthermore, reduced psychological reactance after exposure to messages seeking to correct misinformation about the negative consequences of GMOs will further decrease the perception of GMO food risk and increase acceptance

toward GMOs. By contrast, one-sided messages that only emphasize the advantages of GMOs would be considered biased, coercive, and less credible, which can increase psychological reactance. Accordingly, individuals' increased psychological reactance after being exposed to one-sided messages about GMOs indicates that they may be not willing to accept the intention of the persuasive messages, which means that they may be highly aware of the risks of GMOs and may not accept GMOs. Thus, we propose the following hypothesis:

H4a: Through reducing psychological reactance, two-sided messages are more effective than one-sided messages in reducing GMO food risk perception and increasing GMO acceptance.

There is some evidence in the literature for how gain-loss frames influence psychological reactance. For example, Shen (2015) found that in the context of skin cancer-related behaviors, loss framing leads to stronger fear arousal eliciting psychological reactance, whereas gain framing and providing behavioral choices reduced perceived threats to freedom. Reinhart et al. (2007) revealed that compared with loss-framed messages, gain-framed messages resulted in lower psychological reactance, which in turn promoted positive attitudes toward organ and tissue donation messages.

There are several reasons why messages with loss framing may induce psychological reactance. As pointed out by Cho and Sands (2011), by emphasizing negative effects, the language used in loss framing tends to be more controlling, intense, and coercive. For example, in gain framing, messages suggest the expectation of a better outcome while loss framing focuses on a message communicating that we have a lot to lose if we don't do this. This can be regarded as a kind of moral coercion that affects the individual's freedom of choice. Finally, given that loss framing

messages can lead to stronger negative emotions than gain framing messages, they are considered to be more manipulative (Shen, 2015).

Therefore, messages that emphasize the negative consequences of not adopting GMOs (e.g., famine and massive loss of life in Africa) may be strongly morally coercive and compulsory, leading to activation of individuals' psychological reactance. This increased psychological reactance can further increase the perceived risk of GMO foods and decrease individual attitudes toward GMO acceptance. Gain framing, on the other hand, implies good outcomes due to the emphasis on the positive impact of GMOs on socioeconomic development. This helps to further reduce psychological reactance and increase the persuasiveness of the message. Thus, we propose the following hypothesis:

H4b: Through reducing psychological reactance, gain framing is more effective than loss framing in reducing GMO food risk perception and increasing GMO acceptance.

METHOD

Design and Stimuli

In this study, we used a 2 (one-sided vs. two-sided message) \times 2 (gain-framed vs. loss-framed message) between-subjects experiment to examine the influence of message sidedness and message framing on psychological reactance regarding GMO food risk perception and GMO acceptance. Message sidedness was manipulated through the use of different arguments: a series of arguments support the advantages of GMOs (one-sided message) versus a combination of arguments describing the disadvantages of GMOs (i.e., the harmfulness of GMOs and the possibility of environmental pollution) and arguments supporting the advantages of GMOs (two-sided message). In a two-sided message,

the audience may regard the narrative about the subject's shortcomings as negative information. Therefore, two-sided messages control the proportion of negative opinions to not exceed positive opinions and also add refutations of the negative information (Featherstone & Zhang, 2020).

Given that the information is meant to correct the audience's bias toward GMOs, we used two-sided rebuttal messages in this study. Specifically, in stating that "some studies have also pointed out that GMOs may have problems, such as carcinogenicity and environmental pollution," a counterpoint was provided. Statements used in response to rebuttals included: "The National Academy of Sciences (NAS) of the United States also revealed that there is no scientific evidence that GMOs have negative effects on human health" and "More than 100 Nobel Prize winners joined in a statement urging Greenpeace (NGO) to cancel the anti-GMO campaign."

The gain-framed messages focus on the benefits (socio-economic benefits, environmental preservation, personal consumption) that can be obtained by using GMO technology. For example, one of the gain-framed messages read: "Using genetically modified technology to grow crops. ... The economic benefits would exceed 10 billion US dollars per year. ... Would reduce the use of pesticides by about 600 million kilograms. ... Could save 4 million lives." The loss-framed messages highlighted the potential negative consequences of not using GMO technology with phrases such as "Abandon GMO technology. ... Will suffer 10 billion US dollars in losses. ... increasing pesticide use by about 600 million kilograms. ... Because of famine, 4 million lives will be lost."

Apart from the manipulations, the four experimental stimuli were the same, and the numbers of arguments and words were similar. The arguments were written in a black font on a white background, with an image of GMO crops. In the upper corner, the logo of an online news

website called “NEWS-TODAY” was shown. We used a fictitious online news site in order to prevent any confounding effects of previous familiarity with the site (see Appendix for details).

Participants and Procedure

In total, 142 undergraduate students from a large university in Seoul, South Korea, were recruited as participants for the experiment. The average age was 22.78 years ($SD = 1.71$), and female participants (71.8%, $n = 102$) outnumbered male participants (28.2%, $n = 40$). Monthly household income was US\$2000-US\$8000. Prior to exposure to one of the stimuli, demographic factors, interest in health news, and prior attitudes towards GMOs were measured. Next, each respondent was randomly and individually exposed to one of the four online news stimuli. Subsequently, participants completed the questionnaire containing the manipulation check, followed by questions about the mediating variable and dependent variables (i.e., psychological reactance, GMO food risk perception, and GMO acceptance). Finally, they were debriefed and thanked for their cooperation.

Measures

Psychological Reactance

Referring to Quick and Kim’s (2009) study, we used both negative emotion and negative cognition assessments. First, the arousal of negative emotions was measured on a 5-point scale (1 = *not felt*, 5 = *strongly felt*). The four items included were “I feel [angry/disgusted/displeased/resistant] after reading the news” (Kim & Kim, 2018; Quick & Kim, 2009). These four items were averaged to create an index of negative emotions ($M = 2.25$, $SD = .78$, Cronbach’s $\alpha = .83$). For negative cognitions, Kim and Kim’s (2018) three items were modified to fit this study: “I am unfavorable to what this news is

saying while looking at the news,” “I do not agree with what this news is saying,” and “I thought I would like to present an opinion that contradicts this news.” The items were measured on a 5-point Likert scale (1 = *not at all*, 5 = *very much*), and the three items were averaged to create an index of cognitions ($M = 2.68$, $SD = .79$, Cronbach’s $\alpha = .81$).

GMO Food Risk Perception

For the purpose of this study, risk perception is defined as perceiving a feeling of fear by being aware of the loss that may occur as a result of a specific action. In order to measure GMO food risk perception, the items used in the study by Oh and Kim (2017) were modified to suit the purpose of this study and measured with a total of four items. The specific questions were “Eating GMO food is dangerous,” “Eating GMO food can harm the human body,” “I feel anxious when I think about GMO food,” and “GMO food harms the ecosystem.” Measurements were made on a 5-point Likert scale (1 = *very unlikely*, 5 = *very likely*). These four items were combined into one index, with a higher score indicating a higher risk perception of GMO food ($M = 3.05$, $SD = 1.05$, Cronbach’s $\alpha = .88$).

GMO Acceptance

GMO acceptance is defined in this study as the degree to which GMO technology is socially accepted. In order to measure this variable, a total of three items used in the study of Kim and Jeong (2016) were modified to suit this study: “The development of GM technology is necessary for society,” “The popularization of GM technology is necessary,” and “The development and production of GM products should continue in the future.” Measurements were made on a 5-point Likert scale (1 = *very unlikely*, 5 = *very likely*). These three items were combined into one index, with a higher score indicating more acceptant attitudes regarding GMO technology ($M = 2.97$, $SD = 1.19$, Cronbach’s $\alpha = .89$).

Analysis Procedures

To test the hypotheses (H1, H2 and H3), we performed an analysis of covariance (ANCOVA) to test the influence of the independent variable on the dependent variable and included prior attitudes toward GMOs as covariates in the analysis. To test the proposed potential indirect effects (H4a and H4b), we used Hayes' PROCESS, which allows multiple mediation paths to be tested simultaneously (Hayes, 2017).

Random Assignment Check

A series of chi-square tests and an ANOVA were performed to test the success of random assignment. No significant differences in gender, age, income, religion, and interest in health news were found between the experimental conditions. However, we found statistically significant differences between experimental conditions on prior attitude toward GMOs ($F[3, 138] = 6.72, p < .001$). Those assigned to the one-sided loss frame ($M = 2.51, SD = 1.24$) had more negative prior attitudes toward GMOs than those assigned to the one-sided gain frame ($M = 3.62, SD = 1.06$), the two-sided loss frame ($M = 3.45, SD = 1.14$), and the two-sided gain frame ($M = 3.46, SD = 1.11$). Therefore, referring to the practices and suggestions of previous studies (Goldberg, 2019; Zhao & Nan, 2010), we controlled for prior attitudes toward GMOs in all subsequent analyses².

Manipulation Check

For the manipulation check, a two-sample *t*-test was conducted. Respondents were asked "Does the story contain only one-sided claims

or opinions?" and "Does the story emphasize only gains and not losses?" The results showed that respondents could perceive the difference between one-sided messages and two-sided messages ($M_{one\ sided} = 4.21$ vs. $M_{two\ sided} = 2.21, t = 15.92, p < .001$) as well as between gain frames and loss frames ($M_{gain} = 4.41$ vs. $M_{loss} = 3.15, t = 9.35, p < .001$). Thus, the manipulations of the independent variables were successful.

RESULTS

Results of ANCOVA

For GMO food risk perception, the results of the ANCOVA (see Table 1) showed that the main effects of message sidedness ($F[1,137] = 18.26, p < .001, \eta^2 = .11$) and gain-loss frames ($F[1,137] = 3.98, p = .048, \eta^2 = .02$) were both significant. We observed a lower GMO food risk perception when participants were exposed to two-sided messages ($M = 2.70, SD = .99$) compared to one-sided messages ($M = 3.43, SD = .99$). The main effect of gain-loss frames was a lower GMO food risk perception when participants were exposed to gain-framed messages ($M = 2.88, SD = 1.04$) compared to loss-framed messages ($M = 3.23, SD = 1.04$). As for GMO acceptance, there was only a main effect of message sidedness on GMO acceptance ($F[1,137] = 14.36, p < .001, \eta^2 = .09$), while the gain-loss frames were not significant. Compared with participants who were exposed to one-sided messages ($M = 2.63, SD = 1.16$), those exposed to two-sided messages ($M = 3.30, SD = 1.14$) demonstrated greater levels of GMO acceptance ($M = 3.07, SD = 0.82$). Thus, H1a,

² Goldberg (2019) argues that differences between the conditions retained after random assignment were surprisingly common. Therefore, he suggested including relevant covariates in the analysis. Other studies take the same approach. For instance, in an experimental study on the effect of framing messages on responses to anti-smoking information, Zhao and Nan (2010) checked their random assignment and found significant differences in the number of cigarettes smoked per day across experimental conditions and controlled for the number of cigarettes smoked per day as a covariate in subsequent analyses.

Table 1. Analysis of Covariance for Two Dependent Variables

Dependent variables	Independent variables	df	F	p	η^2
GMO food risk perception	Prior attitudes toward GMOs	1	0.31	.579	< .01
	Message sidedness (a)	1	18.26***	.001	.11
	Gain-loss frames (b)	1	3.98*	.048	.02
	(a) × (b)	1	0.25	.613	< .01
	Prior attitudes toward GMOs	1	2.02	.152	.01
GMO acceptance	Message sidedness (a)	1	14.36***	.001	.09
	Gain-loss frames (b)	1	3.30	.071	.02
	(a) × (b)	1	5.18*	.024	.03

* $p < .05$. ** $p < .01$. *** $p < .001$.

H1b, and H2b were supported.

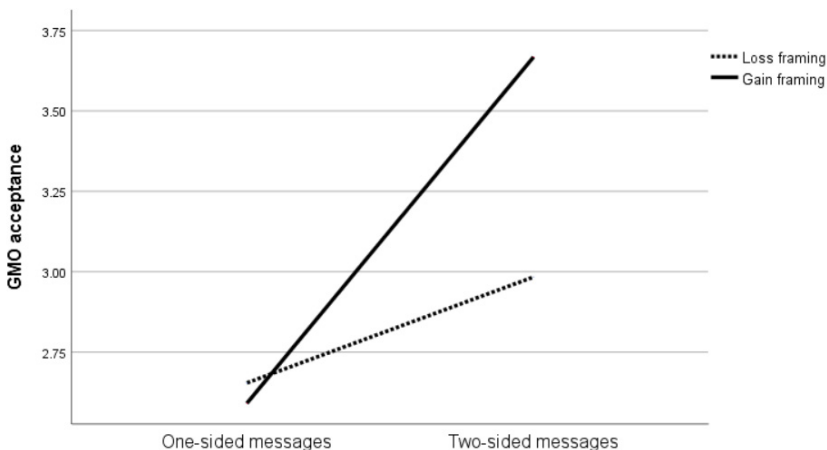
More interestingly, a significant two-way interaction ($F[1,137] = 5.18, p = .024, \eta^2 = .03$) on GMO acceptance was found (see Figure 1). Follow-up simple effects analyses revealed that when the experimental group was exposed to one-sided messages, a loss frame ($M = 2.69, SD = 1.28$) produced slightly higher GMO acceptance than a gain frame ($M = 2.54, SD = 1.05$). The opposite pattern emerged in the two-sided message group, where a gain frame ($M = 3.65, SD = 0.98$) produced significantly higher GMO acceptance than a loss frame ($M = 2.97,$

$SD = 1.19$). In sum, the two-sided message with a gain frame showed the highest level of GMO acceptance. For GMO food risk perception, no significant interaction effect was found ($F[1,137] = 0.25, p = .613, \eta^2 < .01$). Thus, H3 was partially supported.

Results of Mediation Analysis Using Bootstrapping

To test H4a and H4b, we examined whether psychological reactance (negative emotions and negative cognitions) mediates the relationship

Figure 1. Interaction of Message Sidedness × Gain-loss Framing for GMO Acceptance



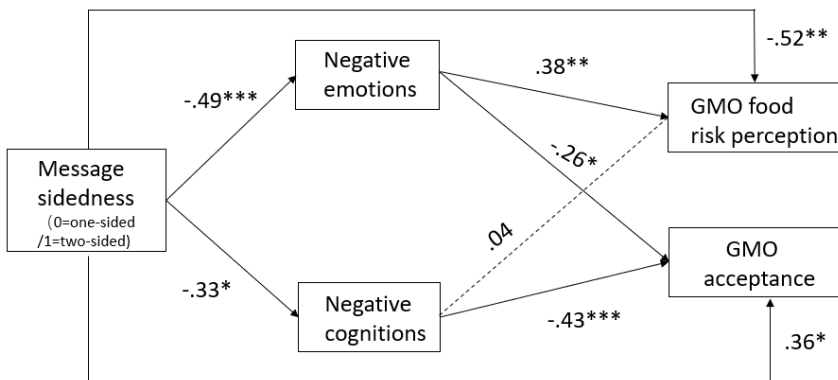
between message sidedness, gain-loss framing, and stages of change in GMO food risk perception and GMO acceptance using the PROCESS macro (Model 6). In light of a strong correlation between negative emotions and negative cognitions, we ran a multiple mediated moderation model, entering both of the proposed mediators in one model. This approach allowed us to examine to what extent a specific mechanism mediates, conditional on the presence of the other mediator. The results are presented for each causal model. The first model used message sidedness as the independent variable; because there are two dependent variables, the results of the two separate analyses are presented in one figure (see Figure 2).

The results show that two-sided messages effectively reduced negative emotions ($b = -0.49$, $SD = 0.13$, $p < .001$) and negative cognitions ($b = -0.33$, $SD = 0.13$, $p = .012$). At the same time, negative emotions increased GMO food risk perception ($b = 0.38$, $SD = 0.11$, $p = .002$) and decreased GMO acceptance ($b = -0.26$, $SD = 0.12$, $p = .044$). Negative cognitions only affected GMO acceptance ($b = -0.43$, $SD = 0.12$, $p < .001$). The

indirect effect of negative emotions was significant on both GMO food risk perception ($b = -0.19$, $CI [-0.42, -0.05]$) and GMO acceptance ($b = 0.13$, $CI [0.01, 0.31]$). Negative cognitions were only significant on GMO acceptance ($b = 0.14$, $CI [0.03, 0.35]$). Therefore, except for the path of negative cognitions to GMO food risk perception ($b = -0.01$, $CI [-0.12, 0.06]$), the indirect effect was significant for these two mediators and shows the presence of mediation. The path coefficient is shown in Table 2. Thus, H4a was supported.

The second model used gain-loss framing as the independent variable (see Figure 3). The result was very similar to the first model: gain-loss framing also effectively reduced negative emotions ($b = -0.45$, $SD = 0.12$, $p < .001$) and negative cognitions ($b = -0.38$, $SD = 0.13$, $p = .003$), while negative emotions increased GMO food risk perception ($b = 0.44$, $SD = 0.11$, $p < .001$) and decreased GMO acceptance ($b = -0.32$, $SD = 0.12$, $p = .012$). Negative cognitions only affected GMO acceptance ($b = -0.50$, $SD = 0.13$, $p < .001$). The indirect effect of negative emotions was significant on both GMO food risk perception

Figure 2. Indirect Effects of Message Sidedness on GMO Food Risk Perception and GMO Acceptance via Psychological Reactance



Note. Coefficients are unstandardized path coefficients. Dashed lines represent non-significant paths.

* $p < .05$. ** $p < .01$. *** $p < .001$.

($b = -0.20$, CI [-0.39, -0.07]) and GMO acceptance ($b = 0.14$, CI [0.03, 0.34]). Negative cognitions were only significant on GMO acceptance ($b = 0.19$, CI [0.05, 0.43]). Gain-loss framing did not have a direct effect on GMO food risk perception and GMO acceptance; negative emotions and negative cognitions have an entirely mediating effect. Thus, H4b was supported.

DISCUSSION

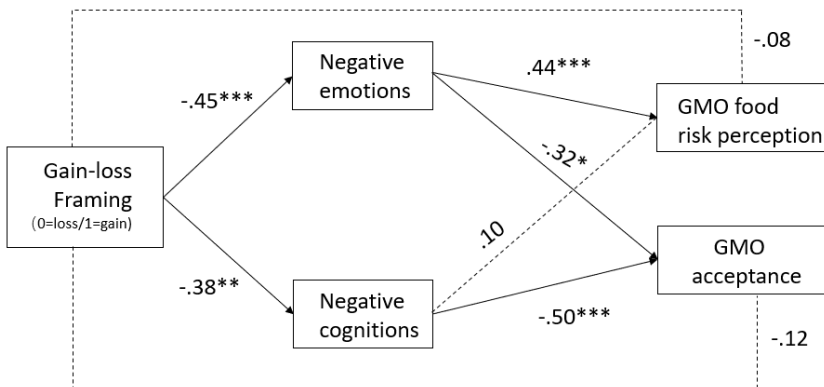
The purpose of this study was to explore the changes of public acceptance based on the two information elements of gain-loss framing and message sidedness when reporting news on GMOs, a socially controversial topic. The findings can be summarized as follows.

Table 2. Results for Mediation Analyses using Bootstrapping

Indirect effect			Effect	SE	LL CI	UL CI
Message sidedness (0 = one-sided / 1 = two-sided)	→ Negative emotions	→ GMO food risk perception	-0.19	0.08	-0.42	-0.05
		→ GMO acceptance	0.13	0.07	0.01	0.31
	→ Negative cognitions	→ GMO food risk perception	-0.01	0.04	-0.12	0.06
		→ GMO acceptance	0.14	0.07	0.03	0.35
Gain-loss frames (0 = loss / 1 = gain)	→ Negative emotions	→ GMO food risk perception	-0.20	0.08	-0.39	-0.07
		→ GMO acceptance	0.14	0.07	0.03	0.34
	→ Negative cognitions	→ GMO food risk perception	-0.03	0.05	-0.18	0.05
		→ GMO acceptance	0.19	0.09	0.05	0.43

Note. Bootstrap resample size = 5,000. SE = bootstrap standard errors; LL = lower limit; UL = upper limit; CI = bias corrected 95% bootstrap confidence interval.

Figure 3. Indirect Effects of Gain-Loss Frames on GMO Food Risk Perception and GMO Acceptance via Psychological Reactance



Note. Coefficients are unstandardized path coefficients. Dashed lines represent non-significant paths.
* $p < .05$. ** $p < .01$. *** $p < .001$.

First, a significant main effect of message sidedness was observed. Specifically, for GMO food risk perception, exposure to two-sided messages can reduce uncertainty about GMOs, thus leading to a lower perception of GMO food risk. The effect can be explained by the Elaboration Likelihood Model (ELM) and inoculation theory. Two-sided messages emphasize rich content and various viewpoints, so the possibility of achieving persuasion is higher because the message is processed through the central route rather than the peripheral route. In addition, according to inoculation theory, negative messages provided in two-sided messages act like a vaccine; a person exposed to an opinion contrary to their prior attitude and belief builds up a resistance to negative messages because of the “vaccination” (from being exposed to negative messages in advance). Hence, an audience exposed to two-sided messages is likely to develop some immunity to arguments about GMOs (i.e., negative messages) and eventually show higher acceptance toward GMOs.

Second, like O’Keefe and Jensen (2007, 2009), we found that the main effects of gain-loss frames are minimal. Only a slight difference was observed in the perception of GMO food risk, and there was no significant influence on GMO acceptance. The focus should be on the reasons for such a difference. One possible explanation is the difference in situational factors (e.g., individual vs. societal). In previous studies, the effects of gain-loss frames were different depending on the topic or situation (Nabi et al., 2020; Quick & Bates, 2010), so it is necessary to consider various situational factors of the arguments and subjects. In the present study, the carcinogenic risk is the most prominent attribute of GMO food risk perception because it is associated with individuals and reflects attributes at the individual level. In contrast, GMO acceptance not only occurs at the individual level but also involves attributes at the societal level, so differences between the factors can be observed. Previous

studies on the effects of gain-loss frames mainly involved gains and losses at the individual level; further studies are needed on how the effects of gain-loss frames change after distinguishing between the individual and societal levels.

Third, the current findings revealed an interaction effect between GMO acceptance, message sidedness, and gain-loss frames, which could explain the previous inconsistent results on the validity of gain-loss frames. To be specific, in one-sided messages, loss frames could lead to higher GMO acceptance than gain frames, possibly because recipients are more interested in avoiding potential losses than pursuing potential gains. However, in two-sided messages, gain frames lead to higher GMO acceptance than loss frames. The explanation of such a result may be linked to uncertainty and perceived risk. Previous studies have indicated that under low information uncertainty (Bartels et al., 2010) and low perceived risk (Quick & Bates, 2010), gain frames can have a greater persuasive effect than loss frames. Two-sided messages can reduce the audience’s perceived risk of the topic and information uncertainty, in which case the audience is more sensitive to actual gains than losses. This can explain why gain frames are more effective in two-sided messages. We empirically observe the interaction between two-sided messages and gain-loss frames, and the results indicate that for topics similar to GMOs, which are controversial and associated with a certain degree of technical dangers, news reports using both two-sided messages and gain frames can maximize public acceptance of GMOs.

Finally, most studies report only the direct effects between message design and attitudes but do not explain why messages are effective or why persuasive effects fail and report inconsistent results in their conclusions. This study adds a significant contribution by exploring the mechanism and function of psychological reactance in influencing GMO attitudes to show that message sidedness and gain-loss frames can

induce the audience's psychological reactance. The results indicate that two-sided messages could lead to lower GMO risk perceptions and higher GMO acceptance by reducing negative emotions and negative perceptions. In contrast, one-sided messages could lead to higher psychological reactance. This is consistent with the results of previous studies (e.g., Kim, 2014) that when the audience perceives news to be overtly biased, they will consider the bias to be an infringement on their freedom of choice, resulting in resistance to the news and rejection of its claims. In this study, we found that psychological reactance could explain this result.

On the other hand, in many prior studies, the effects of negative emotions and negative perceptions are empirically inseparable components (Dillard & Shen, 2005). However, Kim (2017a) argued that their effects would be different for different messages. The results of this study support this view by showing that the two sub-factors constituting psychological reactance are not always consistent in terms of their effects. This finding can provide additional theoretical evidence for related studies on psychological reactance.

It is noteworthy that when gain-loss frames are influencing GMO danger perceptions and GMO acceptance, both negative emotions and negative perceptions show fully mediating effects. Compared with loss frames, audiences exposed to gain frames could have less psychological reactance, resulting in lower perceptions of the danger of GMOs and higher GMO acceptance. An explanation for this result is that the stimulus for psychological reactance is primarily the factor of "freedom of choice." Loss frames could cause audiences to feel cognitive dissonance between the strong persuasive intention of having a "forced choice" and the perception that supporting GMO messages can infringe on their freedom of thought and decision. This psychological burden can lead to psychological reactance, which, in turn, results in the failure of persuasive messages.

Strengths and Limitations of the Study

By explaining the effects of message sidedness and gain-loss frames on attitudes, this study provides some explanation for the inconsistent results of previous studies and contributes to the literature on two-sided messages and gain-loss frames. In particular, previous studies on the two-sidedness of messages and gain-loss frames have mainly paid attention to advertising and health communication, but this study unveiled the influence of online news in the corrective process of attitudes. Moreover, the study further revealed the situations in which two-sided messages and gain-loss frames can influence attitudes and the psychological defense mechanism of psychological reactance. These findings could deepen the understanding of the underlying processes and explain how message design influences audience attitudes through psychological factors.

In today's social media and "post-truth" era, the public needs help in learning to select and read information critically in order to be able to correct misinformation and misconceptions. News providers should avoid ignoring extreme arguments about negative information in controversial topics and instead use two-sided messages that focus on gains to acknowledge and address these controversies, thereby increasing public acceptance. Therefore, we suggest that online news should not only focus on filling the "information deficit" but also find novel strategies to help the public effectively make sense of and process the contradictions and uncertainties of controversial topics.

Despite these contributions, our study has some limitations. First, although a series of high main effect values were observed between the differently framed messages, the small, student-dominated sample may limit further generalization of the study findings to a larger scale. Moreover, although we controlled many variables, other influencing factors may exist, such

as knowledge about GMOs, participants' health status, and individual personality traits. In future studies, it will be helpful to take into account these other influencing factors. For example, individuals with a low level of involvement in controversial topics may not experience psychological reactance, regardless of the type of information they are exposed to.

In addition, this study lacks a measure of the degree of threat to freedom. The aim of our study was to explore whether different framing affects the mediating mechanisms of attitudes by triggering psychological reactance. However, our failure to measure the threat to freedom may have led us to fail to confirm whether the audience's psychological reactance was based on the premise that their freedom was threatened. In order to refine the whole process of psychological reactance, future researchers should consider threat to freedom as an antecedent of psychological reactance.

Finally, it is necessary to investigate the influence on psychological reactance through various message frames in combination with audiences' existing beliefs and attitudes and how they can influence attitudes. For example, given the different effects of gain-loss frames we found on individuals' GMO risk perceptions and acceptance, future researchers should examine the impact of gain-loss frames and psychological reactance after clearly distinguishing the differences between individual and social-level variables.

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