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ARTICLE

You're the apple of my ambivalence: can the primary motivational aspects of GMO foods lessen GMO avoidance?

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Abstract

The United States population reports significant hesitance to consume GMOs. This article examines whether visual food cues can change attitudes, induce attitude ambivalence, and alter intentions to avoid purchasing GMOs. In a between-subjects experiment that varied the imagery cue (positive vs. coactive vs. no cue) accompanying GMO information, participants were randomly assigned to view a news-style article about GMO foods. Overall, positive visual food cues decreased potential ambivalence, resulting in lower felt ambivalence and lower likelihood to avoid GMOs. However, skeptics and uncertain individuals were not significantly affected by visual food cues. Implications and future directions are discussed.

Keywords

Visual communication; Public perception of science and technology; Science and media

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Experts have been concerned that food production would be outpaced by global population growth [e.g., Dyson, 1999]. Indeed, some warned that the food system could collapse, resulting in large swaths of the global population struggling to have enough food to survive [see Sachs, 2008]. However, advancements in food science have helped mitigate these problems. For example, advancements such as recombinant DNA technology, genome editing methods, and modified atmosphere packaging have helped to increase crop yields and the shelf life of food products [Pixley et al., 2022; Sousa-Gallagher et al., 2016]. Although some of these innovations were tied to the ability to reduce food loss and increase production efficiency, some of these new technologies involved the modification of organisms [Valoppi et al., 2021]. In essence, genetically modified organisms (GMOs) are helping feed people around the globe [Pixley et al., 2022; Valoppi et al., 2021].

Despite the positive contributions of GMOs to human well-being, an increasing segment of the population has developed skeptical views of these products. These concerns about the use of GMOs have become a prominent issue in countries around the world [Kennedy & Thigpen, 2020]. Public perception, institutional capacity, trade relationships, and political risk greatly influence how strict or permissive a country's regulation strategies are, leading to a large variety of standards globally [Turnbull et al., 2021]. For example, GMO cultivation is banned widely across Europe due to concerns about their safety and uncertain effects, even though GMOs are heavily imported there [Tagliabue, 2017]. In general, GMO acceptance is much higher in the U.S., largely because of more streamlined regulatory processes and more accommodating policy frameworks [Turnbull et al., 2021]. Still, a significant segment of the population remains skeptical of GMOs. For example, more than a third of U.S. adults surveyed indicated that GMO foods are worse for health than non-GMO foods. Interestingly, this was exacerbated in individuals who indicated they had heard a lot about GMOs; half of those respondents indicated GMOs were worse for health [Funk & Kennedy, 2016].

Given this level of skepticism (and the potential for misinformation that is likely contributing to public opinion and consumer behavior) communication professionals and scholars continue to examine underlying predispositions that may contribute to skepticism [Blancke et al., 2015; Marris, 2001] and what sorts of messaging strategies can be utilized to shift people's views regarding these products. The discourse between opponents and proponents of GMO foods turn on several issues including naturalness perceptions, religious and moral perspectives, benefits in crop production, and negative impacts including safety issues, socioeconomic effects, and intellectual property rights violations [Bekele-Alemu et al., 2025]. This bears out in the psychological and consumer acceptance research regarding GMO foods. Recent research indicates that perceived risk, safety concerns, and a lack of trust in technology all contribute to lack of support for GMOs [Arı et al., 2021; Öz et al., 2018]. Further, data indicate that general attitudes toward science and trust in regulatory practices are key predictors in GMO attitudes [Hanssen et al., 2018], in addition to overall scientific literacy, including knowledge of genetics more specifically [Wunderlich & Gatto, 2015]. Owing to the general deficit model of science communication, a great deal of this research focuses on utilizing the so-called "gateway belief" of scientific consensus to improve the reception of persuasive messages about science and technology [e.g., Hasell et al., 2020; Landrum et al., 2019; van Stekelenburg et al., 2020, 2021]. Other research focuses on ways to deliver arguments that may reduce reactance and improve the likelihood of attitude change [Altay et al., 2022; Hasell et al., 2020; Sleboda & Lagerkvist, 2022]. A smaller portion of this body of work examines how elements of the message structure, rather than message

content, may change GMO attitudes. For example, narrative structure [Hasell et al., 2020], the inclusion of infographics [Lee et al., 2021], and other visuals [Ventura et al., 2017] have been investigated. Though little consensus has emerged, currently held beliefs about GMOs, particularly negative beliefs, seem to be most predictive of attitude outcomes.

Some scholars have argued that this GMO opposition is pervasive and persistent because it appeals to people's unconscious judgments and intuitions about their naturalness, which are often derived from our evolutionary history [Blancke et al., 2015]. Blancke and colleagues contend that people intuitively practice "psychological essentialism", or a belief that organisms have "an unobservable, immutable core determining their identity", which contributes to a negative disposition toward GMOs [Blancke et al., 2015, p. 415]. In other words, genetically engineering organisms contaminates their "essence", which may induce negative attitudes, and even disgust, to varying degrees. Some recent evidence supports this contention [e.g., Chinn & Hasell, 2021; Inbar et al., 2025; Siegrist et al., 2018; Siegrist & Hartmann, 2020; Tenbült et al., 2005].

For example, previous research has found that GMO skepticism is at least partially elicited by disgust responses related to contamination brought on by genetic modification [Chinn & Hasell, 2021] and beliefs that genetic engineering is inherently a moral violation of natural cultivation processes [Inbar et al., 2025]. Other work suggests that GMO acceptance is contingent on the perceived naturalness of different types of GM food [Tenbült et al., 2005] and an individual's priorities regarding naturalness and healthiness of foods they consume [Hallman et al., 2003].

Given that opposition to GMOs may be fostered by these unconscious, often biologically driven assumptions and emotions, one potentially effective strategy to counter these intuitively negative attitudes is the inclusion of cues in the messaging that would maximize its biologically persuasive value. Visual food cues, for example, are thought to automatically increase activation in the appetitive motivational system, subsequently increasing approach and positive emotional responses [Bailey, 2015, 2017; Bradley et al., 2001]. Thus, these cues may increase appetitive responses toward GMO foods, which would translate into more positive attitudes, even toward attitudinal objects already perceived negatively.

Further, evidence suggests that creating this type of attitudinal ambivalence in individuals will affect their behavioral intentions [see Conner & Armitage, 2008]. Ambivalence, or the state of holding conflicting attitudes regarding an attitudinal object, is likely to be experienced when individuals simultaneously experience both positive and negative reactions in response to an attitude object [Song & Ewoldsen, 2015]. Thus, messages that evoke both positive and negative responses are more likely to create ambivalence. If visual food cues automatically activate appetitive motivation, resulting in positive reactions, the inclusion of a coactive food cue (a simultaneously appetitive and aversive cue) may create more ambivalence. For example, a food cue that also indicates the "unnaturalness" of the food (e.g., images of foods in Petri dishes, foods injected with hypodermic needles) could be considered coactive. These depictions of GMO foods are often used in messaging [Siegrist & Hartmann, 2020].

In this paper, we examine whether the inclusion of appetitive visual food cues (versus no food cues and coactive visual food cues) in a pro-GMO message can affect perceptions of these products. First, we examine whether these food cues have a direct influence on behavioral intentions post-message exposure. Second, we examine whether these messages

increase or decrease people's level of potential and felt ambivalence regarding GMOs. We also examine a mediation model in which these increases or decreases in ambivalence lead to changes in behavioral intentions to avoid GMOs.

1 ▪ Food cues as a persuasive strategy

Previous research suggests that individuals' attention is biased toward food and food-related stimuli. For example, visual food cues have been found to be detected and recognized faster than non-food cues [Morris & Dolan, 2001], and high-reward food (i.e., high-fat content) is detected faster than low-reward food [Harrar et al., 2011]. From a motivated attention perspective, this is explained by the motivational relevance of food [Bradley et al., 2001; Lang et al., 1997]. Food is a primary appetitive motivator as it serves the purpose of furthering the biological imperative of surviving and passing on genetic information [Bradley et al., 2001]. Motivation is thought to be modulated by activation in two motivational systems, the appetitive and the aversive [Bradley et al., 2001; Lang et al., 1997]. When encountering stimuli that present opportunities for biological success (e.g., food, sexual stimuli), appetitive activation increases, creating greater approach tendencies, greater attention, more positive emotional responses, and more positive attitudes. Conversely, when encountering stimuli that present threats to biological success (e.g., danger, noxious stimuli), aversive activation increases, creating avoidance tendencies and negative emotional responses [Bradley et al., 2001; Lang et al., 1997].

Thus, when encountering food stimuli, including visual food cues, appetitive activation automatically increases, elevating positive evaluations and attitudes [Bailey, 2015, 2017; Bradley et al., 2001], though this may be modulated by trait and state individual differences [e.g., Stoeckel et al., 2007]. In food marketing contexts, visual food cues being present increased positive attitudes toward products and advertisements; but potentially more important, the foods with visual cues were selected for eating more often and more quickly, and they were rated as healthier than those not visually depicted [Bailey, 2015, 2017; Bailey & Muldrow, 2019].

However, responses to food cues are very sensitive to indications of contamination or disease. Some evidence suggests that visual cues of contaminated or spoiled food elicit speedy identification (as early as 100 ms), avoidance, and negative emotional responses [Becker et al., 2016; Bradley et al., 2001]. Further, some research has indicated that perceived unnaturalness of food technologies (e.g., cultured meat) also increases disgust responses and decreases willingness to consume these products [Chinn & Hasell, 2021; Siegrist et al., 2018; Siegrist & Hartmann, 2020]. Scholars recommended, based on these findings, that the technologies behind the foods not be emphasized in messaging to lower perceptions of unnaturalness and evoked disgust; rather, the recommendations were to emphasize the similarity of GMO foods to "natural" foods [Siegrist & Hartmann, 2020]. Thus, if a visual food cue that would otherwise be viewed as "natural" is paired with an unnatural cue (e.g., hypodermic needle, Petri dish), this may simultaneously evoke both appetitive and aversive responses, with the aversive cue potentially being more activating due to the negativity bias [Bradley et al., 2001]. As this research suggests, pairing a message about GMOs with a positive food cue should result in people being more willing to purchase GMOs. By contrast, the coactive cue (positive and negative) should result in people being more likely to avoid purchasing GMOs. Thus, we predict:

H1: a) A positive food cue message will decrease behavioral intentions to avoid GMOs, while b) the coactive cue message will increase people's behavioral intentions to avoid GMOs.

2 ▪ Food cue effects on attitudinal ambivalence

One potentially important variable that could help explain why certain messages will lead to higher or lower levels of behavioral intentions regarding GMOs is people's level of attitudinal ambivalence. Generally speaking, scholars have described ambivalence as the state of holding conflicting attitudes regarding an attitudinal object. For example, Kaplan [1972] stated that ambivalence increases with polarization of positive and negative judgments. Later, Eagly and Chaiken [1993] defined ambivalence as the extent to which the evaluation of one's beliefs about an attitude-object is inconsistent or contradictory. Drawing from Eagly and Chaiken [1993], the meta-cognitive model [MCM; Petty et al., 2007] suggests that an individual's attitude is a function of both deliberate (explicit) and automatic (implicit) evaluations of an attitude-object, which are further tagged and validated for precision. More recently, Song and Ewoldsen [2015] re-evaluated the MCM [Petty et al., 2007] to propose that "a global attitude object is linked to its subordinate belief (attributes of an object) within one's mental structure, with varying degrees of accessibility of such beliefs" [Song & Ewoldsen, 2015, p. 29]. Thus, ambivalence is a 'state' or a momentary situation that emerges from inconsistent or differently accessible attitudes.

The extant research on ambivalence has pulled apart different aspects of ambivalence to better understand this concept. Specifically, scholars have noted that there are two main types of ambivalence: potential and felt [Armitage & Arden, 2007; Newby-Clark et al., 2002]. Potential ambivalence is typically tied to the definition outlined above, where people hold conflicting evaluations of an attitudinal object [Conner & Armitage, 2008]. This state of holding conflicting views can manifest itself in people feeling psychological discomfort associated with holding these conflicting views, which is typically referred to as felt ambivalence [Armitage & Arden, 2007]. The literature suggests that people can hold conflicting views, but situational factors, such as the need to make a decision, can result in psychological discomfort that they must resolve, similar to the feelings associated with cognitive dissonance [van Harreveld et al., 2009].

Social psychologists, political scientists, and communication scholars have spent time examining the factors that are associated with higher levels of potential ambivalence. For example, scholars have noted the conflicting values often manifest as people holding ambivalent attitudes [Craig & Martinez, 2005a, 2005b]. In this sense, people may end up holding ambivalent attitudes because they place value on personal freedom but also see government regulations encouraging people to engage in specific behaviors as necessary. In this sense, people would likely hold ambivalent attitudes about the policy of interest.

Scholars have also examined the ways that message factors can create higher levels of ambivalence. For example, the literature on message-sidedness has revealed that one-sided and two-sided messages (i.e., if one or two issue positions are presented) have different effects on persuasiveness and credibility of messages, especially when the two-sided message is refutational in nature (i.e., refutes common counterarguments) [Cornelis et al., 2020; O'Keefe, 1999]. Though refutational two-sided messages are considered more effective [O'Keefe, 1999], recent work has indicated that when opposing information or

competing positions are presented without refutation, it tends to increase people's level of ambivalence and decrease their intentions to engage in a behavior [Chang, 2013; Cornelis et al., 2020].

This finding is supported by other literature regarding the influences of conflicting cues. Several studies have shown the ways that conflicting cues can increase people's reports of mixed feelings [Hunter et al., 2008; Larsen et al., 2004; Schimmack & Colcombe, 2007] and level of attitudinal ambivalence [Keele & Wolak, 2008]. These findings lead us to propose that coactive cues, which include conflicting content (i.e., both a ripe, shiny apple and a hypodermic needle sticking in it), could increase levels of potential ambivalence compared to cues that only highlight the positive aspects of GMOs and don't refute the negative information. Thus, we believe that the positive elements of the food cue message will decrease ambivalence, while the addition of negative elements signaling the food's unnaturalness will result in higher levels of ambivalence. Therefore, we propose the following:

H2: The coactive cue will lead to higher levels of potential ambivalence compared to the control or the positive cue conditions.

3 ▪ Message factors, pre-existing beliefs, and potential ambivalence

In addition to examining the main effects of these messages on ambivalence, we also examine whether these effects vary based on people's existing views regarding GMOs. The communication research that has examined the effects of messages on ambivalence has not only shown that two-sided messages can increase ambivalence, but that messages that challenge or support people's extant views can affect levels of ambivalence. In general, there are consistent findings indicating that consuming supportive information tends to be associated with lower levels of attitudinal ambivalence [Huckfeldt et al., 2004; Mutz, 2006], while consuming opposing information can increase ambivalence [Huckfeldt et al., 2004; Keele & Wolak, 2008; Mutz, 2006; Priester & Petty, 2001]. Survey studies have shown that the correlations between different types of media use and ambivalence vary by whether the information supports or opposes people's extant views [Hmielowski & Nisbet, 2016; Kim & Hyun, 2017]. For instance, conservative media, which is supportive of conservative positions, tends to be associated with lower levels of ambivalence among individuals identifying themselves as conservatives [Hmielowski & Nisbet, 2016]. By contrast, use of this same information is associated with higher levels of ambivalence among liberals who view this content as challenging their extant views [Hmielowski & Nisbet, 2016]. In addition to the effects of supportive and opposing information, research has also shown that even when people are exposed to non-refutational two-sided arguments about neutral products, they are more likely to report holding conflicting views [Cornelis et al., 2020]. In essence, when people tend to hold relatively neutral or uncertain attitudes, they are more likely to report holding conflicting attitudes when they encounter conflicting information in a message that does not provide counterargument refutations [Cornelis et al., 2020]. Based on the information presented in this section of the paper, we propose the following:

H3: The effects of the messages on ambivalence will vary based on people's pre-existing views regarding GMOs. Specifically, we propose that a) the positive cue message will decrease ambivalence among supporters of GMOs and b) increase it among skeptics,

while the coactive cue message will c) increase ambivalence among those who are uncertain about GMOs.

4 ▪ Effects of ambivalence

As discussed above, scholars have differentiated two types of ambivalence: potential and felt [Armitage & Arden, 2007; Newby-Clark et al., 2002; Priester & Petty, 1996]. In general, scholars have predicted that potential ambivalence would serve as a precursor to felt ambivalence, with empirical work showing a consistent relationship between the two variables [Armitage & Arden, 2007; Newby-Clark et al., 2002; Ng et al., 2023]. Indeed, some scholars have proposed that potential ambivalence becomes felt ambivalence when a choice must be made [van Harreveld et al., 2015]. This is because felt ambivalence has been shown to mediate the relationship between potential ambivalence and behavioral intentions [Costarelli & Colloca, 2004; DeMarree et al., 2014].

Because ambivalent attitudes are potentially weak or not strongly held, they are often less predictive of behavioral intentions than univalent attitudes [see Armitage & Conner, 2004, for a discussion]. Strong attitudes are more likely to predict behaviors [Krosnick & Petty, 1995]. Both potential [e.g., Armitage & Conner, 2000] and felt ambivalence [e.g., Costarelli & Colloca, 2004; Berndsen & van der Pligt, 2004; Kim & Um, 2016] have been associated with lower behavioral intentions. Thus, as a whole, the literature up to this point outlines a moderated mediation model in which messages increase or decrease potential ambivalence among certain segments of the population. These increases or decreases in ambivalence are then associated with higher or lower levels of intentions to avoid GMOs. Therefore, we propose that different types of food cue images in positive GMO messaging will have different effects on ambivalence and evaluations, leading to different intentions to avoid GMOs among supporters, skeptics, and those uncertain about GMOs. We propose the following:

H4: Potential ambivalence will be associated with higher levels of felt ambivalence.

H5: There will be a negative relationship between felt ambivalence and behavioral intentions, with higher levels of felt ambivalence associated with lower intentions to purchase GMO food products.

H6: There will be conditional indirect effects of our message through ambivalence on behavioral intentions, with the a) positive cue message decreasing behavioral intentions to avoid GMOs among supporters and b) increasing intentions to avoid among skeptics, while the coactive cue message will c) decrease engagement among those uncertain about GMOs.

5 ▪ Methods

5.1 ▪ *Experimental design*

A 3 (article cue: positive ($N = 326$), coactive ($N = 327$), no cue ($N = 328$)) fully between-subjects design that included a 3-level moderator (pre-existing GMO attitude: supportive, skeptical, unsure) was used.

5.2 ▪ *Independent variable*

Article cue. Participants were asked to read a brief news-style story that presented the positive aspects of GMO foods, but the type of cue included varied: positive, coactive, or no cue. The positive cue was a picture of a ripe red apple. The coactive cue was the same picture of the apple, edited to also include a syringe with green liquid appearing to be injected into the apple. A no-image cue condition was also included as a control condition. The cues were included with the article in the same place (top right) across conditions.

A pretest indicated that this article was indeed viewed as GMO-positive. Using the Prolific platform, ($N = 100$) participants were asked on a bipolar scale how negative (1) or positive (5) the issues of GMOs were portrayed in the story ($M = 4.27$ $SD = .802$). Cues were also pretested. Four types of un-branded food (apple, corn, broccoli, and cheeseburger) were pretested. For each food type, the positive cue was an image of the food on a white background, and the coactive cue was the same image with the addition of a syringe containing green liquid, which appeared to be injected into the food. Each was presented in a within-subjects pretest that measured how positive and how negative individuals felt while viewing the images on separate 7-point scales. The foods did not differ in how positive, $F(3,297) = 1.39$, $p = .246$, or how negative, $F(3,297) = .514$, $p = .673$, they were rated. However, apples were selected as the cue in this study as they removed issues of eating preferences (e.g., vegetarianism) and maximized the positivity and negativity rating disparities between cues. The positive apple cue was rated as significantly more positive ($M = 5.17$, $SD = 1.724$) than the coactive cue ($M = 3.32$, $SD = 2.160$), $t(99) = 7.273$, $p < .001$. The coactive apple cue was rated as significantly more negative ($M = 5.10$, $SD = 1.772$) than the positive cue ($M = 3.48$, $SD = 2.240$), $t(99) = 5.498$, $p < .001$.

To confirm whether the randomization procedure was successful, one-way ANOVAs were used. No condition differences were found for political ideology and engagement variables, including political ideology $F(2,993) = 1.15$, $p = .32$, economic ideology $F(2,994) = 0.13$, $p = .88$, social ideology $F(2,986) = 0.44$, $p = .65$, and political interest $F(2,997) = 0.157$, $p = .85$. Chi-square tests likewise indicated no condition differences for gender ($p = .70$), race or ethnicity ($p = .77$), education ($p = .67$), marital status ($p = .35$), family income ($p = .75$), and presence of children under 18 in the household ($p = .44$).

5.3 ▪ *Measures*

Pre-existing GMO attitudes. GMO attitudes were collected using a single-item measure: "Do you think it is generally safe or unsafe to eat genetically modified or bioengineered foods, or do you not know enough about this to say?" The three possible responses were: (1) generally safe ($N = 331$), (2) generally unsafe ($N = 241$), and (3) don't know enough to say ($N = 403$). Generally safe responders were treated as supportive, while generally unsafe responders were treated as skeptical, and those who don't know enough were treated as unsure.

5.4 ▪ *Dependent variables*

Potential ambivalence. Potential ambivalence was measured using a bivariate approach. Positivity was assessed by asking how positive/pleased/happy they felt about GMO foods

after reading the article on a 7-point scale. Negativity was assessed by asking how negative/displeased/unhappy they felt about GMO foods after reading the article on a 7-point scale. The "Griffin formula" was used to compute potential ambivalence as proposed by Thompson et al. [1995] ($M = 1.38$, $SD = 2.30$):

$$\text{Ambivalence} = \left[\frac{(P+N)}{2}\right] - |P-N| \tag{1}$$

Felt ambivalence. Felt ambivalence was measured using the 3-item measure originally created by Priester and Petty [1996]. The three items ask to what extent participants felt (1) conflicted, (2) undecided, and (3) mixed feelings toward GMOs, on a 7-point scale from 1 (not at all) to 7 (extremely). An index was formed by creating an average of the items ($M = 3.55$, $SD = 2.30$, $\alpha = .69$).

5.5 ▪ *Behavioral intentions to avoid GMOs*

Intentions to use or avoid GMOs were measured using a 6-item subset of the GMO attitude scale developed by McPhetres et al. [2019]. The original version was an 11-item scale of GMO attitudes that included items focusing on behavioral intentions but also on positions regarding government regulation and corporate development of GMOs. This scale was developed and used in a series of studies across the U.S. and Europe and was highly internally consistent (αs = .93–.96). As we were interested in behavioral intentions, six items of the original 11 were used: "I check to make sure that the food I buy has not been genetically modified"; I would never eat genetically modified food"; "I prefer to shop at places that I know do not sell genetically modified foods"; "I don't really mind if the food I eat has been genetically modified or not" (reverse coded); "It does not really matter to me whether the food I buy has been genetically modified" (reverse coded); and "I would be okay giving genetically modified food to my family members" (reverse coded). An index was formed by creating an average of the items ($M = 2.42$, $SD = 1.61$, $\alpha = .94$). Higher scores indicate more behavioral avoidance.

5.6 ▪ *Sample*

Data were collected by the sampling firm, YouGov. YouGov utilizes a sample-matching procedure, wherein they initially oversample and then create a final sample that matches national population characteristics. To create the final sample, a sampling frame was generated using benchmarks from large, high-quality probability samples. YouGov's sample matching procedure has been empirically compared to random sampling procedures and was found to exhibit little to no selection bias [Ansolabehere & Schaffner, 2014]. Participants ($N = 1000$) were sample-matched using frames that matched respondents on gender, age, race, education, party identification, ideology, political interest, voter registration, and voter turnout. After removing missing data, $N = 981$ respondents were included in the final analyses. Participants in the final sample have an average age of 49.92 ($SD = 17.37$); among them, 52.7% are women and 1.5% are either non-binary or prefer not to answer; 33% have a 4-year college, college equivalent, or higher level of education. Among all the participants, 68.1% are White, 11.5% are Black, and 12.1.% identify as Hispanics or Latino/as, 2.6% as Asians, .8% as Native Americans, .4%. as Middle Eastern, 2% as mixed race, and 2.6% as

others. Politically, 49% lean or identify as Democrats, 19.3% identify as Independent, and 28.8% lean or identify as Republicans. A priori power analysis indicates that to adequately power (.9) a 3×3 between-subjects *F*-test using an alpha of .05 and a small effect size (.15), 847 participants were required.

5.7 ▪ *Procedure*

Participants completed the study online via the YouGov platform. After completing informed consent, participants answered questions about their trust in institutions and their values in decision-making. Next, participants were randomly assigned to read the stimulus article under one of the three cue conditions (no cue, positive cue, or coactive cue). After reading the story, they answered the attitudinal ambivalence questions. Participants always answered the potential ambivalence questions first, followed by the felt ambivalence questions. Then, participants answered questions about the desirability and likelihood of the potential consequences of GMO development and utilization, general GMO attitudes, and demographics, including political orientation and religiosity. All participants successfully answered an attention check question. The entire procedure was approximately 10 minutes. The protocol was approved by the University of Florida Institutional Review Board.

5.8 ▪ *Data analysis*

Data were analyzed using ANOVA and OLS regression. To test our main effects, we utilized one-way ANOVA to examine the effects of our conditions on potential ambivalence and behavioral intentions. To assess our interaction, we utilized model 1 with the process macro [Hayes, 2013]. Use of the macro allowed us to probe the interaction to assess which individuals were affected by the different messages. Finally, we utilized the process macro model 83 to assess our proposed moderated mediation model. This model allowed us to assess the conditional indirect effects of our messages on our primary outcome of interest. Point estimates and 95% confidence intervals are reported.

6 ▪ Results

6.1 ▪ *Message cue effects*

Hypothesis 1 predicted an effect of our messages on people's intentions to avoid GMOs. The results from a one-way ANOVA found partial support for H1. We predicted that the positive food cue would decrease intentions to avoid GMOs and the coactive cue message would increase intentions to avoid GMOs. Overall, our model revealed that the message condition had a small but significant effect on intentions to avoid GMOs, $F(2,978) = 4.72$, $p = 0.01$, $\eta^2 = 0.01$. However, the results of a post-hoc analysis using the Games-Howell method only found that the positive food cue condition ($M = 2.21$, $SD = 1.60$) decreased intentions to avoid GMOs compared to the control condition ($M = 2.59$, $SD = 1.60$). These findings did not reveal that the coactive message increased people's intentions to avoid GMOs ($M = 2.45$, $SD = 1.61$). Therefore, we only found support for H1a (see Table 1).

Hypothesis 2 predicted message cue effects on potential ambivalence. The one-way ANOVA did not reveal any differences between the cue conditions in terms of potential ambivalence, $F(2,978) = 0.53$, $p = 0.59$. Therefore, we did not find any support for H2 (see Table 1).

Table 1. ANOVA table for avoidance of GMOs and potential ambivalence.

	Avoid GMOs					
	Sum of squares	*df*	*Mean square*	*Calculated F-ratio*	*p*	*Eta*^{2}
Between groups	24.31	2	12.15	4.72	0.009	0.010
Within groups	2516.11	978	2.57			
Total	2540.42	980				
	Ambivalence					
Between groups	5.59	2	2.80	0.53	0.529	0.001
Within groups	5167.98	978	5.28			
Total	5173.57	980				

Table 2. Regression model for condition by GMO attitudes.

	Potential ambivalence
Positive vs. Control	0.103 (0.274)
Mixed vs. Control	0.168 (0.270)
Support GMO	-0.400 (0.290)
Oppose GMO	-1.13*** (0.308)
Positive X Support	-0.841* (0.406)
Positive X Oppose	0.306 (0.445)
Mixed X Support	-0.967** (0.407)
Mixed X Oppose	-0.146 (0.442)
R^2	0.009^{+}

Note: cell entries are unstandardized coefficients with standard errors in parentheses.
$^{+}$ p = .05, * p < .05, ** p < .01, *** p < .001.

Hypothesis 3 proposed conditional effects of message cues on potential ambivalence. Specifically, we proposed that the positive cue would decrease ambivalence among individuals who are supportive of GMOs (H3a) and increase it among skeptics (H3b), while the coactive message would increase ambivalence among those who are uncertain about GMOs (H3c). Utilizing model 1 in the process macro, overall interaction between message cue and prior GMO attitude was not statistically significant, $F(8,972) = 2.38$, $p = 0.50$, $R^2 = 0.01$ (see Table 2). Given theoretical interest, we examined simple effects descriptively. When probing the interaction shown in Figure 1, we found that the positive food cue ($M = 0.77$, $d = .28$) and the coactive cue ($M = 0.71$, $d = .32$) decreased potential ambivalence among individuals who were supportive of GMOs ($F(8,972) = 4.28$, $p = 0.01$) compared to the control condition ($M = 1.51$). Among GMO supporters, message cues were associated with lower

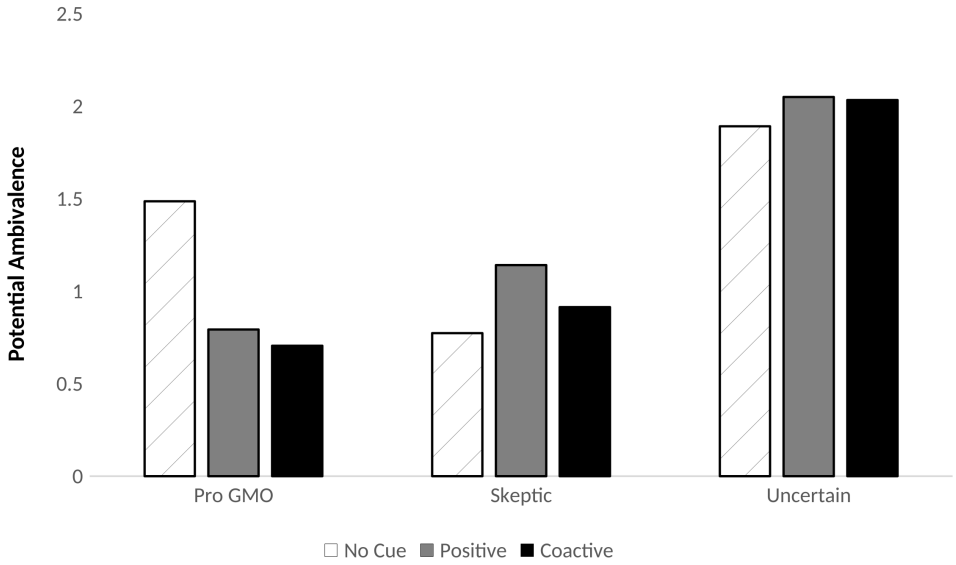

Figure 1. Potential ambivalence as a function of message cue and existing attitude.

ambivalence. The cues did not significantly influence skeptics or those who were uncertain. Hence, H3b and H3c were not supported.

6.2 ▪ *Relationships between potential and felt ambivalence and behavioral intentions*

H4 predicted a correlation between potential and felt ambivalence, and H5 predicted a correlation between felt ambivalence and behavioral intentions. In terms of H4, our correlation analysis did indeed find that higher levels of potential ambivalence were associated with higher levels of felt ambivalence ($r = 0.36$, $p < 0.001$). We also found that the higher levels of felt ambivalence were associated with being more likely to avoid GMOs ($r = 0.47$, $p < 0.001$).

Finally, we examined the full moderated mediation model that examined the conditional indirect effects of the message cues on behavioral intentions through potential and felt ambivalence. Overall, we found support for H6a. Specifically, the effect of the positive food cue message decreased potential ambivalence among individuals who were already supportive of GMOs. This decrease in potential ambivalence was then associated with lower levels of felt ambivalence, which corresponded with respondents being less likely to avoid GMOs. Overall, the index of moderated mediation suggests that the indirect effect for the positive message through our intervening variables by people's extant attitudes about GMOs is significant ($b = -0.11$ [95% CI = -0.23–0.00]). Specifically, the results showed a statistically significant indirect effect for individuals in the positive food message among supporters of GMOs through our two intervening variables ($b = -0.10$ [95% CI = -0.19–0.01]). However, this was the only conditional indirect effect we found. We did not find that positive message cues affected skeptics in the expected direction (H6b), and we did not find that the coactive message affected those uncertain about GMOs in the expected direction (H6c). Therefore, our results suggest that, among individuals already supportive of GMOs, exposure to the positive cue message was associated with lower potential and felt ambivalence.

7 ▪ Discussion

In this study, we aimed to examine the effects of food cues in messages. Overall, our results found some evidence that certain cues could lead to changes in people's attitudes and behavioral intentions regarding GMOs. First, our findings revealed that the positive food cue message resulted in people being less likely to avoid GMOs. Second, positive food cue messages decreased potential ambivalence among individuals who generally supported GMOs. We also found that these lower levels of potential ambivalence were then associated with lower levels of felt ambivalence resulting in a lower tendency to avoid GMOs. In sum, we only found that the positive food cue had any effect in the expected direction on our outcomes of interest, and only for GMO supporters. While this is interesting and potentially useful from a messaging standpoint, supporters are not the target of pro-GMO messaging.

Despite small effects outside of the target, these results can become practically meaningful when applied at scale. In public health and science communication contexts, even modest attitude shifts within a supportive segment may have value, especially when those individuals act as message disseminators and influencers in online or interpersonal settings. Strengthening supportive attitudes can also reduce susceptibility to future persuasion attempts, depending on the importance of the attitude to the individual and the social context [Fransen et al., 2015]. Thus, our findings offer insights for refining audience segmentation and targeting strategies within GMO communication campaigns.

However, though we did not find support for many of our hypotheses about skeptics and uncertain people, the pattern of results is intriguing. Exploratory analyses, including examinations of component measures of potential ambivalence (separate positivity and negativity ratings), as shown in Figure 2, suggest three things. First, as would be expected, supporters and skeptics are clearly influenced by their existing attitudes (strong in one direction, weak in the other); however, uncertain individuals are more evenly divided, reporting both positive and negative views regarding GMOs.

Second, the addition of the hypodermic needle to the positive food cue was not particularly strong as a coactive cue. This issue is highlighted when looking at reactions for people with

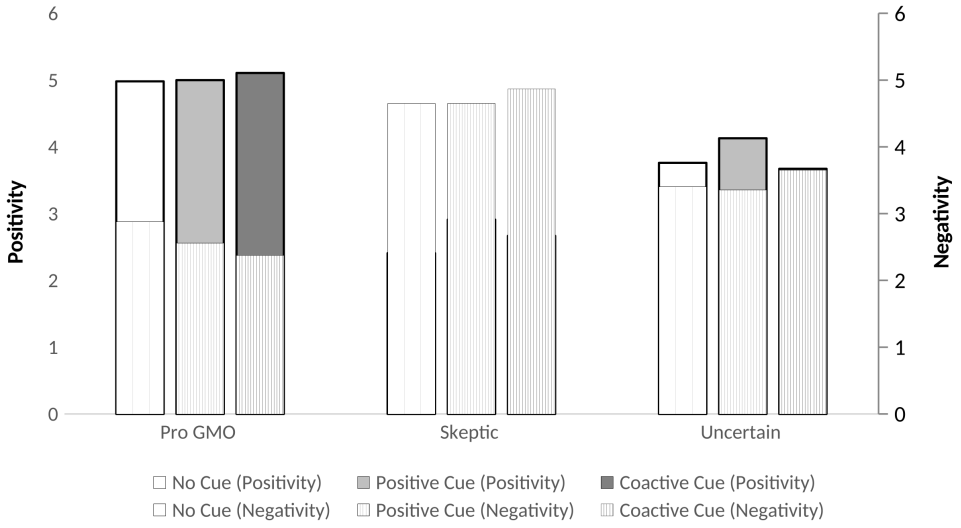

Figure 2. Positivity and negativity ratings as a function of message cue and existing attitude.

different views of GMOs. For the supporters, the coactive cue was just as positive as the positive cue, and interestingly, less negative than no cue at all. In fact, either cue significantly decreased negativity ratings for the supporters, $F(1,337) = 4.58$, $p = .03$. Additionally, the skeptics and uncertain individuals showed no difference in negativity ratings for the positive and coactive cues. This can be explained by considering a key difference of this research from previous work: most research looking at competing cues in a message typically includes opposing arguments within the text of the message. In our case, we had positive cues within the text, and the negative cue was part of the image. Hence, we have arguments in images and text on one side (positive) and only as part of an image on the other side (negative). It could have been that the image included was not enough of a counter to the content within the text of the message.

Lastly, the positive cue *did* significantly increase positivity ratings among the skeptics and those who reported uncertain views regarding GMOs, $F(1,432) = 8.00$, $p = .01$. This suggests a directional increase in potential ambivalence for skeptics and those who are uncertain about GMOs (see Figure 1), although this difference did not reach statistical significance. We also see that the coactive cue significantly decreased positivity ratings of skeptics and uncertain people compared to the positive cue ratings, $F(1,425) = 5.75$, $p = .02$. This lends support to the recommendations of those investigating the "unnaturalness" effects of GMO's [Siegrist & Hartmann, 2020]; hinting at unnaturalness with the hypodermic needle decreased positivity among the individuals that these messages are trying to reach. Interestingly, all of the differences were within the positive/appetitive motivation system, not the negative/aversive. Motivation is complex and multifaceted, and while we can tie the simplest motivations back to evolutionary pressures, the development of more advanced motivations may not be directly derived from more basic ones [Baumeister, 2016]. The imagery used in this study seems to have only made a primary motivator (i.e., food) less appetitive rather than coactive (i.e., both positive and negative). This may mean that the addition of the syringe wasn't seen as a threat to the individual that would independently activate the aversive system, but rather just an attribute of the food itself. If this is the case, the syringe would be more likely to operate on more advanced motivations like social acceptance and affiliation with like-minded individuals (e.g., the supporters rating the "coactive" cue less negative than the control condition).

Potentially, these three takeaways mean that if the food cues can be amplified (to be more appetitive), possibly through greater energy density or other factors we know increase appetitive activation [Bailey et al., 2021; Rolls, 2017], attitudes for skeptics and uncertain individuals could be pushed toward greater ambivalence. Why is that important, especially if ambivalence typically means less likelihood to adopt behaviors? Some evidence suggests that ambivalence can shift attitudes by increasing discomfort and the subsequent likelihood that systematic elaboration will take place to resolve the discomfort associated with holding these opposing views [Jonas et al., 1997]. If these cues can be paired with messages that are also known to create more systematic processing and, therefore, be more effective (e.g., two-sided refutational messages), more stable attitude shifts might occur. This type of two-sided message is also known to reduce reactance [Cornelis et al., 2020]. Thus, future research should examine the effectiveness of this message cue and type combination.

In particular, these findings can inform media design on digital platforms. For example, on social media platforms such as Instagram or TikTok where visual cues dominate, our results imply that food-centric imagery without overt "lab" associations may foster less avoidance and more positivity among GMO supporters. Communication professionals can apply these

insights to minimize negative heuristics tied to unnaturalness while promoting more favorable consumer engagement. Thus, our findings may help build an evidence base for cue-based message strategies that can be refined through further research and deployed strategically in public-facing GMO campaigns.

As with any research, there are strengths and weaknesses associated with our study. In terms of strengths, our study utilized higher-quality data that attempts to match the population characteristics of people living in the U.S. Indeed, the use of YouGov for our study means we have a more representative data set that comes closer to a probability sample than a sample using students or a quota sample. While we consider this a strength of our study, GMO ingredients are common in the U.S. food supply, are more widely accepted, and are differently regulated compared to other parts of the world. Results should be interpreted within this context. Effects may differ in countries with alternative regulatory regimes and cultural views. Replication with non-U.S. samples would test the boundary conditions for these findings.

Another strength of our study is that we utilized an experimental design to test our hypotheses. The use of an experimental design that includes random assignment to groups increases the internal validity of our findings and provides some evidence that our messages could be causing changes to our outcomes of interest, which was the primary purpose of this investigation. With this in mind, we did not include control variables in our models, including factors that are known to be influential in this context, such as trust in science and regulatory agencies [e.g., Hanssen et al., 2018], scientific literacy [e.g., Wunderlich & Gatto, 2015] and attitude certainty [e.g., Cheatham & Tormala, 2017], as well as factors that are influential in food acceptance in general such as satiation of participants [e.g., Otterbring et al., 2023]. Though we report tests that support the success of our randomization procedure above, bolstering the confidence in our data interpretations regarding message effects, the contribution of these and other potentially influential variables may play an important role in understanding the mechanisms behind GMO acceptance. Although we do have statistically significant findings for some of our proposed hypotheses, the overall effects tied to our messages are small (i.e., 1% of variance explained). Future research should investigate whether these and other control variables could increase the explanatory power of similar investigations.

There were also other limitations to our research design. First, we chose to use only positive and coactive cues. We were interested in seeing if those who were skeptical or against GMO foods could be nudged with primary appetitive motivators. However, GMO food media commonly use hypodermic needles and other medical or lab visual cues in coalition with food cues to accompany their stories; thus, we examined what we called a coactive cue to capture this common occurrence. We did not use a purely negative cue. In part, this was because images that accompany media coverage of GMO foods typically contain food imagery, which is inherently appetitive. A purely aversive cue would necessarily omit food imagery, which would not be ecologically valid. Future research could examine how purely aversive cues function in this context to extend this work.

In terms of measurement, we used only a single-item measure of existing GMO support as a predictor in the statistical model. While some research has indicated that this methodology is adequate [e.g., Bergkvist & Rossiter, 2007; Gardner et al., 1998], a single item may not have ultimately captured important variance in GMO support. Lastly, given the cross-sectional design, causality beyond the effects of our messages on the outcomes

outlined in our mediation model cannot be examined. In other words, we cannot determine whether potential ambivalence causes felt ambivalence or if felt ambivalence causes changes to people's intentions to avoid GMOs.

In conclusion, although we did not find support for many of our hypotheses, we believe there is potential in this line of inquiry, as outlined above. Because GMO foods are intuitively violating the essential characteristics and origins of what humans understand to be food, utilizing biological-level appeals and cues may be particularly useful in altering those perceptions. In this paper, we took a first step toward trying to understand how the use of food cues in messages focused on GMO food could lead to specific persuasive outcomes.

Research transparency statement
The authors are willing to share their data, analytics methods, and study materials with other researchers. The material will be available upon request.

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