Journal of Applied Communications

Volume 106 | Issue 1 Article 1

Persuasive Effects of Metaphors Regarding Gene-Editing in Agriculture

Nellie Hill
Kansas State University

Courtney Meyers
Texas Tech University

Nan Li
University of Wisconsin-Madison

See next page for additional authors

Recommended Citation

Hill, Nellie; Meyers, Courtney; Li, Nan; Doerfert, David L.; and Mendu, Venugopal (2022) "Persuasive Effects of Metaphors Regarding Gene-Editing in Agriculture," *Journal of Applied Communications*: Vol. 106: Iss. 1. https://doi.org/10.4148/1051-0834.2416

Persuasive Effects of Metaphors Regarding Gene-Editing in Agriculture

Abstract

Gene-editing provides an opportunity to address the significant challenges of population growth and climate change that impact food production. Given the important role of gene-editing in our food system, exploring opportunities to persuade public acceptance of the technology is needed. The purpose of this study was to investigate persuasive effects of metaphorical concepts regarding gene-editing in agriculture. The Elaboration Likelihood Model was used as the conceptual framework. Metaphors stand to influence public acceptance because metaphors encourage issue-relevant thinking and enhance persuasion. A quantitative, randomized, between-subjects, experimental research design was delivered via an online survey to a nationally representative sample of U.S. residents. The manipulation was four mock news articles differentiated by metaphorical concept for gene-editing in agriculture (creation versus text editor versus tool versus control). Even when controlling for confounding variables, the results indicated no significant differences between the treatments on issue-relevant thinking or willingness to share the article on social media. Future research should explore the impact of metaphorical concepts on attitude and other behavioral outcomes associated with elaboration.

Keywords

gene-editing, agriculture, persuasion, metaphors, experimental, elaboration likelihood model

Cover Page Footnote/Acknowledgements

The article was previously presented at the 2021 National AAAE Conference.

Authors

Nellie Hill, Courtney Meyers, Nan Li, David L. Doerfert, and Venugopal Mendu

Introduction/Literature Review

Gene-editing has been heralded as an innovation with the potential to address the most pressing challenges facing food production – population growth and climate change (Anders et al., 2021; Lenaerts et al., 2019; Llewellyn, 2018; Shew et al., 2018). Gene-editing is a group of technologies that gives scientists the ability to change a plant or animal's DNA. Using these technologies, genetic material can be added, removed, or altered at particular locations in the genome without the introduction of foreign genes into the organism (National Institutes of Health, 2020). Gene-editing allows novel improvements to plants and animals to come into production more quickly than using traditional breeding to achieve the same results (Llewellyn, 2018).

There is a gap between the advances in gene-editing technology and public acceptance of such innovations (Anders et al., 2021). For scientists to develop safe and efficient solutions to food scarcity with the additional pressures of a growing population and changing environment, they must have continuous communication with the public so as to positively influence acceptance of such solutions (Georges & Ray, 2017). This communication must promote public understanding of risks, benefits, goals, and means of science so as to combat misinformation (Georges & Ray, 2017). Public discussion of the merits of gene-editing applications in agriculture has only just begun. As products get closer to retail shelves, it is important for the public to have accessible information regarding the implications of the technology (Brossard, 2018).

The public often turns to mass media sources such as web-based versions of newspapers and popular magazines to form their opinions of agricultural biotechnology, including gene-editing (O'Keefe et al., 2015; Schäfer, 2017). How the news media frame biotechnology issues is reflected in the public's attitudes and beliefs about such scientific topics (Nisbet et al., 2002; Meraz, 2009; Ruan et al., 2019). Although people are knowledgeable about science, they have little direct experience with it (Kennedy & Hefferon, 2019). Individual deference to scientific authority can influence how people form opinions of agricultural biotechnology by way of "intervening orientation or behavior" (Brossard & Nisbet, 2007, p. 27). To gain an understanding of gene-editing technology, how it works, and current advancements in applications, lay citizens and decision-makers receive science information, sometimes exclusively, from news media (Marks et al., 2007; McCluskey et al., 2016; Scheufele, 2007). The perception of gene-editing technology created through media coverage affects how the topic is discussed among the public, in turn affecting public support, policy, and funding (Perrault & O'Keefe, 2019; Schäfer, 2017).

Mass media coverage of gene-editing links the scientific community with the general public to allow for the continuous flow of information needed to influence public acceptance of the technology (Georges & Ray, 2017). Scientists continue to find new ways to utilize gene-editing technology, which leads to greater prominence in discussion and debate (Molteni, 2019). While there is enthusiasm for the potential of gene-editing technologies, there is also concern. Societal, cultural, and ethical conversations surround the possible impacts of the technology (Brossard, 2018). Those conversations include public uncertainty regarding how genetically modified food and food enhanced by gene-editing differ as well as a lack of knowledge about how gene-editing works (Ishii & Araki, 2016; Lusk et al., 2018; Rainie, 2017). Public opinion of gene-editing in the United States has been studied by way of analysis of social media monitoring, surveys, and public opinion polls (Busch et al., 2021; Rose et al., 2020; Yabar et al., 2018). In their own way, each study called for continued investigation of effective public discourse about gene-editing.

Use of Metaphors to Explain Gene-editing

Scientists, science communicators, and journalists utilize metaphors to explain gene-editing in a manner that connects the everyday experiences of the audience with the complex and abstract science of gene-editing (O'Keefe et al., 2015; Taylor & Dewsbury, 2018). Steen et. al. (2010) found 16.4% of words used in news writing are metaphorical. Metaphors transfer the characteristics, relations, and operation of one familiar domain to an unfamiliar domain (Gentner, 1982). Metaphors present the novel in terms of the known. O'Keefe et al. (2015) found newspapers and magazines likened CRISPR technologies to the development of HTML webpage markup language in the news media and magazines. This comparison indicates a widely applicable, technological advance can change the world (O'Keefe et. al., 2015). As an important part of language, researchers call for "empirically-grounded research in critical discussions of metaphor use in the life sciences" (Taylor & Dewsbury, 2018, p. 3). Although previous research has identified common metaphors used to describe gene-editing, empirical studies testing the persuasive effects of these metaphorical concepts on receivers is lacking.

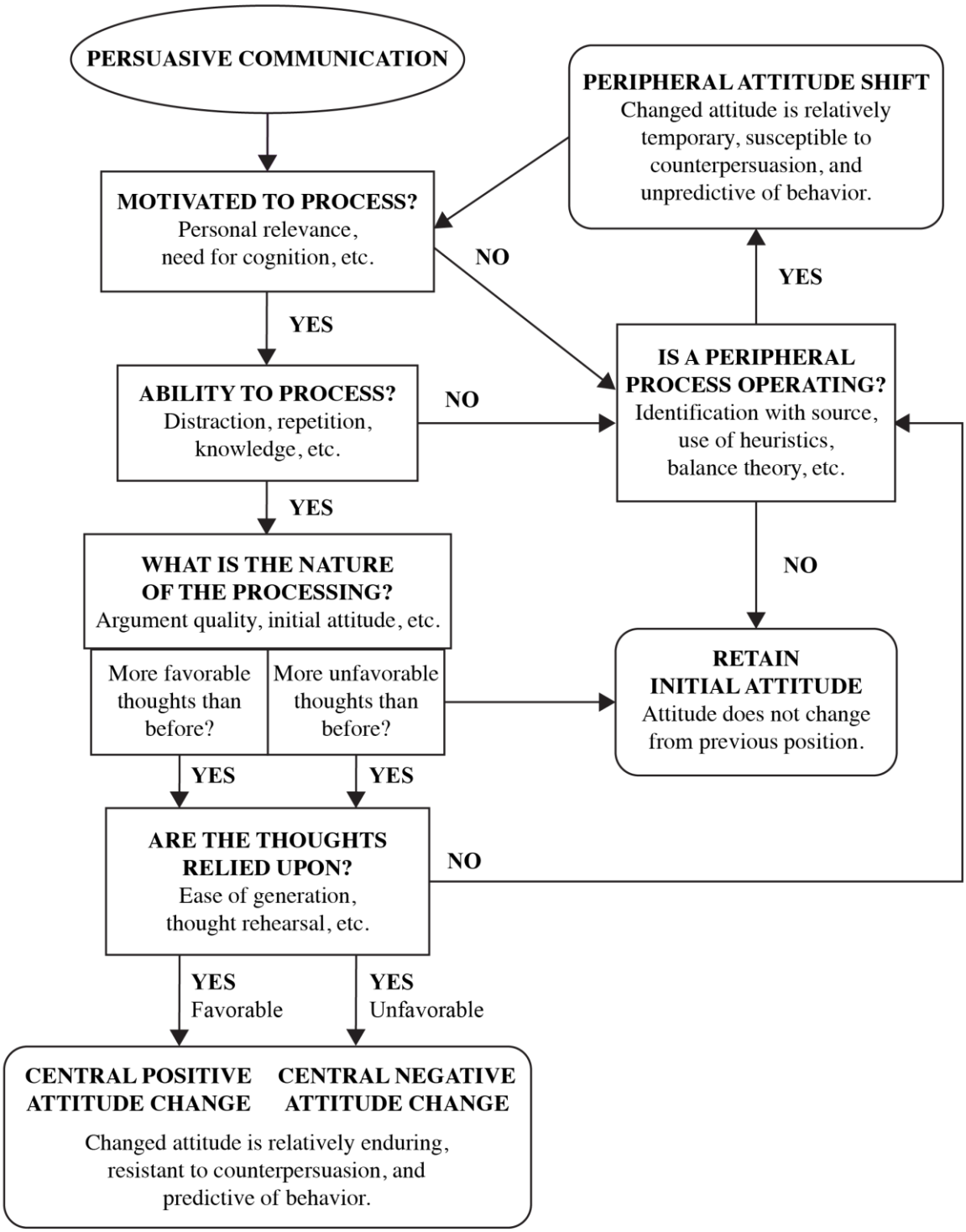
The utility of metaphors to communicate science is not without criticism (Taylor & Dewsbury, 2018). Executed poorly, metaphors can be imprecise, ambiguous, and misleading. The results can vary from proliferating public misunderstanding of science to exploitation of social and political agendas (Taylor & Dewsbury, 2018). For example, genetic engineering has been explained in terms of "blueprints" and "recipes", yet these metaphors have been criticized for representing static directions to a tangible product, oversimplifying complex interactions, and lacking a reflection of advancements in the field (Pigliucci & Boudry, 2011; Rose et al., 2020; Rothman, 2001; Taylor & Dewsbury, 2018). Nevertheless, metaphors hold promise for helping the public gain an understanding of science (Taylor & Dewsbury, 2018).

The future of agriculture is closely tied to agricultural products of gene-editing (Rose et al., 2020). Given the important role of gene-editing in our food system, exploring opportunities to persuade public acceptance of gene-editing technology is needed (Anders et al., 2021; Gupta et al., 2021). The news media, especially when publishing online, use metaphors to convey complex topics and connect the science community with the public (Marcon et al., 2019; Taylor & Dewsbury, 2018). The metaphors selected by news media affect public opinion (O'Keefe et al., 2015). Metaphorical messages cause more elaboration and persuasion than literal messages, but it is unknown which metaphors regarding gene-editing are most effective (O'Keefe et al., 2015; Sopory & Dillard, 2002; Van Stee, 2018). The persuasive effect of the different metaphors used to explain how gene-editing in agriculture works should be tested in the online news environment (Blasimme et al., 2015; Nelson et al., 2016; O'Keefe et al., 2015; Taylor & Dewsbury, 2018).

Conceptual Framework

The Elaboration Likelihood Model (Figure 1) formed the conceptual framework for this study. Metaphors stimulate thought because the message receiver uses a rich set of schemas to make connections between a familiar concept and an unfamiliar concept. The more connections are made, the greater the elaboration, and the greater the persuasive effects of the message (Sopory & Dillard, 2002; Petty & Cacioppo, 1986; Perloff, 2017; Wolff & Gentner, 2011). The Elaboration Likelihood Model refers to the extent and probability that an individual will consider a persuasive message (Petty & Wegener, 1999).

Figure 1
Elaboration Likelihood Model



Note. From "The Elaboration Likelihood Model: Current Status and Controversies" by R.E. Petty and D. T. Wegener (1999) in S. Chaiken and Y. Trope (Eds.), *Dual-Process Theories in Social Psychology* (pp. 41-72). Guilford.

Elaboration is "engaging in issue-relevant thinking" (O'Keefe, 2016, p. 149). Persuasion of an individual can be achieved through high elaboration using the central, systematic processing route or low elaboration using the peripheral, heuristic processing route (O'Keefe, 2016). High elaboration, characterized by deep cognitive consideration of a persuasive message, is more likely to achieve an attitude that predicts behavior, endures over time, and resists counter-persuasion (O'Keefe, 2016; Petty & Cacioppo, 1986; Perloff, 2017). Researchers have explored behavioral intentions and outcomes related to persuasive, metaphorical communications concerning topics in academics, advertising, health, and politics (Van Stee, 2018).

The use of the central versus peripheral processing routes is dependent on the motivation and ability of the message receiver (Petty & Cacioppo, 1986). The motivation of the receiver is determined by their personal involvement with the topic and need for cognition. As personal involvement, or the relevance of the topic to the receiver, increases so does the receiver's issue-relevant thinking regarding the message (O'Keefe, 2016; Petty et al., 1981). Need for cognition is "the tendency for an individual to engage in and enjoy thinking" (Cacioppo & Petty, 1982, p. 116). Those with a higher need for cognition have a greater motivation to elaborate when presented with a persuasive message (O'Keefe, 2016).

Ability to use the central processing route is determined by the amount of distraction and prior knowledge of the receiver. Distraction from a persuasive message inhibits issue-relevant thinking. COVID-19 coverage consumed much of the news media during the time of this study (Gottfriend et al., 2020) and may have been a distraction. The pandemic was found to have "profound impacts on the personal lives of Americans in a variety of ways" (Pew Research Center, 2020, para. 1).

Prior knowledge of the persuasive message topic is another determinate of the ability of a receiver to engage in elaboration. As prior knowledge increases, so does issue-relevant thinking. Ability and motivation combine to determine the degree of elaboration a receiver may engage in to process a persuasive message (O'Keefe, 2016).

How and what is said in a message also affects the elaboration and resulting persuasive effect of a message. The crafting of a message is concerned with three factors: structure, content, and language (Perloff, 2017). Metaphors are a message factor and a linguistic tool used to craft intense, powerful language that has been shown to be more persuasive than powerless language (Perloff, 2017; Sopory & Dillard, 2002). Metaphors demand cognitive elaboration (Ortony, 1979). Metaphors should lead to greater elaboration, which utilizes the central processing route by demanding cognitive, issue-relevant thinking (Sopory & Dillard, 2002).

Thought-listing is a method to measure individual elaboration. This technique is perceived as a private, non-threatening, and non-reactive means of gathering self-generated arguments without affecting reported behavior (Cacioppo & Petty, 1981). Thought-listing was carried out as recommended by Cacioppo and Petty (1981) in terms of topic instruction, time limits, and delivery post-stimuli. According to Cacioppo and Petty (1981), participants should be asked immediately after stimuli exposure to list all the thoughts they had while viewing the stimulus. This sequence is an effort to replicate as closely as possible the affective and cognitive responses present in everyday conditions (Cacioppo & Petty, 1981; Burnett et al., 2019).

Cacioppo and Petty (1981) stated the most consistent measure of coding thought-listing is using the polarity dimension of positive, neutral, or negative thoughts. It is important to note, though the researchers use the words positive, neutral, and negative, the code indicates the attitude of the thought as well as its relevance to the message (Cacioppo & Petty, 1981). Positive thoughts are those "in favor of the referent that mention specific desirable attributes or positive

associations, statements that support validity or value of situation/stimulus and statements of positive effect" (Cacioppo & Petty, 1981, p. 319). Neutral thoughts are those that "express no affect with regards to the referent," (Cacioppo & Petty, 1981, p. 319). Negative thoughts are those that, "mention specific undesirable attributes or negative associations, challenges to the validity of the stimulus or situation, and statements of negative affect" (Cacioppo & Petty, 1981, p. 319).

Researchers have explained the persuasive effects of metaphors in terms of garnering audience attention, source credibility, relief, reduced counterarguments, stimulated elaboration, superior organization, and resource matching (Van Stee, 2018). Sopory and Dillard (2002), as well as Van Stee (2018), conducted a meta-analytic review of the effects of metaphors on persuasion by analyzing pertinent studies published between 1983 and 2000 and 2001 to 2015, respectively. They found metaphorical language provides superior structure and organization to a message as well as increases receiver interest and concept associations in thoughts. This results in greater attitudinal change than a literal message (Sopory & Dillard, 2002). These characteristics of cognitive processing indicate metaphors can encourage the use of central processing to validate a message. In short, "metaphors enhance persuasion" (Sopory & Dillard, 2002, p. 382) more so than literal messages (Van Stee, 2018).

Purpose and Research Questions

The purpose of this study was to determine if there are persuasive effects of metaphorical concepts regarding gene-editing in agriculture. The following research questions guided the study:

RQ1: Does the metaphorical concept used to explain gene-editing applications in an agricultural context influence elaboration?

RQ2: Does the metaphorical concept used to explain gene-editing applications in an agricultural context influence willingness to share the information on social media?

Methodology

This study utilized a quantitative, randomized, between-subjects, experimental research design. This design is appropriate as it accounts for confounding variables to isolate the influence of the independent variable on the dependent variables. In addition, it supports investigating differences between groups and interpreting causal inferences (Ary et al., 2010). The manipulation was four mock news articles differentiated by metaphorical concept for gene-editing in agriculture (creation versus text editor versus tool versus control).

Instrumentation

Qualtrics, an online survey building and delivery platform, was used to construct and disseminate the instrument for this study to ensure the sample reflected U.S. adults in terms of gender, race, education, and region. Randomization of four stimuli were built into the survey instrument as well as attention checks to ensure participants were providing thoughtful responses. The individual difference variables measured were news consumption preferences, deference to scientific authority, factors affecting degree of elaboration, and coronavirus outbreak experience. The independent variable in the study was the metaphorical concept of

gene-editing in agriculture embedded in a mock news article stimulus. The dependent variables in the study were elaboration and willingness to share on social media. The demographics captured by the instrument were participant age, gender, level of education, political affiliation, and geographic location in terms of region as well as urban-rural classification.

News consumption preferences. Eleven items, adapted from Funk et al. (2017) were used to determine participants' news, science news, and social media preferences. Participants were asked to answer items regarding how often they read news via online news sites, how often they read news online about science, and if they have a social media account. Participants who reported having a social media account were asked about how often they see science-related news on social media. Next, they were asked a series of seven items regarding how often, if ever, they take action such as liking, commenting, or sharing posts.

Deference to scientific authority. The seven Likert-type items on the General Social Survey's scale were used to determine participant's deference to scientific authority (Smith et al., 2015). The scale asked participants to indicate their level of agreement with seven statements regarding science and technology on a 7-point Likert-type scale (1 = *Strongly Disagree* to 7 = *Strongly Agree*). A sample statement from the measure was, *Because of science and technology, there will be more opportunities for the next generation.* Bigham (2017) previously reported a reliability of the entire scale by a Cronbach's $\alpha = 0.561$ before removing two items and raising the reliability coefficient to Cronbach's $\alpha = 0.754$.

Factors influencing degree of elaboration. Motivation was measured by way of the need for cognition scale developed by Cacioppo et al. (1984). Participants indicated their agreement with 18 items on a 5-point Likert-type scale (1 = *Strongly Disagree* to 5 = *Strongly Agree*). A sample statement from the measure was, *I like to have the responsibility of handling a situation that requires a lot of thinking*. Cacioppo et al. (1984) reported the reliability coefficient of the scale is Cronbach's $\alpha = 0.90$.

Ability was measured by assessing the participant's perceptual and factual knowledge of gene-editing in agriculture. Five Likert-type items were adapted from Critchley et al. (2019) and Gatica-Arias et al. (2019) to assess perceptual knowledge. The items asked participants to indicate their level of agreement with statements regarding their perceived knowledge of gene-editing in agriculture on a 5-point Likert-type scale (1 = *Strongly Disagree* to 5 = *Strongly Agree*). A sample statement was, *I feel I could explain gene-editing in agriculture to a friend.* Six true or false questions regarding genome engineering topics, including gene-editing in agriculture, were adapted from Scheufele et al. (2017) to assess the participants' factual knowledge to determine their ability. A sample statement was, *Scientists have changed more than 30 genetic characteristics of commercially available plants with gene-editing* (True).

Coronavirus outbreak experience. Four items were used to explore the influence of the COVID-19 pandemic on participants' lives, well-being, and news consumption. These items were adapted from previous measures used by the Pew Research Center (2020; Gottfriend et al., 2020) to determine how Americans are responding to the coronavirus outbreak.

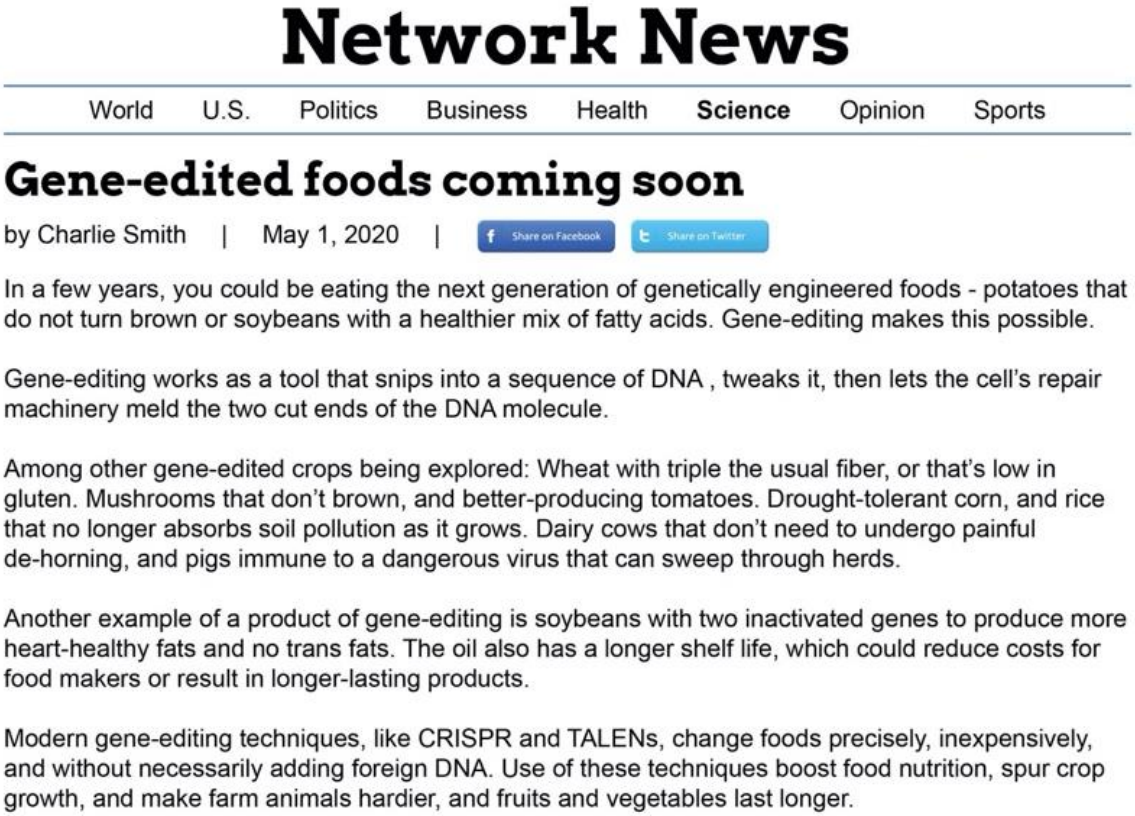
Elaboration. To assess elaboration in each participant, thought-listing was used immediately after stimuli exposure (Cacioppo & Petty, 1981; Burnett et al., 2019). Participants were presented 10 blanks to fill and asked to spend no more than five minutes listing thoughts they had while viewing the mock news article. They were instructed they did not have to fill every blank.

Willingness to share on social media. Four items adapted from Stevens and McIntyre (2019) were used to assess the willingness and reasoning of each participant to share the mock

news article they read on social media. Three items asked participants to indicate their level of likelihood to share the article on their Facebook, Twitter, or another social media channel of choice on a 6-point Likert-type scale (1 = *Definitely not* to 6 = *Definitely*). Participants were then asked to describe their reasoning for sharing or not sharing the story.

Metaphorical concept. The independent variable manipulated in this study was the metaphorical concept. The concept was operationalized as researcher-developed statements to reflect the top three metaphorical concepts found in online U.S. news by Hill (2020). Three metaphorical statements were written as well as a literal, control statement. The control statement was verified for accuracy by a plant scientist and professor with expertise in gene-editing. All four statements were similar in terms of journalistic writing style, visual length, and word count. The statements were created to be as alike as possible concerning persuasive message factors (Perloff, 2017). The articles were standardized, presenting all of the same information with the exception of a metaphorical concept statement or control statement contained in the second paragraph. A metaphorical concept mock news article news article stimulus is presented in Figure 2 and the statements for the metaphorical concepts are provided in Table 1.

Figure 2
Mock News Article for Metaphorical Concept of Tool


Network News

World U.S. Politics Business Health **Science** Opinion Sports

Gene-edited foods coming soon

by Charlie Smith | May 1, 2020 | Share on Facebook Share on Twitter

In a few years, you could be eating the next generation of genetically engineered foods - potatoes that do not turn brown or soybeans with a healthier mix of fatty acids. Gene-editing makes this possible.

Gene-editing works as a tool that snips into a sequence of DNA , tweaks it, then lets the cell's repair machinery meld the two cut ends of the DNA molecule.

Among other gene-edited crops being explored: Wheat with triple the usual fiber, or that's low in gluten. Mushrooms that don't brown, and better-producing tomatoes. Drought-tolerant corn, and rice that no longer absorbs soil pollution as it grows. Dairy cows that don't need to undergo painful de-horning, and pigs immune to a dangerous virus that can sweep through herds.

Another example of a product of gene-editing is soybeans with two inactivated genes to produce more heart-healthy fats and no trans fats. The oil also has a longer shelf life, which could reduce costs for food makers or result in longer-lasting products.

Modern gene-editing techniques, like CRISPR and TALENs, change foods precisely, inexpensively, and without necessarily adding foreign DNA. Use of these techniques boost food nutrition, spur crop growth, and make farm animals hardier, and fruits and vegetables last longer.

Table 1

Statements for Each Metaphorical Concept Included in Mock News Articles

Metaphor	Statements
Creation	*Gene-editing works as a revolutionary creator, using precision breeding to make designed changes that reshape a specific DNA sequence that would take years of traditional breeding to create.*
Text Editor	*Gene-editing works as a word processor by moving the cursor to a particular location in a manuscript and making a small change to the text using a "search and replace" function.*
Tool	*Gene-editing works as a tool that snips into a sequence of DNA, tweaks it, then lets the cell's repair machinery meld the two cut ends of the DNA molecule.*
Control	*Gene-editing works by way of making deliberate alterations to the genetic sequence in a living cell by changing, adding, or removing DNA to adjust how the genes function.*

In order to establish the validity of the stimuli, a manipulation check was conducted prior to deploying data collection for the primary experiment of the study. The purpose was to ensure each stimulus represented the metaphorical concept it was designed to present. Thirty-three agricultural communications and agricultural education graduate students completed the manipulation check due to the accessibility of this group. The results led to confirmation of the three metaphorical stimuli and adjustment of the control stimuli for final implementation.

Participants

With regards to the sample for full analysis, a nationally representative population was selected for this study because the intent was to explore which metaphorical concept(s) have the most persuasive effects on the general public in the United States. A quota sampling method carried out using Qualtrics was used to gather participants for the study who were nationally representative in terms of gender, education, race, and geographic region. We paid Qualtrics $5.00 per complete questionnaire, then Qualtrics compensated the participants. Given the research budget, 315 responses were recorded. However, 15 responses were removed from the sample for including gibberish or nonsensical responses to open-ended text questions resulting in $N = 300$ usable responses for subsequent analysis.

Procedure

Prior to launch, the instrument was reviewed for face and content validity by a panel of experts in agricultural communications as well as plant and soil science. A pilot test was conducted through Qualtrics to establish reliability of the instrument used. Participants were a random sample of 25 adults in the U.S, recruited and compensated by Qualtrics. All data were reviewed and wording adjustments were made to some items in the instrument. Cronbach's alpha was used to determine reliability of the researcher-developed measures, perceived knowledge, and willingness to share the article information on social media post-stimuli. The reliability coefficient for perceived knowledge was $\alpha = 0.667$. The reliability coefficient for willingness to

share on social media post-stimuli was $\alpha = 1.00$. Although acceptable alpha values are typically .8 or greater (Kline, 1999), Nunnally (1978) argued in the early stages of research values as low as .5 will suffice. All three items were included in the final analysis. Following the pilot testing phase, data collection resumed in Qualtrics. All data were collected May 15-18, 2020.

Data Analysis

Of the participants ($N = 300$), 76 viewed the control mock news article stimulus, 76 viewed the text editor stimulus, 75 viewed the creation stimulus, and 73 viewed the tool stimulus. Descriptive statistics were used to describe the sample population. In order to address the research questions, individual ANCOVAs were conducted to assess the effects of the independent variable, metaphorical concept, on elaboration and willingness to share on social media. Demographic data as well as individual difference variables data were used as covariates when appropriate to address the research objectives of this study.

Results

Individual Difference Variables

Slightly more than half of the participants ($n = 151$, 50.3%) identified as female. The average age of the participants was 48.1 ($SD = 17.10$) with a minimum age of 18 and a maximum age of 88. The largest percentage of participants ($n = 122$, 41%) indicated their permanent residence was in a state in the southern region of the United States. The majority of participants, 154 (51%), reported living in an urbanized area of 50,000 of more people. The largest percentage of participants ($n = 67$, 22%) had a four-year degree. When asked about political ideology, the largest percentage of participants ($n = 78$, 26%) reported being middle of the road.

News consumption preferences, willingness to share on social media measured pre-stimuli, deference to scientific authority, need for cognition, and knowledge were measured as individual difference variables in this study. News consumption was explored through a series of questions about participants' news, science news, and social media preferences. The greatest number of participants ($n = 124$, 41.3%) reported reading the news on an online news website *several times a day.* When asked specifically about how often they read news online about science, 67 (22.3%) participants indicated *a few times per week*.

The majority of participants ($n = 272$, 90.7%) reported having a social media account. When asked how often they would share the post to show it is wrong, 116 participants (38.7%) indicated *never*. When asked how often they would share the post to show it is right, 88 participants (29.3%) indicated *sometimes*. For each participant, the responses to the two items questioning how often they share a post were averaged for a measure of individual willingness to share on social media pre-stimuli ($M = 2.46$, $SD = 1.03$). Higher mean values indicated a greater willingness to share on social media.

Deference to scientific authority was measured using the scale from the General Social Survey (Smith et al., 2015). A *post hoc* reliability analysis established a Cronbach's $\alpha = 0.69$. Two items were removed (*Science makes our way of life change too fast* and *Scientists are apt to be odd and peculiar people*), which raised the reliability coefficient to a Cronbach's $\alpha = 0.92$. Bigham et al. (2017) also removed these two items to raise the reliability coefficient of the scale. For each participant, the responses the seven items were averaged for a measure of individual deference to scientific authority ($M = 5.49$, $SD = 1.48$). Deference to scientific authority ranged from 1.00 to 7.00. Higher mean values indicated higher deference to scientific authority.

The need for cognition scale was used as a measure of motivation (Cacioppo et al., 1984). A *post hoc* reliability analysis established a Cronbach's α = 0.86. Removal of items from this scale did not increase reliability so all 18 items remained intact. Nine of the 18 items were reverse coded, then each participant's responses were averaged for a measure of individual need for cognition (M = 3.14, SD = 0.60). Need for cognition ranged from 1.22 to 4.94. Higher values indicated greater need for cognition held by the individual.

The elaboration factor of ability was measured by assessing each participant's perceptual and factual knowledge of gene-editing in agriculture. Perceived knowledge was assessed with three items before the stimuli. A *post hoc* reliability analysis of the items established a Cronbach's α = 0.620. This was a researcher-developed measure deployed for the first time, so items were not removed to increase reliability (Nunnally, 1978). Each participant's responses were averaged for a measure of their perceptual knowledge of gene-editing in agriculture pre-stimuli exposure (M = 2.98, SD = 0.96). Perceptual knowledge ranged from 1.00 to 5.00. Higher values indicated greater perceived knowledge regarding gene-editing in agriculture.

The average factual knowledge score of the participants was determined by scoring the responses to six true or false statements delivered prior to the stimulus, then determining a percentage of questions correct. The average factual knowledge score was 64.7% (SD = 21%). Factual knowledge scores ranged from 17% to 100%.

The influence of the COVID-19 pandemic on participants' lives, well-being, and news consumption was assessed as data collection was conducted during the coronavirus outbreak, May 15-18, 2020. More than half of participants (n = 153, 51.0%) indicated they had been following the news about the outbreak known as COVID-19 *very closely*. When asked how the amount of news they read via an online news sites changed during the outbreak, 128 (42.7%) participants indicated they read such news *more often*.

Dependent Variables

Elaboration was measured through a thought-listing exercise immediately after participants read the stimulus mock news article. Coding of the thought-listing exercise was conducted by two independent judges (graduate students) because "independent judges have demonstrated a high degree of agreement in their classification of responses along the polarity dimension" (Cacioppo & Petty, 1981, p. 325).

The judges were trained how to code polarity by first reading the definitions of the codes set forth by Cacioppo and Petty (1981) and asking any clarifying questions. Then the judges coded a random sample of 10% (n = 30) of the participants' thought-listings as positive, negative, or neutral with regards to the relevance and attitude of the thought. Krippendorff's alpha test was used to estimate the inter-judge reliability (Krippendorff, 2011). When measuring reliability using Krippendorff's alpha, a reliability coefficient greater than 0.800 is ideal, but alphas as low as 0.667 are considered acceptable for gathering tentative conclusions (Krippendorff, 2004). After initial coding, judges showed low reliability, with α = 0.68.

To reach an acceptable level of intercoder reliability, additional coder training was conducted, which was a discussion of discrepancies as well as any uncertainties the judges experienced while coding. Judges were reassigned a new random sample of 10% (n = 30) of the participants' thought-listings. After the second round, an acceptable alpha level was reached with judges showing high reliability, with α = 0.86. Each judge was then assigned an equal share of the remaining thought-listings to code. Elaboration was operationalized as the number of total relevant thoughts, positive or negative, expressed by each participant (O'Keefe, 2016). Neutral

thoughts are not issue-relevant (Cacioppo & Petty, 1981). Participants reported an average of 3.26 thoughts (*SD* = 2.46), with the number of relevant thoughts reported ranging from 0 to 10 for all participants.

The behavioral intent measure in this study was the participants' willingness to share the mock news article they read on their social media accounts. Participants were asked to indicate their level of likelihood to share the article on their Facebook, Twitter, or another social media channel of choice. Only responses provided by participants who indicated they had a social media account were included in analysis. A *post hoc* reliability analysis of the items established a Cronbach's $\alpha = 0.87$. Each participant's responses were averaged for a measure of their willingness to share the mock news article (*M* = 3.27, *SD* = 1.95), indicating participants were overall *somewhat unlikely* to share the article on social media platforms. If the participant noted a social media channel of choice in addition to Twitter and Facebook, their likelihood to share on that channel was included in their average score.

RQ1: Does the metaphorical concept used to explain gene-editing applications in an agricultural context influence elaboration?

A one-way ANCOVA was conducted to determine if there was a statistically significant difference between exposure to the control, creation, text editor, or tool metaphorical concepts on elaboration. The covariates in this analysis were age, gender, education, race, political ideology, geographic region, deference to scientific authority, factual knowledge, pre-stimuli perceptual knowledge, need for cognition, how often the participant reads online new sites, and how news consumption has changed during the COVID-19 outbreak. These covariates were included because of their known effects on elaboration, especially in the context of science. Analysis was guided by Field (2017) and Laerd Statistics (2017). Independent ANOVA analyses were conducted to ensure independence of all covariates and the treatment effect. Revealed by the ANCOVA model, the assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances ($p = .013$). Inspection of histograms revealed elaboration was positively skewed, so the data were converted using a square root transformation (Laerd, 2017).

Using the transformed elaboration variable in the ANCOVA model, assumptions of homoscedasticity and homogeneity of regression slopes were evaluated and met. There was homogeneity of variances, as assessed by Levene's test for homogeneity of variances ($p = .454$). Data presented are adjusted means and standard error. Elaboration was highest in the text editor metaphorical concept group (*M* = 1.72, *SE* = .09) compared to the creation metaphorical concept (*M* = 1.68, *SE* = .09), control stimuli (*M* = 1.57, *SE* = .09), and tool metaphorical concept (*M* = 1.52, *SE* = .09). There were no significant differences in elaboration between treatment groups ($p = .280$, $\eta^2 = .014$). The inferential statistics reported for this ANCOVA are shown in Table 2.

Table 2

Analysis of Covariance of Elaboration Regarding Gene-Editing in Agriculture, with Individual Difference Variables as Covariates

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Metaphorical Concept	3	2.13	.71	1.30	.280	.014
Covariates						
Need for cognition	1	4.85	4.85	8.89	.003	.030
Factual knowledge	1	1.91	1.91	3.49	.063	.012
Perceptual knowledge	1	2.36	2.36	4.33	.038	.015
Deference to scientific authority	1	2.23	2.23	4.08	.044	.014
Online news reading	1	2.20	2.20	4.03	.046	.014
COVID-19 news change	1	2.68	2.68	4.91	.028	.017
Age	1	4.03	4.03	7.39	.007	.025
Gender	1	1.42	1.42	2.61	.108	.009
Education	1	.03	.03	.04	.822	.000
Race	1	.11	.11	.21	.651	.001
Political ideology	1	.12	.12	.21	.645	.001
Region	1	.03	.03	.06	.806	.000
Error	284	155.03	.546			
Total	300	979.00				

RQ2: Does the metaphorical concept used to explain gene-editing applications in an agricultural context influence willingness to share the information on social media?

A one-way ANCOVA was conducted to determine if there was a statistically significant difference between exposure to the control, creation, text editor, or tool metaphorical concept on willingness to share the information on social media. Only participants who reported having a social media account were included in analysis (n = 272). The covariates in this analysis were age, gender, education, race, political ideology, geographic region, urban/rural classification, willingness to share on social media measured pre-stimuli exposure, elaboration, and how closely the participants reported following the news about the COVID-19 outbreak. These covariates were included because of their known effects on willingness to share on social media. Analysis was guided by Field (2017) and Laerd Statistics (2017). Independent ANOVA analyses were conducted to ensure independence of all covariates and the treatment effect. Assumptions of homoscedasticity and homogeneity of regression slopes were evaluated and met. There was homogeneity of variances, as assessed by Levene's test for homogeneity of variances (p = .394).

Data presented are adjusted means and standard errors. Willingness to share the information regarding gene-editing in agriculture was highest in the tool metaphorical concept group (M = 3.54, SE = .19) compared to the control stimuli (M = 3.41, SE = .17), creation metaphorical concept (M = 3.07, SE = .18), and text editor metaphorical concept (M = 3.07, SE = .18). There were no significant differences between the treatment groups (p = .153, η^2 = .020). The inferential statistics reported for this ANCOVA are shown in Table 3.

Table 3

Analysis of Covariance of Willingness to Share on Social Media Information Regarding Gene-Editing in Agriculture, with Individual Difference Variables and Elaboration as Covariates

Source	*df*	*SS*	*MS*	*F*	*p*	η^2
Metaphorical Concept	3	11.51	3.84	1.77	.153	.020
Covariates						
Elaboration	1	1.60	1.60	.74	.394	.003
Willingness to share pre	1	242.85	242.85	112.32	<.001	.302
COVID-19 news following	1	19.03	19.03	8.80	.035	.033
Age	1	37.60	37.60	17.39	<.001	.063
Gender	1	.13	.13	.06	.809	.000
Education	1	5.35	5.35	2.46	.117	.009
Race	1	.56	.56	.26	.612	.001
Political ideology	1	1.66	1.66	.77	.382	.003
Region	1	.11	.11	.05	.824	.000
Urban/Rural	1	1.14	1.14	.76	.385	.003
Error	259	560.01				
Total	272	3971.08				

Discussion, Conclusions & Recommendations

The purpose of this study was to determine the persuasive effects of metaphorical concepts regarding gene-editing in agriculture. Metaphors have been found to enhance elaboration and influence behavioral intentions (Sopory & Dillard, 2002; Van Stee, 2018). However, this study found changing the metaphorical concepts for gene-editing in agriculture did not elicit these outcomes.

RQ1 found no significant differences between the metaphorical concepts on participants' elaboration, or issue-relevant thoughts, regarding gene-editing in agriculture. Following the Elaboration Likelihood Model, perhaps with additional controls for factors affecting processing route and elaboration, a significant difference between conditions may have been viewed. These factors include attitude and involvement with the issue (Petty & Cacioppo, 1986). Without the ability to control for distractions, another factor affecting elaboration, the topic may not have been relevant enough to the participants to overcome distractions while completing the questionnaire especially given the prevalence of COVID-19 pandemic news coverage (Petty & Cacioppo, 1986; Gottfriend et al., 2020). The ability to elaborate is also enhanced by repetition (Perloff, 2017; Petty & Cacioppo, 1986), which was not part of this study's design.

Future research using a similar design may want to further integrate the metaphorical concept throughout the stimuli. The direction of participants' elaboration (positive or negative) was not analyzed in this study, so future research may warrant identifying if a significant difference in attitude lies between treatment groups. Furthermore, the elaborative thoughts of the participants could be investigated in terms of their origin dimension and target dimension (Cacioppo & Petty; 1981). Metaphors for gene-editing have been criticized, so future research should also test the persuasive effects of novel metaphorical concepts (Taylor & Dewsbury, 2018).

RQ2 found no significant differences between the metaphorical concepts on participants' willingness to share information regarding gene-editing in agriculture. The Elaboration Likelihood Model posits elaboration has a persuasive effect on behavioral intent (O'Keefe, 2016; Petty & Cacioppo, 1986; Perloff, 2017). As the topic of gene-editing gains coverage in the popular press, so too may willingness to share information about it on social media. People are still forming opinions about gene-editing in agriculture so they may not yet be ready to share information about it on their social media pages (Brossard, 2018; Miller, 2004; Rainie, 2017). Previous research suggested people share information on social media in an effort to build their identity (Berger, 2014; Boyd & Ellison, 2007). Sharing on social media has been found to indicate agreement with the message (Grabbert et al., 2019; Kee et al., 2016).

Participants in this study may still be forming an opinion about gene-editing in agriculture, even after viewing the informative article. Additional research should investigate persuasive effects of metaphorical concepts on other behavioral outcomes associated with elaboration, such as willingness to tell friends and family or willingness to consume gene-edited foods. Ability is also an indicator of elaboration, so the perceptual outcomes of enhanced ability through perceived knowledge assessment should also be assessed in future studies.

This study only explored elaboration on three metaphorical concepts commonly found in U.S. online news. Additional metaphors should be explored for their ability to persuade as well as their correctness in explaining the complex science of gene-editing in agriculture (Perrault & O'Keefe, 2019). Future research should also test the metaphorical concepts in other forms of media, such as social media posts, blogs, television broadcasts, podcasts, and public service announcements. The use of visual metaphors for gene-editing in agriculture should also be explored for their effect on elaboration and behavioral outcomes as they may differ from written metaphors.

While this study did not reveal any significant differences between the metaphorical concepts, researchers and practitioners can still draw important lessons and guidelines for communicating science to the public from the theoretical and literary foundations of this study. The Elaboration Likelihood Model should be tested to find out how the theory operates in contexts with as much ecological reliability as possible. Understanding how the public responds to messages enhances communicators' ability to develop effective messaging that influences elaboration and desirable behavioral outcomes. Gene-editing in agriculture remains a novel topic and should be studied over time to understand how public opinion of the topic evolves and how communication efforts can influence those opinions.

References

Anders, S., Cowling, W., Pareek, A., Gupta, K. J., Singla-Pareek, S. L., & Foyer, C. H. (2021). Gaining acceptance of novel plant breeding technologies. *Trends in Plant Science, 26(*6), 575–587. https://doi.org/10.1016/j.tplants.2021.03.004

Ary, D., Jacobs, L. C., Razavieh, A., & Sorenson, C. (2010). *Introduction to research in education* (8th ed.). Thomson Wadsworth.

Bigham, A. (2017). *The effect of source credibility and gender on message persuasiveness* [Master's thesis, Texas Tech University]. TTU Electronic Theses and Dissertation Collection. https://ttu-ir.tdl.org/handle/2346/73515

Berger, J. (2014). Word of mouth and interpersonal communication: A review and directions for future research. *Journal of Consumer Psychology*, *24*, 586–607. https://doi.org/10.1016/j.jcps.2014.05.002

Boyd, D. M., & Ellison, N. B. (2007). Social network sites: Definition, history, and scholarship. *Journal of Computer-mediated Communication, 13*(1), 210–230. https://doi.org/10.1111/j.1083-6101.2007.00393.x

Blasimme, A., Anegon, I., Concordet, J. P., De Vos, J., Dubart-Kupperschmitt, A., Fellous, M., Fouchet, P., Frydman, N., Giovannangeli, C., Jouannet, P., Serre, J.-L., Steffann, J., Rial-Sebbag, E., Thomsen, M., & Cambon-Thomsen, A. (2015). Genome editing and dialogic responsibility: "What's in a name?". *The American Journal of Bioethics, 15*(12), 54–57. https://doi.org/10.1080/15265161.2015.1103811

Brossard, D. (2018). Biotechnology, communication and the public: Keys to delve into the social perception of science. *Mètode Science Studies Journal, 9*, 39–45. https://doi.org/10.7203/metode.9.11347

Brossard, D., & Nisbet, M. C. (2007). Deference to scientific authority among a low information public: Understanding US opinion on agricultural biotechnology. *International Journal of Public Opinion Research*, *19*(1), 24–52. https://doi.org/10.1093/ijpor/edl003

Burnett, E., Holt, J., Borron, A., & Wojdynski, B. (2019). Interactive infographics' effect on elaboration in agricultural communication. *Journal of Applied Communications, 103*(3), 1–12. https://doi.org/10.4148/1051-0834.2272

Busch, G., Ryan, E., von Keyserlingk, M. A., & Weary, D. M. (2021). Citizen views on genome editing: effects of species and purpose. *Agriculture and Human Values*, 1–14. https://doi.org/10.1007/s10460-021-10235-9

Cacioppo, J. T., & Petty, R. E. (1981). Social psychological procedures for cognitive response assessment: The thought listing technique. In T. Merluzzi, C. Glass, & M. Genest (Eds.), *Cognitive Assessment* (pp. 309–342). Guilford.

Cacioppo, J. T. & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology, 42*(1), 116–131. https://doi.org/10.1037/0022-3514.42.1.116

Cacioppo, J. T., Petty, R. E., & Feng Kao, C. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment, 48*(3), 306–307. https://doi.org/10.1207/s15327752jpa4803_13

Critchley, C., Nicol, D., Bruce, G., Walshe, J., Treleaven, T., & Tuch, B. (2019). Predicting public attitudes toward gene editing of germlines: The impact of moral and hereditary concern in human and animal applications. *Frontiers in Genetics*, *9*, 1–14. https://doi.org/10.3389/fgene.2018.00704

Field, A. (2017). *Discovering statistics using IBM SPSS statistics* (5th ed., North American ed.). SAGE.

Funk, C., Gottfried J., & Mitchell, A (2017, September 20). Science news and information today. *Pew Research Center*. https://www.journalism.org/2017/09/20/science-news-and-information-today/

Gatica-Arias, A., Valdez-Melara, M., Arrieta-Espinoza, G., Albertazzi-Castro, F. J., & Madrigal-Pana, J. (2019). Consumer attitudes toward food crops developed by CRISPR/Cas9 in Costa Rica. *Plant Cell, Tissue and Organ Culture, 139*(2), 417–427. https://doi.org/10.1007/s11240-019-01647-x

Gentner, D. (1982). Are scientific analogies metaphors? In D. Miall (Ed.), *Metaphor: Problems and perspectives* (pp. 106–132). Harvester Press.

Georges, F., & Ray, H. (2017). Genome editing of crops: A renewed opportunity for food security. *GM Crops & Food, 8*(1), 1–12. https://doi.org/10.1080/21645698.2016.1270489

Gottfriend, J., Walker, M., & Mitchell, A. (2020, May 8). Americans' views of the news media during the COVID-19 outbreak. *The Pew Research Center*. https://www.journalism.org/2020/05/08/americans-views-of-the-news-media-during-the-covid-19-outbreak/

Grabbert, M., Khoder, W. Y., Gratzke, C., Paffenholz, P., Salem, J., & Bauer, R. M. (2019). Comprehensive analysis of Twitter activity on #incontinence. *Neurourology and Urodynamics, 39*, 440–446. https://doi.org/10.1002/nau.24227

Gupta, S., Kumar, A., Patel, R., & Kumar, V. (2021). Genetically modified crop regulations: scope and opportunity using the CRISPR-Cas9 genome editing approach. *Molecular Biology Reports*, *48*, 4851–4863. https://doi.org/10.1007/s11033-021-06477-9

Hill, N. (2020). *Public opinion of gene-editing in agriculture: A mixed-method study of online media and metaphors* [Doctoral dissertation, Texas Tech University]. TTU Electronic Theses and Dissertation Collection. https://hdl.handle.net/2346/86569

Ishii, T., & Araki, M. (2016). Consumer acceptance of food crops developed by genome editing. *Plant Cell Reports*, *35*(7), 1507–1518. https://doi.org/10.1007/s00299-016-1974-2

Kee, K. F., Sparks, L., Struppa, D. C., Mannucci, M. A., & Damiano, A. (2016). Information diffusion, Facebook clusters, and the simplicial model of social aggregation: A computational simulation of simplicial diffusers for community health interventions. *Health Communication, 31*(4), 385–399. https://doi.org/10.1080/10410236.2014.960061

Kennedy, B. & Hefferon, M. (2019, March 28). What Americans know about science. *Pew Research Center*. https://www.pewresearch.org/science/2019/03/28/what-americans-know-about-science

Kline, P. (1999). *The handbook of psychological testing* (2nd ed). Routledge.

Krippendorff, K. (2004). Reliability in content analysis: Some common misconceptions and recommendations. *Human Communication Research, 30*(3), 411–433. https://doi.org/10.1111/j.1468-2958.2004.tb00738.x

Krippendorff, K. (2011). Computing Krippendorff's alpha-reliability. http://repository.upenn.edu/asc_papers/43

Laerd Statistics (2017). One-way ANCOVA using SPSS Statistics. *Statistical tutorials and software guides*. https://statistics.laerd.com/

Lenaerts, B., Collard, B. C., & Demont, M. (2019). Improving global food security through accelerated plant breeding. *Plant Science, 287*, 1–8. https://doi.org/10.1016/j.plantsci.2019.110207

Llewellyn, D. (2018). Does global agriculture need another green revolution?. *Engineering, 4(*4), 449–451. https://doi.org/10.1016/j.eng.2018.07.017

Lusk, J. L., McFadden, B. R., & Wilson, N. (2018). Do consumers care how a genetically engineered food was created or who created it? *Food Policy, 78*, 81–90. https://doi.org/10.1016/j.foodpol.2018.02.007

Marcon, A., Master, Z., Ravitsky, V., & Caulfield, T. (2019). Crispr in the North American popular press. *Genetics in Medicine, 21*(10), 2184–2189. https://doi.org/10.1038/s41436-019-0482-5

Marks, L. A., Kalaitzandonakes, N., Wilkins, L., & Zakharova, L. (2007). Mass media framing of biotechnology news. *Public Understanding of Science, 16*(2), 183–203. https://doi.org/10.1177/0963662506065054

McCluskey, J. J., Kalaitzandonakes, N., & Swinnen J. (2016). Media coverage, public perceptions, and consumer behavior: Insights from new food technologies. *Annual Review of Resource Economics*, 8, 467–486. https://doi.org/10.1146/annurev-resource-100913-012630

Meraz, S. (2009). Is there an elite hold? Traditional media to social media agenda setting influence in blog networks. *Journal of Computer-Mediated Communication, 14*(3), 682–707. https://doi.org/10.1111/j.1083-6101.2009.01458.x

Miller, J. (2004). Public understanding of, and attitudes toward, scientific research: What we know and what we need to know. *Public Understanding of Science, 13*(3), 273–294. https://www.doi.org/10.1177/0963662504044908

Molteni, M. (2019, March 12). The WIRED guide to Crispr. *WIRED*. https://www.wired.com/story/wired-guide-to-crispr/

National Institutes of Health (2020). *Help me understand genetics: Genomic research*. https://ghr.nlm.nih.gov/

Nelson, S. C., Crouch, J. M., Bamshad, M. J., Tabor, H. K., & Yu, J. H. (2016). Use of metaphors about exome and whole genome sequencing. *American Journal of Medical Genetics*, *170*(5), 1127–1133. https://doi.org/10.1002/ajmg.a.37571

Nisbet, M. C., Scheufele D. A., Shanahan J., Moy P., Brossard D., & Lewenstein, B. V. (2002). Knowledge, reservations, or promise? A media effects model for public perceptions of science and technology. *Communication Research, 29*(5), 584–608. https://doi.org/10.1177/009365002236196

Nunnally, J. S. (1978). *Psychometric theory*. McGraw-Hill.

O'Keefe, D. (2016). *Persuasion: Theory and research* (3rd ed.). SAGE Publications Inc.

O'Keefe, M., Perrault, S., Halpern, J., Ikemoto, L., Yarborough, M. & UC North Bioethics Collaboratory for Life & Health Sciences (2015). "Editing" genes: A case study about how language matters in bioethics. *The American Journal of Bioethics*, *15*(12), 3–10. https://www.doi.org/10.1080/15265161.2015.1103804

Ortony, A. (1979). Beyond literal similarity. *Psychological Review, 86*(3), 161–180. https://doi.org/10.1037/0033-295X.86.3.161

Perloff, R. M. (2017). *The dynamics of persuasion: Communication and attitudes in the 21st century* (6th ed.) Taylor & Francis.

Perrault, S. T., & O'Keefe, M. (2019). New metaphors for new understandings of genomes. *Perspectives in Biology and Medicine, 62*(1), 1–19. https://doi.org/10.1353/pbm.2019.0000

Petty, R. E., & Cacioppo, J. T. (1986). *The elaboration likelihood model of persuasion*. Springer.

Petty, R. E., Cacioppo, J. T., & Goldman, R. (1981). Personal involvement as a determinant of argument-based persuasion. *Journal of Personality and Social Psychology, 41*(5), 847–855. https://doi.org/10.1037/0022-3514.41.5.847

Petty, R. E., & Wegener, D. T. (1999). The Elaboration Likelihood Model: Current status and controversies. In S. Chaiken and Y. Trope (Eds.), *Dual-process theories in social psychology* (pp. 41-72). Guilford.

Pew Research Center. (2020, March 30). Most Americans say coronavirus outbreak has impacted their lives. https://www.pewsocialtrends.org/2020/03/30/most-americans-say-coronavirus-outbreak-has-impacted-their-lives/

Pigliucci, M., & Boudry, M. (2011). Why machine-information metaphors are bad for science and science education. *Science & Education, 20*(5–6), 453–471. https://doi.org/10.1007/s11191-010-9267-6

Rainie, L. (2017, June 27). U.S. public trust in science and scientists. *Pew Research Center.* http://www.pewinternet.org/2017/06/27/u-s-public-trust-in-science-and-scientists/

Rose, K. M., Brossard, D., & Scheufele, D. A. (2020). Of society, nature, and health: How perceptions of specific risks and benefits of genetically engineered foods shape public rejection. *Environmental Communication,* 1–15. https://doi.org/10.1080/17524032.2019.1710227

Rothman, B. K. (2001). *The book of life: A personal and ethical guide to race, normality and the human gene study*. Beacon Press.

Ruan, Y., Yang, J., & Jin, J. (2019). One issue, different stories: The construction of GMO issues on Chinese, American and British mainstream media portals. *Cultures of Science, 2*(4), 255-275. https://doi.org/10.1177%2F209660831900200403

Schäfer, M. S. (2017). How changing media structures are affecting science news coverage. In K. H. Jamison, D. Kahan, & D. A. Scheufele (Eds.), *The Oxford handbook of the science of science communication* (pp. 51–59). Oxford University Press.

Scheufele, D. A. (2007). Opinion climates, spirals of silence and biotechnology: Public opinion as a heuristic for scientific decision-making. In D. Brossard, J. Shanahan, & T. C. Nesbitt (Eds.), *The media, the public and agricultural biotechnology* (pp. 231–244). CAB International.

Scheufele, D. A., Xenos, M. A., Howell, E. L., Rose, K. M., Brossard, D., & Hardy, B. W. (2017). U.S. attitudes on human genome editing. *Science, 357*(6351), 553–554. https://doi.org/10.1126/science.aan3708

Shew, A. M., Nalley, L. L., Snell, H. A., Nayga Jr., R. M., & Dixon, B. L. (2018). CRISPR versus GMOs: Public acceptance and valuation. *Global Food Security, 19*, 71–80. https://doi.org/10.1016/j.gfs.2018.10.005

Smith, T. W., Marsden, P., Hout, M., & Kim, J. (2015). *General social surveys, 1972–2012: Cumulative codebook*. NORC at the University of Chicago.

Sopory, P., & Dillard, J. P. (2002). The persuasive effects of metaphor: A meta-analysis. *Human Communication Research, 28*(3), 382–419. https://doi.org/10.1111/j.1468-2958.2002.tb00813.x

Steen, G. J., Dorst, A. G., Herrmann, J. B., Kaal, A. A., & Krennmayr, T. (2010). Metaphor in usage. *Cognitive Linguistics, 21*(4), 765–796. https://doi.org/10.1515/cogl.2010.024

Stevens, E. M., & McIntyre, K. (2019). The layers of The Onion: The impact of satirical news on affect and online sharing behaviors. *Electronic News, 13*(2), 78–92. https://doi.org/10.1177/1931243119850264

Taylor, C., & Dewsbury, B. M. (2018). On the problem and promise of metaphor use in science and science communication. *Journal of Microbiology & Biology Education, 19*(1). https://dx.doi.org/10.1128%2Fjmbe.v19i1.1538

Van Stee, S. K. (2018). Meta-analysis of the persuasive effects of metaphorical vs. literal messages. *Communication Studies, 69*(5), 545–566. https://doi.org/10.1080/10510974.2018.1457553

Wolff, P., & Gentner, D. (2011). Structure-mapping in metaphor comprehension. *Cognitive Science, 35*(8), 1456–1488. https://doi.org/10.1111/j.1551-6709.2011.01194.x

Yabar, A. S. T., Guertin, L. E., & McGuire, R. M. (2018). *Public perception of human applications of CRISPR gene editing* (Interactive qualifying project). Worcester Polytechnic Institute. https://digitalcommons.wpi.edu/iqp-all/2911/