PUBLIC PERCEPTION OF SCIENCE COMMUNICATION: FACTUAL VS. NONFACTUAL INFORMATION ABOUT ORGANIC FOODS

A Dissertation

by

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ABSTRACT

This dissertation focuses on factors affecting public perception of science when communicating controversial scientific issues. First, following an integrative literature review method, five categories of factors that influence public perception of science were identified: type of science, audience beliefs, socio-demographics, source of communication, and environment. A conceptual framework, *Rings of Public Perception of Science*, was developed to show the factors and their degree of influence on public perceptions of science.

Second, using organic foods as the type of science communicated, associations between levels of agreement with scientific information about organic foods and 19 identified factors from the rings of public perception of science were examined. Data from a descriptive survey (N = 763) were analyzed following multinomial and multiple linear regression. Benefit perceptions contributed most, having a negative association with agreement levels, while trust in scientists and credibility of communicator had positive associations. Food preference, overall trust in science, and events related to science (in particular, COVID-19) had weak associations with agreement levels.

Third, using a posttest-only control group design (N = 640), factual and nonfactual information influence on public perception of organic foods was tested. Participants were randomly assigned to watch one video, and then asked to indicate changes in perception. Data were analyzed using one-way ANOVA and two-way ANOVA tests. The nonfactual video had the most influence on public perception of organic foods. Findings confirmed the effect of misinformation was greater for individuals who had preexisting beliefs consistent with the message communicated and people with average to a high frequency of exposure to news about health effects of foods and drinks.

Communication about organic foods should be designed considering the audience's preexisting beliefs, frequency of news exposure, and perceived benefits about organic foods. Such communication should be aimed to increase healthy skepticism to reduce susceptibility for misinformation and convey scientific facts by engaging trusted scientists or nutritionists. Studies identifying context-specific factors are needed because of changing communication forms. Additionally, measuring changes in perception using two scales (numerical rating and summed scale) provides better insights into the influence made by the message.

DEDICATION

This dissertation is dedicated to my loving husband Nalin for his unwavering support and my loving son Skylar.

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1. INTRODUCTION

Several factors shape public perceptions when communicating science, such as conflicting values, competing for economics, religious beliefs, political ideologies, and personal interests (National Academies of Sciences, Engineering, and Medicine, 2017; Rowe & Alexander, 2017). Some studies have contended that the effect of these factors on public perceptions of science varies by the topic of science communicated (American Academy of Arts & Science, 2018; Drummond & Fischhoff, 2020). This dissertation addresses factors affecting public perceptions of science when communicating scientific controversies. The current study focuses on factors that affect public perception when communicating scientific information related to organic foods.

The topic of “organic foods” was suitable for examining the factors’ effects on public perceptions of science for several reasons. First, a distinct mismatch exists between scientific evidence and people’s beliefs about organic foods. Even though a lack of scientific evidence confirms the clinically significant health benefits of organic foods (Vigar et al., 2020), 55% of Americans perceived organic foods are healthier than conventionally grown foods (Pew Research Center, 2016). The perceived health benefits of organic foods are the key motivating factor to purchase organic foods (Rana & Paul, 2020). Second, organic food is a familiar topic to the public. For example, in the United States in 2016, four in ten Americans had brought organic foods within the past month (Pew Research Center, 2016). In 2020, organic sales recorded the highest sales over a decade, which was over 12% growth (McNeil, 2021) Third, persuading individuals with scientific facts when a topic becomes politically polarized is difficult (Morin, 2018). A politically neutral topic such as organic foods (Larson, 2018) provides an avenue to examine how the public perceives scientific information.

When it comes to scientific controversies, exposure to factual (truthful) and nonfactual (untruthful) news plays a key role in public perception of science. News delimits people's acceptance or rejection of scientific facts. Exposure to truthful information influences people's ability to distinguish nonfactual from factual information (Allcott & Gentzkow, 2017; Balmas, 2014; Latré et al., 2018). For example, people could identify realistic information from political satire if exposed to factual information (Balmas, 2014). Moreover, when communicating science related to climate change, scientific consensus (i.e., the majority of scientists have agreed on scientific facts) has significantly increased public perceptions, and nonfactual news has undermined public perception (van der Linden et al., 2017). Although nonfactual information exists surrounding organic foods (Berezow & Hartsfield, 2012), limited studies have examined how people perceive scientific information about them (Olson, 2017) or how nonfactual information impacts public perceptions of organic foods. Therefore, the present study examined how factual and nonfactual communications affect public perceptions and what factors contribute to the level of agreement with scientific information about organic foods.

Research Objectives

The purpose of this study was to determine factors that affect public perceptions of science when communicating scientific controversies. Three main objectives guided this study. They were to:

1. Examine factors affecting public perceptions of science in the presence of misinformation surrounding controversial issues;
2. Identify the most influential factors affecting communicating scientific (factual) information about organic foods; and
3. Measure the effects of factual and nonfactual communications on public perception of organic foods.

Each objective was accomplished by conducting individual studies. The first objective was completed by conducting an integrative literature review (ILR), which reviewed 40 studies and identified five categories of factors affecting the communication of scientific information. This study proposed a conceptual framework called *Rings of public perception of science* that explains the relationship between factors and the degree of influence. The second study identified 19 possible factors from rings of public perception of science and examined the influence of each factor on the levels of agreement with scientific information about organic foods. A descriptive survey (N = 763) was used to determine the association between 19 factors and the levels of agreement with scientific information about organic foods. The findings suggested that perceptions of benefits of organic foods is the key factor that determines how people perceived scientific information about organic foods. The third study assessed the effect of factual and nonfactual information by conducting a posttest-only control group study ($N = 640$). Participants were randomly assigned to watch one video: a factual, nonfactual, or control. Immediately after watching the video, participants indicated changes in perception about organic foods. The third study revealed that changes in perception levels after exposure to factual and nonfactual news stories varied by the levels of preexisting beliefs about organic and/or conventionally grown foods as well as the level of exposure to news about the health effects of foods and drinks.

Definition of Terms

Science Communication

Scholars have defined science communication in several ways (Jucan & Jucan, 2014). One example is the "use of appropriate skills, media, activities, and dialogue to produce one or more personal responses (awareness, enjoyment, interest, opinion forming, and understanding) to science" (Burns et al., 2003, p. 191) The current study adopted the definition from the report of *Communicating Science Effectively: A Research Agenda*.

> Science communication is defined as the exchange of information and viewpoints about science to achieve a goal or objective such as fostering greater understanding of science and scientific methods or gaining greater insight into diverse public views and concerns about the science related to a contentious issue. (National Academies of Sciences, Engineering, and Medicine, 2017, p. 14)

Controversy

Merriam-Webster’s dictionary defines controversy as “a discussion marked especially by the expression of opposing views” (Merriam-Webster's dictionary, n.d.), and Cambridge dictionary defines it as “ a disagreement, often a public one, that involves different ideas or opinions about something”(Cambridge Dictionary, n.d.). The present study defines controversy as expressions of opposing views against scientific findings that were accepted by most scientists in relevant fields.

Organic Foods

The current study defines organic foods following the United States Department of Agriculture (USDA) definition. Organic food is defined as produce that was certified as grown on soil that had no prohibited substances applied for three years prior to harvest. Prohibited substances include most synthetic fertilizers and pesticides (McEvoy, 2019).

Conventionally Grown Foods

The definition of conventionally grown foods also followed the USDA definition of conventional farming. Conventional farming is the use of seeds that have been genetically altered using a variety of traditional breeding methods, excluding biotechnology, and are not certified as organic (United States Department of Agriculture, 2015).

Factual News

Different terms are used by scholars to define factual news: truthful, accurate, verifiable, and credible. Gualda and Rúas (2019) used credibility to discuss the factual nature of communication and they categorized it as information with felt and perceived truth instead of emphasizing sensations and emotions. Furthermore, Sahu and Majumdar (2017) defined facts "as something that has occurred or is actually correct" (p. 2) and factual news articles as articles that reported "what actually happened and statements which claim to be true in nature" (p. 2). This current study identifies factual news as news stories that describe scientific findings, accepted by most scientists in relevant fields.

Nonfactual News

Several terms can describe nonfactual news similar to factual news, such as fake news, misinformation, mistaken or misleading information, and false news. Allcott and Gentzkow (2017) defined fake news as "news articles that are intentionally and verifiably false and could mislead readers" (p. 213). *The Council of Europe's Information Disorder Report of November 2017* claimed that the complexity of false information cannot be explained by using the term fake news (Wardle & Derakhshan, 2017). Thus, the council described three types of false information; misinformation, disinformation, and mal-information. Fetzer (2004) defined misinformation as false, mistaken, or misleading information. Wardle and Derakhshan (2017) noted that misinformation does not have the intention of causing harm. According to Wardle and Derakhshan (2017), "disinformation is when false information is knowingly shared to cause harm; mal-information when genuine information is shared to cause harm, often by moving information designed to stay private into the public sphere" (p. 5). Furthermore, Karlova and Fisher (2013) claimed that misinformation and disinformation are closely linked related to how they are diffused and shared and how people used the information to make judgments.

The presence of various definitions and terms for false news creates the need for selecting and defining what is meant by nonfactual news. The current study identifies nonfactual news as misinformation. Using definitions by Cook and Lewandowsky (2011) and Meinert et al. (2018), this study defines nonfactual information as any inaccurate or discredited information that diverts or deceives the audience about factual science-related communications.

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2. FACTORS ABOUT PUBLIC PERCEPTION OF SCIENCE IN THE PRESENCE OF MISINFORMATION

Overview

This literature review identified factors affecting public perception of science when the presence of misinformation surrounds scientific issues. Forty studies were analyzed using an integrative literature review method. Five categories of factors were identified: type of science, audience beliefs, socio-demographics, source of communication, and environment. A conceptual framework, *Ring of Public Perception of Science*, was developed to show the factors and their degree of influence on public perception of science. Most research about public perception of science was conducted in developed countries' contexts. Studies identifying context-specific factors are needed, especially new environmental factors because of changing communication forms.

Introduction

Communicating science with policymakers and the public can be difficult in today's complex media-focused environment. The Committee on the Science of Science Communication stated that new issues affect the scientific community such as how to formally engage with the public regarding science, how to understand the complexities of communicating science in regard to/about public controversies, and how to communicate science in complex and competitive media environments (National Academies of Sciences, Engineering, and Medicine, 2017, p. 4). Another pressing issue is how misinformation affects scientists' ability to convey scientific facts to the public, as well as how it affects the public opinion of science in general. Fake news, as something that misleads, deceives, and/or otherwise confuses audiences, is a component of communication that has effects on society that simply cannot be ignored (Lewandowsky et al., 2012). Scientists face a challenge to convince the public and policymakers about the value of science when anti-science activists with large followings on social media negatively influence the public.

Although the public should weigh factual, science-based news reports over individual beliefs to form educated opinions, many audiences do not consider such information. Instead, they often do not strongly consider accurate scientific information (Broomell & Kane, 2017), and they commonly make decisions based on their own perception, rather than based on scientific facts (Lundgren & McMakin, 2018). Misinformation (Scheufele & Krause, 2019) about controversial scientific issues such as the autism-childhood vaccination connection (Dixon et al., 2015) and/or genetically modified organisms (GMOs) (Bode & Vraga, 2015) may decrease public trust in fact-based scientific communications about autism or GMOs. When there is a presence of misinformation surrounding scientific issues, there exists a need to identify factors shaping public perception.

The science communication literature identifies several factors affecting public perception of science, such as cognitive bias (Tsipursky & Morford, 2017), source of credibility (Flemming et al., 2015; Fleury et al., 2019), audience predispositions of beliefs (Rowe & Alexander, 2017), audience socio-demographics (American Academy of Arts & Science, 2018; Boudet et al., 2014), and exposure to true or false information (Balmas, 2014; Hwang & Southwell, 2009; Latré et al., 2018). Tsipursky and Morford (2017) discussed four types of cognitive biases that impact audience perception and reason for sharing misinformation on social media. The four types are: 1) Confirmation bias 2) In-group, 3) The Dunning-Kruger effect, and 4) Social networks (Tsipursky & Morford, 2017, pp. AA7-AA8). Rowe and Alexander (2017) stated that predispositions of beliefs, such as political or emotional character, social and cultural beliefs, and values-related mindsets, can all heavily influence public perception of science.

Sources of credibility can also affect public perceptions of science (Flemming et al., 2015; Fleury et al., 2019; Kim & Fang, 2020). Fleury et al. (2019) observed that when communicating information about autism treatment, participants' perception of information depends on the credibility of the source, rather than considering the balance between both evidence and credibility. Flemming et al. (2015) found a decreased perception of scientific credibility after presenting information on therapy for

Parkinson's disease using contradicting sources. Scientific consensus messages are another factor influencing perceptions of science. When members of the public perceive a high level of scientific consensus about the science being communicated, they typically develop positive perceptions toward the scientific information offered (Kim & Fang, 2020; Sarathchandra & Haltinner, 2019).

Exposure to true or false information can also influence people's perceptions (Balmas, 2014; Hwang & Southwell, 2009; Latré et al., 2018). Hwang and Southwell (2009) showed that exposure to science-related TV news stories elicited positive perceptions of science, and Latré et al. (2018) found that people who were exposed to nuclear emergency preparedness information had more positive perceptions of nuclear mitigation actions than those that had not. Balmas (2014) demonstrated that people can distinguish realistic information from misinformation if they were exposed to truthful information.

The report *Perceptions of Science in America* compared factors that influenced public perception such as childhood vaccines, safe use of genetically modified (GM) foods, and human-caused global warming and concluded that factors influencing perceptions of the scientific issues differed depending on the issue in question. For example, race and ethnicity strongly influenced perceptions of childhood vaccines, while these factors only moderately influence public perceptions of GMOs and global warming. Knowledge strongly influenced perceptions of GMOs, though it did not play as big a role in the other issues (American Academy of Arts & Science, 2018).

Perceptions of Science in America (2018) showed that most of the research on public perception regarded non-controversial issues, meaning that there is a need for research on factors influencing public perception of controversial scientific issues. *Communicating Science Effectively: A Research Agenda* identified a need for investigating perception factors in individual, social, and contextual terms when communicating contentious and polarizing scientific controversies (National Academies of Sciences, Engineering, and Medicine, 2017). Concerning context-specific factors, the authors of the current study identified the need for identifying factors that affect public perception of science when in the presence of misinformation. Because some people reject scientific facts and build scientifically unsupported beliefs about controversial scientific topics such as climate change, vaccines, and genetically modified foods due to misinformation they consider to be factual (Flynn et al., 2017).

Torraco (2005) and Torraco (2016) explained that when research on a particular topic grows, a need for a review, critique, and reconceptualizing of the topic arises. Literature reviews can help resolve inconsistencies in the literature and provide new perspectives for analysis (Torraco, 2016). Therefore, the current study aims to synthesize existing literature on factors that affect public perception of science in the presence of misinformation that surrounds the scientific issues in question. Paré et al. (2016) noted that "Literature reviews can play a significant role in advancing or disseminating knowledge, supporting evidence-based practice, developing new theories and shaping future research studies" (p. 495). We believe a literature review is perfect to identify factors influencing public perception of science and will increase understanding of how to convey scientific facts more effectively. This review provides a simple, yet flexible conceptual framework to portray relationships between the factors that influence public perceptions of science. Among several other methods of literature review to choose from, we used the integrated literature review (ILR) method.

Method

Compared with other literature review methods such as meta-analysis and systematic reviews, the ILR method allows researchers to incorporate diverse methodologies, both quantitative and qualitative, to help understand the context, process, and subjective elements of the topic (Doolen, 2017; Whittemore & Knafl, 2005). An ILR may produce biased results if reviewers do not follow transparent and organized frameworks to identify and synthesize the literature (Paré et al., 2016; Whittemore & Knafl, 2005). Therefore, the protocol was developed using the ILR method proposed by Torraco (2016) and Paré et al. (2016), including the guidelines for systematicity and transparency. Table 2.1 shows methodical steps in detail.

Table 2.1

Description and Specifications of the Methodological Steps

Step	Description	Specification followed in each methodical step
Search literature	• Searched literature using terms of public perception of science, fake news, and misinformation. • Assigned a unique identification number to each search result. • Developed a simple matrix (Torraco, 2016) with the title of publication, unique number, search term, and specific filters used for literature searches	• Searched Google Scholar, ProQuest, Communication Source, Academic Search Ultimate, PsycINFO, and Social Sciences Citation Index • Included journal articles, theses, and dissertations published from 2009 to 2019. • Excluded non-peer-reviewed articles, books, patents, and citations. • Considered studies published in English
Select articles	• Read titles and removed duplicates during the first screening. • Read abstracts, retained articles that fulfilled the inclusion criteria, and discarded the articles that fulfilled the exclusion criteria during the second screening. • Retrieved relevant studies and stored them in EndNote.	Inclusion criteria: • Considered studies about public perception of science (i.e., attitude) and/or perception as a factor or variable of interest. • Included studies that quantitatively or qualitatively analyzed or explained the relationship between public perceptions and science-related factual or nonfactual news. Exclusion criteria: • Excluded studies about public perception of non-science discipline (such as public perception related to health communication between patient to caregiver or physician, and consumer perceptions for commercial products—price and product labeling).

Table 2.1 Continued

Step	Description	Specification followed in each methodical step
Extract data	• Read each retrieved article and identified factors that affect public perception during the third screening.	• Determined study's topics, characteristics, research type, data analysis, and results (i.e., factors affecting public perception). • Summarized perception factors and created annotated bibliography for each article. • Used latent content analysis (Fraenkel et al., 2012) to analyze the literature. • Conducted qualitative synthesis (Paré et al., 2016) by evaluating perception factors and identifying their influence on public perception.
Synthesize	• Developed a conceptual framework of factors affecting public perceptions of science.	• Identified common factors and categorized them into themes and sub-themes based on similarity and relationship. • Developed the conceptual diagram with factors (see figure 2.2)

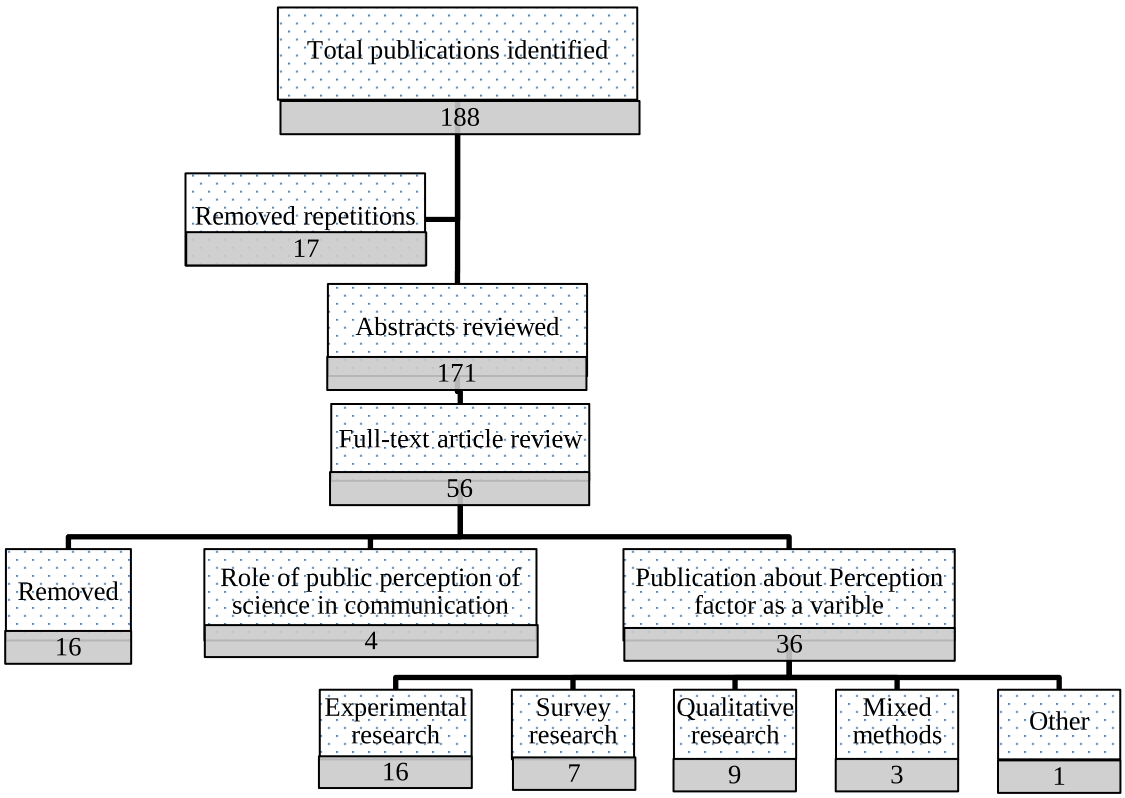
The literature search was performed in early April 2020 and was limited to literature published between 2009 to 2019. The 11-year frame was selected because of the increased use of social media that has exacerbated the spread of fake news since 2008 (Bessi, 2017; Karlova & Fisher, 2013; Popat et al., 2017; Scheufele & Krause, 2019) and the increased social media use among American adults in general (Ortiz-Ospina, 2019; Pew Research Center, 2018). Scheufele and Krause (2019) noted that the appearance of the term "fake news" in the U.S. and global newspapers increased dramatically after 2009. Therefore, analyzing literature between 2009 and 2019 helped us capture the dynamic of the spread of misinformation and its effect on public perception of science.

We used the databases Google Scholar (58 items found), Academic Search Ultimate (57), Social Sciences Citation Index (36), ProQuest (22), Communication Source (14), and PsycINFO (1) to search and acquire the literature. The literature search used the core terms “public perception of science,” combined with “fake news,” and “misinformation.” Scholars have used several terms to describe fake news such as “nonfactual news,” “misleading information,” “false news,” and “misinformation.” Therefore, we conducted the preliminary literature search using the terms “nonfactual news,” “misleading information,” and “false news,” but it did not yield a robust number of studies (less than 10). We combined the terms “public perception of science” and “fake news” in the first search; the second search combined “public perception of science” and “misinformation.” We considered materials published in English only; thus, the English language filter was used in each search. Studies were selected if they met the following inclusion criteria: 1) The study discusses public perception of (or attitude toward) science and/or perception of science as a factor or variable of interest, 2) The study quantitatively or qualitatively analyzed or explained the relationship between public perceptions and science-related factual or nonfactual news.

Through the literature searches, 188 artifacts with factors affecting public perceptions of science were identified. The studies were screened to identify these factors. Figure 2.1 illustrates the flow of studies through each screening step.

Figure 2.1

The Flow of Studies



Characteristics of Reviewed Studies

We reviewed the full text of 56 artifacts. In 36 of the artifacts, factors affecting public perception of science were identified as experimental variables or variables of interest. Four artifacts discussed the role of public perception of science in communications but did not discuss the factors affecting public perception of science when communicating science. Another 16 artifacts were excluded from the full review because they did not discuss factors affecting public perception of science. Studies on factors affecting public perception of science commonly used survey research methods. Sixteen studies used experimental survey research, seven nonexperimental survey research, nine qualitative methods, and three mixed methods. Sixty-three percent of studies were conducted in the United States, and 33% were conducted in other countries such as the United Kingdom, China, Canada, Germany, Israel, Spain, Belgium, and New Zealand. Some studies discussed factors affecting public perception of science in a specific discipline of science, while other studies considered science in general. For example, 28% discussed themes regarding GMOs, and 23% regarded climate change.

Results

This review sought to identify factors affecting public perception of science in the presence of misinformation that surrounds scientific issues. Appendix A shows the factors we identified in the current study. We categorized factors into five themes: type of science, audiences' beliefs, audiences' socio-demographic variables, communication sources, and environment. We also identified sub-themes that emerged within each main theme.

Type of Science

First, our analysis revealed that influence on public perception of science varies based on types of science communicated such as GM, nanotechnology, and climate change. For example, perceptions of scientific certainty were influenced by exposure to debate, and the influence varied based on issues discussed (Morin, 2018). Scientific certainty perceptions increased after exposure to debate on GMOs and evolution, but there was not the same effect on climate change (Morin, 2018). Also, the effect of knowledge on perception varied by type of science. Perceptions of GMOs had a strong association with the audience's knowledge level (Cui & Shoemaker, 2018; Nawaz et al., 2019), but for nanotechnology, knowledge had weak (Zhang et al., 2015) or no association (Ho et al., 2010). Moreover, the influence of credibility on perception was varied by the type of science communicated (Osman et al., 2018). Therefore, we agree with the American Academy of Arts & Science (2018) that perception factors have different influences on public perceptions depending on the type of science that has been communicated.

Audience Beliefs

Religious and Political Beliefs

We also observed that based on the scientific topic being communicated, the effect of religious and political beliefs varied. Studies often examined changes in perception of science due to religious beliefs using evolution as a topic and political ideology using climate sciences as a topic. Political ideology affected perceptions when climate science was communicated, and religious beliefs affected perceptions when evolution was communicated (Kahan, 2015a, and Kahan, 2015b, as cited in Bonney, 2018). A similar conclusion was made by Morin (2018), who stated that when a scientific subject becomes politically and/or religiously aligned with the audience's view, it is difficult to persuade individuals to change their perceptions of science. Examining public support for nanotechnology funding, Ho et al. (2010) found that religious beliefs had a negative association with perception. However, these studies were conducted solely in the USA, so the findings have limited generalizability to other countries.

Trust in Science

Trust in science is a key variable affecting public perceptions of science. "Trust in science is a multidimensional concept, which can be oriented toward diverse actors or areas, such as scientists themselves, and also scientists from different fields, scientific institutions, utilized methodology, or presented findings" (Lakomý et al., 2019, p. 249). The current IRL study, trust in science is discussed based on how it is reflected in perception studies: first, trust in science as a field, and second, trust in scientists (i.e. trustworthiness discussed later in this study). Wong-Parodi and Bruine de Bruin (2017) stated that trust and emotions affect perceptions and willingness to implement recommended behaviors. Palmer (2018) noted that having trust in science helps the audience identify conspiratorial information. However, trust in science has beneficial and detrimental effects on perceptions of science (Palmer, 2018). For instance, when pseudo-scientific information on controversial topics was available, trust in science had a negative influence on public perceptions of science (Palmer, 2018). Moreover, Zhang et al. (2015) noted that support for nanotechnology in China was positively associated with people's trust in nanotechnology. Support for nanotechnology were strongly associated with people's trust in nanotechnology than knowledge (Zhang et al., 2015). In this instance, the Chinese trusted in a scientific process, supporting its use, although they lacked knowledge of the process itself.

The level of trust in science affects public perceptions of science as well (Howell et al., 2018; Palmer, 2018). Palmer (2018) observed that respondents with higher levels of trust in science tended to base their beliefs on scientific content compared with those with low trust levels, who did not base their beliefs on content. Similarly, Howell et al. (2018) found that after the release of the NASEM report, people who had the least level of trust in science reduced their risk perception of GMOs. Additionally, Sonntag et al. (2019) found "the lack of confidence and trust in modern poultry farming systems had a major influence on the citizens' perception of poultry farming systems" (Sonntag et al., 2019, p. 211). The level of trust in science determines which way science communication changes the audience's perception.

Perceived Risks and Benefits

Perceived risks and benefits of scientific outcomes or technology shape public perceptions of science. In China, risk perceptions of GM foods were a contributing factor in determining public support of GM foods (Cui & Shoemaker, 2018). Nawaz et al. (2019) demonstrated that when people identified benefits of GM foods, their perceptions and willingness to consume GM foods increased. Meanwhile, in the USA, Ho et al. (2010) observed that perception of risks was negatively associated with public support for funding nanotechnology, while the perception of benefits was positively associated. Zhang et al. (2015) had a similar observation in China, where the greater the benefit/risk ratio, the more support was shown for nanotechnology. These studies support the argument that the perceived risk and benefit of science shaped public perceptions of GM foods and nanotechnology.

Our literature searches did not find studies that examined the effect of perceived risks and benefits on climate change perception as the main variable, even though it is a popular controversial issue. However, we found Lewandowsky et al.'s (2013) and Bass's (2016) studies that indirectly discussed perceptions of risks and benefits related to climate change. Lewandowsky et al. (2013) observed that audience free-market ideology had a higher level of effect on the rejection of climate change, which is due to the importance of fossil fuels. Bass (2016) observed that when citizens see economic impacts of climate change at the individual level (e.g., increased taxes on gasoline), their support for emission reduction policies relied more on their factual knowledge rather than their political ideology.

Preexisting Attitudes

Preexisting attitudes affect audiences' perceptions of science differently and have often been recognized as a moderating variable that influenced public perceptions of science together with other variables such as credibility, consensus messages, and type of science communicated. Concerning communicators' credibility, Lefevere et al. (2011) found that exemplars (common people who are arbitrarily selected by journalists and are featured in news coverage) who appeared in news stories had the highest influence, and the influence increased with preexisting beliefs. Likewise, the credibility of journalists and scientists was increased when the communicated story matched with readers' preexisting beliefs (Martins et al., 2018). Similarly, Landrum et al. (2018) noted that preexisting attitudes on GMO safety were generally associated with the perceived trustworthiness of researchers. Related to consensus messages, Dixon (2016) found that levels of prior beliefs created different levels of influence when communicating consensus messages. For instance, respondents with a low level of prior GM food beliefs were the least influenced by the consensus message (Dixon, 2016).

Concerning the moderating effect of preexisting beliefs together with types of science communicated, first, we found that Nagy et al. (2018) observed negative stigma around certain scientific issues as a result of preexisting beliefs in the Frankenstein myth (i.e., scientific research identified as dangerous because of irresponsible scientists). Second, Lewandowsky et al. (2013) noted that people who believed that previous environmental problems had been resolved were less willing to accept climate science (Lewandowsky et al., 2013). Third, Bass (2016) found that preexisting beliefs about the causes of climate change predicted people's support for climate mitigation policies.

Audiences' Socio-demographics

Within the pool of literature considered in this study, only a few studies reported relationships between perceptions of science and socio-demographic variables such as gender, age, income level, education, and/or knowledge. In China, Cui and Shoemaker (2018) found that age (being born before 1969) and income level had a negative association with attitude toward GMOs, while gender was unassociated. In the USA, Ruth et al. (2018) found that males had a positive attitude toward GMOs, while females had negative attitudes. Moreover, Ruth et al. (2018) noted that in the USA, those who earned more than $75,000 annually tended to have positive attitudes toward GMOs, which is opposite from China's high-income earners, who tended to have negative attitudes toward GMOs (Cui & Shoemaker, 2018). Mnaranara et al. (2017) noted that in

Tanzania, occupation was related to the perception of GM foods. Regulatory authorities and academicians had positive perceptions due to a higher level of awareness on GM foods and GM regulations, while farmers and media (who disseminate information) had negative perceptions because of risks and ethical issues related to GM foods (Mnaranara et al., 2017).

Most studies used socio-demographic data to characterize the sample population, but not as factors that influence the perception of science. We speculate that this may be for two reasons. First, researchers are not identifying socio-demographic facts as factors that influence public perception of science. Second, the literature often reports statistically significant results and excludes nonsignificant results. The elimination of nonsignificant results might be from a lack of evidence showing no relationship between public perception of science and socio-demographic factors.

Knowledge

The effects of knowledge on perceptions of science can be positive or negative. Concerning GMOs, when the audience had a higher knowledge of GMOs, their support and/or acceptance of GMOs increased (Cui & Shoemaker, 2018; Nawaz et al., 2019). When communicating nanotechnology, knowledge had a weaker association with their support of the technology in China (Zhang et al., 2015), while no association in the USA (Ho et al., 2010). Further, Lakomý et al.'s (2019) review concluded that knowledge had a positive but weak association with public perception of science.

Another dimension of the knowledge effect was studied by Smith et al. (2011). They found that people perceived astronomical images differently based on knowledge levels. Experts looked at astronomical images from a data-orientation perspective, and nonexperts perceived aesthetic or emotional values of the images (Smith et al., 2011). Cataldo et al. (2019) observed differences between credibility judgments of science news sources and educational stages. Findings of the current study suggested that knowledge impact on perceptions varied based on the type of science communicated, as well as levels of knowledge.

Sources of Communication

We identified three common subthemes under the main theme of the source of communication: Communicators' characteristics, Communication media characteristics, and Message characteristics.

Communicators' Characteristics

Characteristics of communicators (who share scientific findings with the public) influence public perception of science. We identified three characteristics: expertise, trustworthiness, and credibility as factors that influenced science perceptions. Communicators' expertise had positive and negative effects on people's perceptions of science. For example, Lefevere et al. (2011) found that when communicating scientific information related to local issues, common people who appeared in news can have higher influence than local politicians and scientists at local universities. Lefevere et al. (2011) noted that similarity, trustworthiness, and vividness of their accounts with the audience had the highest influence on common people, although they did not have technical expertise.

Osman et al. (2018) contended that source of credibility was an influencing factor on public perception of science. For example, the public perceived scientists as more credible than governmental groups. Martins et al. (2018) found that when communicating research about how media affects people, scientists' and journalists' credibility was positively associated with audience attitude change. Moreover, respondents who had a positive view of certain news organizations were more likely to consider science news coming from those organizations as more credible than those who did not have a positive opinion of the organization they received information from (Wilner, 2018).

Communicators' trustworthiness is closely related to trust in science generally, as noted earlier. However, we found specific studies that discussed trust in scientists and how it affected public perception of science. For example, Ho et al. (2010) and Zhang et al. (2015) found that people who trusted scientists more were more supportive of nanotechnology funding than those who had low trust in scientists (Ho et al., 2010). However, Sarathchandra and Haltinner (2019) stated that when communicating climate science, people who did not believe in the anthropogenic effect of global warming did not trust scientists or scientific methods used in climate science research. The trustworthiness of an organization that conducts open and transparent scientific research practice was positively associated with public perception of GMO safety (Landrum et al., 2018). This evidence shows trust in the communicator and the level of trust's effect on science perceptions.

Communication Media Characteristics

Format of Communication. Science communication appears in various formats, and we found studies on the effects of videos, print articles, debates, and satirical television news on audiences' perception of science. Young et al. (2017) concluded that videos (humorous or non-humorous) were more effective than printed articles in reducing audience misperceptions because videos helped to increase audience attention to the message and reduce message confusion more than printed articles. However, the humorous or non-humorous nature of the video did not affect the audience's perception (Young et al., 2017). Morin (2018) found that exposure to debate increased participants' perceptions of scientific certainty related to GMOs and evolution but did not have the same effect on climate change. Satirical television news coverage of global warming affected viewers' perceptions of climate change (Brewer, 2013; Brewer & McKnight, 2015, 2017). Overall, we noticed that studies tested the effect of the format using specific topics; thus, we could not select the most effective format for science communication. However, communicators should consider the type of communication format closely because it can help change their audience's perceptions of science.

Message Characteristics

The Tone of Communication. We found literature on how framing, ambiguous message, and consensus message reporting affected public perceptions of science. Kastenhofer (2009) studied how framing influences policymakers and society's perception of agribiotechnology and medical technology in Germany and Great Britain. In the early phase of technology, ethical framing was dominant, but when technology moved to the market, risk framing was dominant (Kastenhofer, 2009). Content analysis of media coverage during the Disneyland measles outbreak showed that a highly moralized tone changed risk perceptions and caused a regulation push that made vaccination mandatory in Canada (Capurro et al., 2018).

Martins et al. (2018) examined how conflicting sources' reporting affected the perception of journalists' and scientists' credibility. They found that the use of conflicting sources reduced public perception of scientists' credibility but not journalists' credibility (Martins et al., 2018). Brewer and McKnight (2015) found that the ambiguity of the presenter's message on controversial issues affected the viewer's interpretation of scientific information. They found *The Colbert Report's* led to biased ideological processing because of the presenter's ambiguity in the message but *The Daily Show with Jon Stewart* did not (Brewer & McKnight, 2015). In summary, the literature suggests that framing and ambiguity of messages changed public perceptions of science. We believe that when communicating controversial scientific topics, it is important to follow framing that emphasizes scientific evidence. Doing so will help the public to get a better understanding of the scientific facts.

Consensus Reporting. Several scholars found that when many scientists agree on facts related to controversial issues (i.e., consensus message reporting), the public belief about scientific issues became more accurate. Furthermore, the effect of consensus messages on the audience's perceptions varies based on the audience's prior beliefs (Dixon, 2016) and interest level in the type of science communicated (Brewer & McKnight, 2017). Dixon (2016) found that the consensus message had a positive influence on GMO beliefs, but those with low levels of prior GMO food beliefs were less influenced by the consensus message. Conversely, Brewer and McKnight (2017) found that participants with the lowest levels of interest in climate change experienced the strongest influences from the consensus messages on climate change. Lewandowsky et al. (2013) also stated that acceptance of climate science can be influenced by consensus information. Therefore, we agree with Martins et al.'s (2018) suggestion to follow the "weighting evidence approach" when the majority of scientists agree on scientific facts on a controversial issue.

Use **of Visuals.** The role of images' ability to change audience perception has been studied in specific contexts before. Gruber and Dickerson (2012) examined how the use of brain images changed the audience's perception. They concluded that images did not influence the reader's perception regardless of its uses: functional magnetic resonance imaging (fMRI), artistic renderings, and an image from a science fiction film. Moreover, Li et al. (2018) found that graph format and graph interactivity were not related to the perception of data credibility. Although these two studies did not find an effect of images on perception, we cannot conclude that images do not change or help to change perception; the absence of proof is not proof of absence. Rather, we urge communicators to use images or graphs suited to the purpose of communication because images and graphs help to convey meaning and clarify scientific information (Trumbo, 1999).

Environmental Factors

The fourth theme was environmental factors that affect public perception of science. Under this theme, we identified factors that cannot be directly controlled by the communicator or audience but resulted from the medium of communication. Exposure to information, social bots, geographic proximity to the event, the occurrence of an event related to science or technology, competing for economics, and authority and/or government endorsement are environmental factors identified in this literature search.

Exposure to Information

The quality of information that the audience has been exposed to can affect their perceptions of science. For example, Clayton et al. (2019) noted that audiences who were exposed to false information were more likely to take false statements as accurate than those who were exposed to true information. Gesser-Edelsburg et al. (2017) found that public awareness of health issues varied depending on the type of exposure (web news, forum, Facebook, and blogs). They reported that news websites use different types of sources to report scientific facts and the quality of information varies across websites, even though the news is about the same event (Gesser-Edelsburg et al., 2017). Climate blog readers perceived blogs as unbiased factual information sources that provided information not available through mainstream media such as newspapers (Zoukas, 2019).

Social Bots

Compared with other communication media, social media has different environmental factors that influence the user's perceptions of science. Automated actors or software-controlled profiles or pages, called "social bots," are one environmental factor that influences public or user perception of science. Using a simulated model, Ross et al. (2019) found that "In a highly polarized setting, depending on their network position and the overall network density, bot participation by as little as 2–4% of a communication network can be sufficient to tip over the opinion climate" (Ross et al., 2019, p. 407). This evidence shows that social bots have tangibly influenced public opinion.

Events Related to Science

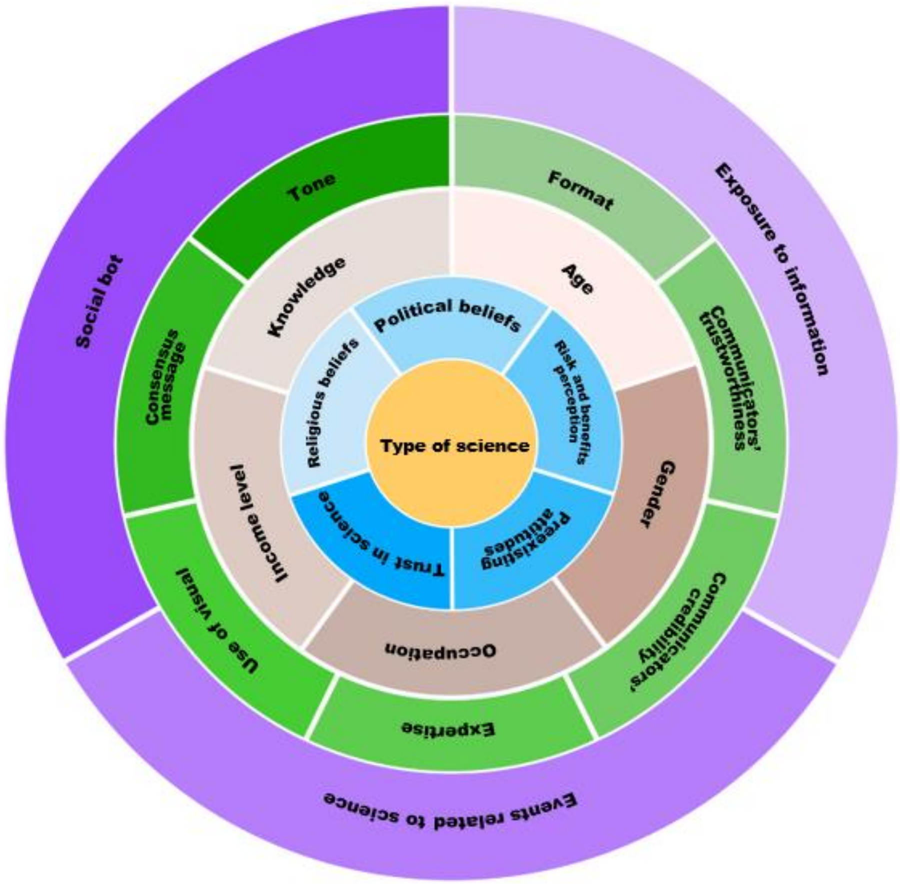
Events related to science or technology triggers perception differently. We identified studies that described the event, its geographic proximity, and when the event happened, which impacted public science perception. How the nuclear incident in Fukushima was discussed in tweets in the USA was studied by Li et al. (2016), who noted that geographically closer states to Japan discussed the incident and were more concerned about the event. The same study looked at whether having nuclear plants in their state influenced opinion, but a correlation was not found. Furthermore, Li et al. (2016) observed that negative sentiment and pessimistic views on nuclear accidents changed over time. Negative sentiments become neutral comments and uncertain over time (Li et al., 2016). Similarly, Suthanthangjai et al. (2013) examined the effect of changes in perception over time related to environmental reporting in New Zealand and concluded that overall perception is stable with few changes, which are not statistically significant. This study confirmed that short term variability in perception is possibly related to events (Suthanthangjai et al., 2013).

Discussion

This integrative literature review was aimed to identify and synthesize studies about factors affecting public perception of science when the presence of misinformation surrounds scientific issues. A total of 40 studies were included in this review, from which we found that various factors have different levels of influence on public perception of science. We created a framework, *Rings of public perception of science* (see Figure 2.2), to show how factors combine to influence public perception. The framework proposed does not reflect statistical comparisons of perception factors with other factors. It found that audience beliefs factors are the most influential factor theme. However, we argue that factors affecting public perception of science require a holistic approach to examine the influence because these factors interact and so cannot be separated.

Figure 2.2

Proposed Framework: Rings of Public Perception of Science



Note. Each ring represents the main themes of perception factors identified from this review. The foundational ring (yellow) represents the type of science, the first ring (blue) audience beliefs, the second ring (brown) socio-demographic factors, the third ring (green) communication source factors, and the fourth ring (purple) environmental factors.

Rings of public perception of science were arranged by level of influence which can be created by each factor theme. We speculated that inner (i.e., audience beliefs), more than outer rings (i.e., environmental), had greater effects on public perception of science. In our review, we found that the type of science communicated plays a key role in determining which factor influences public perception of science. Each discipline of science has unique rings that show how the different factors contribute to changing perceptions in particular scientific disciplines. For example, perceived risks and benefits influence communications of GMOs, but not climate change. The application of the ring of perception on climate change would not reflect perceived risks and benefits as a factor. Thus, we placed the type of science as the foundational ring of public perception of science. Our suggestion of the type of science as the foundational ring supports the findings of the American Academy of Arts & Science (2018) report, where it was noted that perception of science varied by the discipline of science communicated. Similarly, Jang (2013) noted that information-seeking patterns varied by science domains.

In this review, we found most studies noted preexisting attitudes as mediating variables that enhanced the effect of other perception factors. Recent studies on science communication showed preexisting attitudes significantly influenced people's use of information when communicating controversial scientific issues (Ecker et al., 2014; Knobloch-Westerwick et al., 2015; Rowe & Alexander, 2017; Yuan et al., 2019). Thus, we placed the audience's beliefs as the first ring. Identifying audience beliefs as the highest influencing factor theme concurs with recent recommendations to improve science communication using the mental models' approach. The mental models' approach prioritized appealing to audience beliefs more than providing factual information (Scheufele, 2013, 2014; Wong-Parodi & Bruine de Bruin, 2017). Recent scholarly recommendations to improve science communication have considered audience heuristics, biases, and values, which showed the key role of audience beliefs (Akin & Landrum, 2017; Landrum, 2017). We found that the audience's preexisting beliefs have a main effect on public perception of science, and thus we identify the need for research that explores the effect of preexisting attitudes on science perceptions as a main independent variable of interest rather than moderating variable.

We placed socio-demographic factors as the second layer of the ring because of the confounding influence that can be exerted by these factors together with audience beliefs. For example, Cui and Shoemaker (2018) noted respondents' attitudes toward GM foods were correlated with age. Moreover, socio-demographic factors such as knowledge can lead to healthy skepticism about scientific facts and overturn the impact of audience beliefs. This idea is further supported by the finding that political predisposition is overshadowed by factual knowledge about climate science (Bass, 2016). Thus, we believe that placing socio-demographics immediately after audience beliefs is appropriate. However, there is a need for future research to statically examine the confounding influence of socio-demographic factors together with beliefs and assess the strength of the relationship. In our review sample, we did not find studies that consider race and its effect on public perception of science. Therefore, similar to Ruth et al. (2018), we see the need to further examine how demographic factors affect the perception of science.

Although this review did not find evidence to support the impact of visuals on the perception of science, we found evidence that showed that communicators' credibility and trustworthiness, format, tone, and consensus message considerably affect public perception of science. Thus, factors related to communication sources laid the foundation as the third layer of the perception ring. Martins et al. (2018) stated that "media framing of scientific research clearly has the power to change minds after encountering just one story" (p. 114). Scheufele (2014) noted how media coverage primes the audience's attitude, while Yuan et al. (2019) found communication styles significantly influenced audience perceptions. Bucchi (2017) emphasized the importance of credibility and reliable information in changing the communication environment. However, we believe that the influence of communication sources is less powerful than that of audience beliefs because the audience analyzed new information along with confirmation biases and then selected information aligned with their beliefs (Knobloch-Westerwick et al., 2015).

The fourth ring consists of environmental factors affecting public perceptions of science. Our review found evidence that environmental factors such as exposure to information, social bots, and events related to science affected public perception of science. We presumed that environmental factors had the least influence on perceptions for two reasons. First, in our literature sample, we could not achieve data saturation related to environmental factors. Second, these factors are context bound and/or change over time. For example, Suthanthangjai et al. (2013) and Li et al. (2016) observed short-term variation in the perception of science with events related to science, but the effect became neutral over time.

Weingart and Guenther (2016) reported algorithms that personalized communication preferences and social bots influenced science communication. Scheufele (2014) contended that lay audiences do not pay attention to all available information, but rather to information created by mediated organizations (i.e., called "mediated realities"). He thus concluded that "mediated realities heavily influence both public perceptions of science more generally—fact-based or not—and public understanding of scientific topics" (Scheufele, 2014, p. 13588). Ongoing transformations of communication infrastructures create new factors that affect public perception of science (Castelli et al., 2013; Scheufele & Krause, 2019).

Factors affecting public perception of science have been studied at two stages. In the first stage, researchers examined associations or relationships between factors and perception (religious beliefs and knowledge). In the second stage, they examined degrees of influence on public perception of science (high vs. low levels of trust in science). In-depth studies are needed to determine what levels of influence these factors have on public perception of communicating science. For example, exposure to information needs further research to see how the frequency of news exposure affects one's perception of science on controversial issues. This review is limited to specific studies based on search criteria; other studies may have investigated the degree of influence on perceptions that are not reported herein.

Our analysis found that perceived risks and benefits of science were major influencing factors that are often studied in perception research. We identified a need for a clear definition of perceived risks and benefits as influences on public perception of science. Perceived risks and benefits vary contextually, for instance, a specific science or technology may have benefits related to human wellbeing, personal health, environmental, or financial issues associated with specific science disciplines and their effect on science perceptions. For example, the audience may have unfavorable risk perceptions towards global warming due to environmental concerns, but not related to potential health risks associated with global warming. Applications of specific technologies also need further study. For example, the risks of using GMO technologies to produce food are perceived differently from uses of GMOs in nonfood applications (Cui & Shoemaker, 2018; Dijkstra & Gutteling, 2012; Knight, 2006).

In our review sample, 63% of studies on factors influencing public perception of science have been conducted in the United States; few studies have been conducted elsewhere. Therefore, when discussing the influence of political and religious beliefs on public perception of science, a limitation exists in generalizing our findings beyond the United States. Because religious and political ideologies vary by country, their effects on public perception of science may vary as well. Lee et al. (2015) found that factors that influence risk perception of climate change varied by country. We see the need for studies in other countries to increase global understanding of factors influencing public perception of communicating science. We identified the need for research in developing countries because new scientific technologies have the potential to improve the quality of life in those places, but acceptance of these technologies is largely based on the perception of science (Peters & Slovic, 1996; Shew et al., 2018; Siegrist, 1999). For example, Mbabazi et al. (2016) found that public perception of GMO and anti-GMO group activities were the main factors impacting biotechnology development in Africa, Asia, Latin America, and Europe.

Most studies examined were based on survey research and quantitative methods to determine the factors affecting public perception of science. We speculate that surveys limited the discovery of new or underlying factors that affect public science perception. Quantitative survey research often relies on respondents answering pre-selected questions and cannot explore the complex reality of research themes, as done in qualitative research (Lincoln & Guba, 1985; Merriam, 2009).

With the increasing use of social media to communicate science, we speculate that new factors such as social media use, social networks, and following influential users impact one's own perception of science. Therefore, we identified a need to explore new factors that affect public perception of science because the landscape of science-related communication is ever-changing. We propose conducting case studies to identify new factors, as case studies are the best approach when "it is impossible to separate the phenomenon variables from their context" (Merriam, 2009, p. 43). Our suggestion aligns with that of Nisbet and Goidel (2007), who urged combining qualitative approaches with quantitative surveys to examine factors influencing public perception at group, community, and national levels.

Limitations

We also realize that our study has limitations. First, the literature search was limited to 11 years, used specific terms and search engines, used findings reported in peer-reviewed articles, dissertations, and theses, and was limited to English-based literature. Second, this review does not cover all published research on factors affecting public perception of science. Third, selected literature was analyzed using latent content analysis; thus, the conclusions made might reflect the researchers' subjectivity, which is common for qualitative studies (Creswell, 2013). Fourth, we did not achieve data saturation to support relationships between factors and perceptions, and some observations were based on only one or two studies. Therefore, our categorization and placement of themes in the ring of public perception of science may not reflect the overall literature about public perception of science or statistical relationships among all possible factors. Finally, we intended to identify factors specific to communicating science in the presence of misinformation. Therefore, the factors identified may not apply to communicating scientific issues that are not affected by misinformation. Despite these limitations, this research can be seen as the first step toward a holistic approach to examining factors that affect public perception of science.

Conclusion

It is difficult to include all factors that influence public perception of science, due to the changing landscape in scientific research and its communication. This review summarizes factors affecting public perception of science when in the presence of misinformation; the influence made by each factor illustrated through the framework of rings of public perception of science. The rings of science perception could improve our understanding of factors affecting science perceptions. This study clarified that type of science is a fundamental factor that determines the level of influence of other factors. The ring framework could improve research on perception factors by identifying the need for a holistic approach and systematic thinking to see the influence of different factors as a whole.

The proposed ring framework can be used to design communication strategies when considering factors affecting controversial scientific issues. This study identified the need for future research on degrees of influence exerted made by the factor on public perception of science, research in developing countries, and qualitative studies to identify context-specific factors. There is a need to identify emerging environmental factors because of the changing landscape of scientific communication with the increased use of social media. Future studies should include statistical relationships among factors to assess the positioning of factors and rings proposed in this review.

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3. FACTORS AFFECTING PUBLIC AGREEMENT ABOUT SCIENTIFIC INFORMATION ON ORGANIC FOODS

Overview

Public perception of organic food does not always align with scientific evidence. This misalignment raises the need to identify factors that contribute to the mismatch of public perception with factual information about organic foods. Using data from a descriptive survey (*N* = 763), we examined the association between levels of agreement with scientific information and 19 factors that potentially contribute to agreement levels. Multinomial and multiple linear regression analyses were used to identify the association between factors and agreement levels. Benefit perceptions about organic foods had a negative association with levels of agreement with scientific information, while trust in scientists and credibility of communicator had a positive association. Food preference, overall trust in science, and events related to science (in particular, COVID-19) had a weaker association with agreement levels. Age, gender, income level, education, and factual knowledge of science had no statistically significant relationship with levels of agreement with scientific information about organic foods. To increase public agreement with scientific information about organic foods, future communication should be designed considering misconceptions related to perceived benefits of organic foods and convey the scientific facts engaging trusted scientists or nutritionists.

Introduction

Past research (Brantsæter et al., 2017; Forman & Silverstein, 2012; Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012; Sobieralski et al., 2013) found that although some organic foods had higher levels of bioactive compounds (polyphenols, vitamin C, and carotenoids) and lower levels of cadmium and other pesticides than were found in conventional foods, organic foods did not provide significant health benefits over conventional foods. Moreover, some scientists (Brantsæter et al., 2017; Forman & Silverstein, 2012; Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012; Sobieralski et al., 2013) have argued for long-term experimentally controlled studies to determine the health benefits, if any, of organic foods. People who consume organic foods generally follow a healthy lifestyle; therefore, the conclusion could not be reached that an organic-food diet provided health benefits (Brantsæter et al., 2017; Hurtado-Barroso et al., 2019; Mie et al., 2017).

Despite a lack of scientific evidence showing significant health benefits of organic foods over conventional foods, some consumers believe that organic foods are healthier and better than conventional foods (Anghelcev et al., 2020; Guido et al., 2010; Pew Research Center, 2016; Rana & Paul, 2017). Furthermore, the organic foods industry often promotes its products as nutritionally superior to conventional foods (Rosen, 2010). Why do some prefer organic foods despite the lack of scientific evidence that those foods are healthier than conventional foods? A need exists to find perception factors that affect agreement levels of scientific information about organic foods to answer this question. Current research on perception factors regarding organic foods have often examined consumers ‘perceptions and purchase intentions (Asif et al., 2018; Teng & Wang, 2015) but rarely considered perceptions about scientific information (Olson, 2017). Among the scant available research, one study (Hoefkens et al., 2009) in Belgium reported that the mismatch (i.e., gap) between consumers’ perceptions and scientific evidence was higher among consumers who frequently consumed organic foods.

To address this knowledge gap, the research problem of the current study centers on identifying factors that affect public agreement with scientific information about organic foods. Accordingly, the research objectives included: 1) measuring participants’ levels of agreement with scientific information about organic foods, 2) examining the relationship between levels of agreement with scientific information about organic foods and selected perception factors, and 3) identifying the best predictors of public agreement with scientific information about organic foods.

The conceptual framework *Rings of Public Perception of Science* (see Figure 2.2) was used to identify possible factors influencing agreement levels with scientific information (Koswatta et al., 2021). Rings of public perception of science presents five main themes that influence public perception when communicating science in the presence of misinformation. The current research selected 19 factors from the conceptual framework that might contribute to levels of agreement with scientific information about organic foods. The possible associations between factors and the agreement levels were identified by reviewing past literature on consumer perceptions and communication about organic foods.

Literature Review

First Ring – Audience Beliefs

Trust in Science

A person's trust in science plays a critical role in accepting scientific evidence (Palmer, 2018). In terms of organic foods, building trust is considered an important component to increase a consumer's intention to purchase organic foods. In particular, trust in scientific facts is the main element that boosts the consumption of organic foods (Vega-Zamora et al., 2019). Furthermore, a higher level of perceived trustworthiness of sellers and manufacturers increases consumers' purchase intentions (Anisimova, 2016). Therefore, the current study was interested in examining whether trust toward science in general influences the level of agreement with scientific information about organic foods.

Preexisting Attitudes

Consumer perception research on organic foods shows that preexisting attitudes on the superiority of organic foods over conventional food are closely related to purchase intentions (Massey et al., 2018; Yiridoe et al., 2005). When communicating scientific evidence about the ambiguity of health benefits related to organic foods, preexisting attitudes lessened the impacts of scientific information (Costanigro et al., 2014; Koswatta et al., 2022; Olson, 2017). Therefore, this study assumed that those who prefer organic foods would be less likely to agree with the scientific information presented to the participants about organic foods. Preexisting attitudes will be a significant factor when predicting agreement levels.

Religious and Political Beliefs

Many religions have specific dietary practices, and often these practices are unsupported by scientific evidence (Ayoob et al., 2002). Religiosity factors were not linked with organic food attitudes in the United States (Larson, 2018) and Norway (Honkanen et al., 2006). However, Minton et al. (2015) found that more religious consumers participate in sustainable behaviors and buying organic foods in the United States.

Influences of political ideology on public perception of science vary by the controversial topic being communicated (Drummond & Fischhoff, 2020). Drummond and Fischhoff (2020) found that even though there were discussions about pesticide-free food supply in the 1980 and 1984 political platforms in the United States, national surveys conducted in 1979 and 1983 did not show relationships between political ideology and attitude toward food additives and preservatives. Larson (2018) concluded that political preference was not associated with organic food preferences in the United States. However, among a Norwegian sample, political motives positively influenced consumer attitudes toward organic foods (Honkanen et al., 2006). Therefore, the current study was interested in examining how religiosity and political ideology contribute to the agreement levels of scientific information about organic foods.

Perception of Risks and Benefits

Some consumer perception research has shown that consumers who perceived organic foods had health benefits (had less health risk and were more nutritious) were more likely to purchase organic foods (Anisimova et al., 2019; Özfer Özc¸elik & Uçar, 2008; Truong Thien et al., 2012). Moreover, perceived animal welfare (Truong Thien et al., 2012) and environmental benefits (Forman & Silverstein, 2012; Jensen et al., 2019) influenced preferences for organic foods over conventional foods. In terms of risks, Forman and Silverstein (2012) noted that people prefer organic foods over counterparts to avoid synthetic chemical exposure, products containing antibiotic-resistant bacteria, genetically modified foods, or growth hormones. Furthermore, consumers perceived that eating conventionally grown food had a higher pesticide-related risk than other public health hazards encountered in daily life (Williams & Hammitt, 2001). Therefore, the current study assumed risk and benefit perceptions were negatively associated with levels of agreement with scientific information about organic foods.

Second Ring – Socio-Demographic Factors

Several scholars have noted that knowledge about organic foods is one of the main predictors that increases purchase intention (Mesías Díaz et al., 2012; Yiridoe et al., 2005). However, perceived knowledge about the nutrition values of foods did not relate to believing scientific information about the ambiguity of the health benefits of organic foods (Koswatta et al., 2022). Further, perceived knowledge about organic foods did not impact attitudes toward organic foods but did help build trust in organic foods (Teng & Wang, 2015). These studies considered perceived knowledge and did not specifically discuss factual knowledge of science. This current study considered factual knowledge and its influences on levels of agreement with scientific information about organic foods.

Studies have highlighted the relationship between demographics and the intention to purchase organic foods. Age was negatively related to organic food consumption in the United States (Curl et al., 2013; Larson, 2018). Females are more likely than males to consume organic foods (Curl et al., 2013; Larson, 2018; Williams & Hammitt, 2001). Considering education, those with higher levels of education prefer purchasing organic foods (Curl et al., 2013; Larson, 2018). In terms of associations between income levels and purchase intentions, consumers with high incomes prefer buying organic foods (Curl et al., 2013).

Limited studies revealed the relationships between public perception and scientific information about organic food. A study conducted in Belgium found a mismatch (i.e., gap) between how consumers perceived organic foods and scientific evidence; the mismatch did not vary by gender, education, or income level (Hoefkens et al., 2009). Therefore, it is unclear how socio-demographic factors influence public agreement on scientific information about organic foods in the United States.

Third Ring – Communication Source

Format and Credibility of Communicator

Different studies conducted in several locations have found that the credibility of communication channels is perceived differently from one channel to another when it comes to organic foods. Among East European consumers, the Internet has been identified as the most common channel for receiving information about organic foods, but information from it had a lower level of credibility than information received from friends and acquaintances, which had the highest credibility (Nasir & Nasir, 2017).

Having friends and family who buy organic foods significantly increased the purchase intention of consumers in Taiwan (Teng & Wang, 2015). In Australia, communication received from friends and social media (i.e., uncontrolled media) increased purchase intention. In contrast, traditional media channels such as newspapers, magazines, and advertisements from sellers (controlled media) increased the clarity of communication about organic foods (Anisimova et al., 2019). Thus, the current study assumed that the source of information and audience who they believed as a credible communicator influenced the level of agreement on scientific information about organic foods.

Trust in Scientists

Trust in scientists has been studied in several contexts. Trust in scientists has been associated with support for nanotechnology research in the United States and China (Ho et al., 2010; Zhang et al., 2015). Similarly, in climate science, trust in scientists influences how people accept evidence about global warming (Hmielowski et al., 2013). Further, Hmielowski et al. (2013) noted that trust in scientists is an important heuristic that people use when communicating science-related topics. There is merit in identifying the relationship between trust in scientists and agreement levels with scientific information. Many studies on the nutritional benefits of organic foods found no clinically significant health benefits from organic foods over conventional foods (Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012; Sobieralski et al., 2013). The current study assumed that those who have high levels of trust in scientists would agree with scientific information about organic foods more than those who have low trust in scientists.

Fourth Ring – Environmental Factors

Information Exposure

Confusion resulting from information overload is a challenge in nutrition communication (Spiteri Cornish & Moraes, 2015). Higher exposure to health communication from various media creates fear among participants and leads to unhealthy behavior (Nagler, 2014; Spiteri Cornish & Moraes, 2015). Regarding organic foods, participants with exposure to conflicting news have a confused view of the nutritional benefits of organic and conventional foods (Northup, 2017). Further, people who have a higher level of exposure to news about the health effects of foods and drinks were more susceptible to misinformation related to organic foods (Koswatta et al., 2022). Therefore, the current study was interested in examining whether the frequency of news exposure on organic foods influences levels of agreement with scientific information on organic foods.

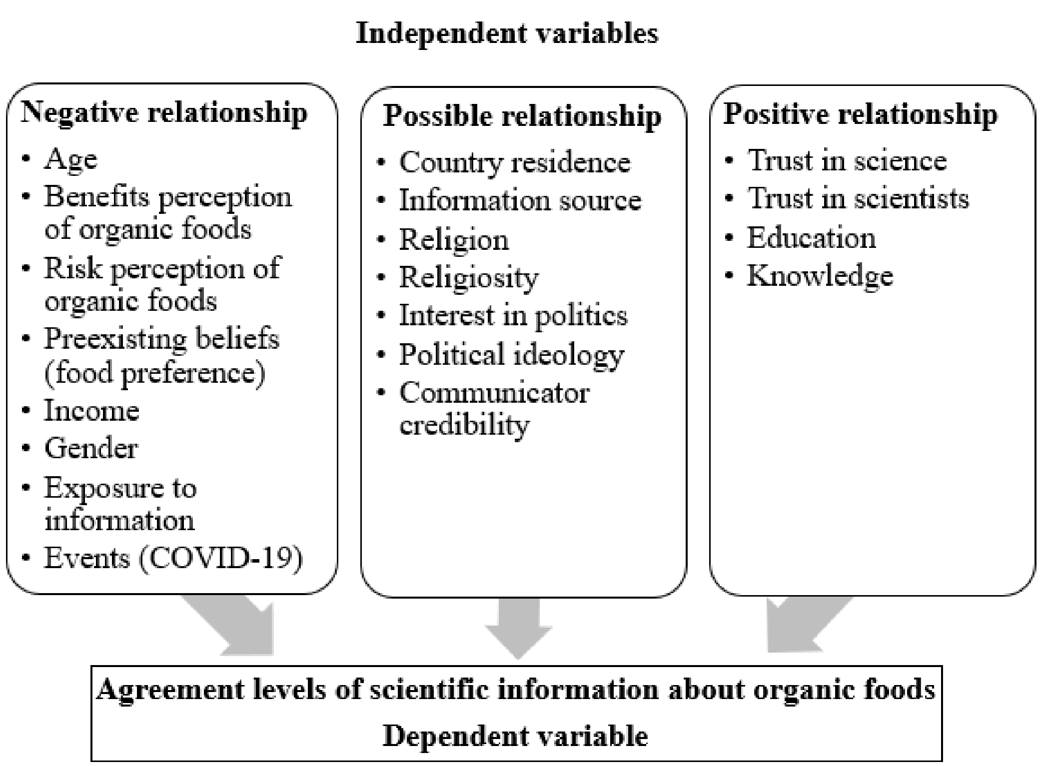
Events Related to Science

Events related to science change the public's perception of science for a short period (Li et al., 2016; Suthanthangjai et al., 2013). We selected the coronavirus disease 2019 (COVID-2019) pandemic as the event to test whether events influence levels of agreement with scientific information about organic foods. COVID-19 impacted the whole world during the study period. In China, COVID-19 positively influenced attitudes about organic foods because of perceived health benefits from organic foods (Xie et al., 2020). Therefore, the current study assumed that those who started to eat organic foods rather than conventional foods or increased consumption of organic foods to strengthen the immune system would not agree with scientific information about organic foods.

The primary research hypothesis was that there would be a relationship between levels of agreement with scientific information about organic foods and identified factors. Figure 3.1 summarizes the assumed relationships between the factors and agreement levels.

Figure 3.1

Conceptual Framework of the Current Study



Methods

A descriptive survey was conducted to determine the relationship between factors and levels of agreement with scientific information on organic foods. Descriptive surveys help to describe phenomena (Cook & Cook, 2008; Reio, 2016), determine population characteristics (Fraenkel et al., 2015), and assess the attitudes, beliefs, and behaviors of participants (Weisberg, 2008). Survey errors (measurement, non-response, and sampling) and survey effects (question-related effects, model effects, and comparison effects) are common constraints for survey research (Weisberg, 2008). However, a carefully planned survey can overcome those constraints (Dillman et al., 2014). Moreover, previous studies of perception factors often used survey research to collect science perception data (Jordan & Elnagheeb, 1991; Li et al., 2018). Thus, we identified descriptive survey research as the appropriate method to identify public levels of agreement with scientific information about organic foods. We selected a web-based survey because web-based surveys reach many higher numbers of individuals more quickly than mail surveys.

The required sample size was determined using the equation $N > 50 + 8m$ (where m denotes the number of independent variables) that Tabachnick and Fidell (2013) recommended, assuming a medium-size relationship at $\alpha = .05$ and $\beta = .20$. To examine the relationship between agreement levels and 19 independent variables, we identified that a minimum of 202 cases was required to achieve generalizability. Moreover, Pituch and Stevens (2015) recommended 15 subjects per predictor to have a reliable multiple regression equation. Thus, we aimed to achieve a minimum of 285 responses for this study.

The population comprised registered students and employees at a major land grant university in the Southwestern United States and the public. A survey link was shared with registered users via the university bulk e-mail service, which had 53,047 subscribers. The study followed a five-contact e-mail strategy that Dillman et al. (2014) suggested. Approximately 950 subscribers to bulk e-mail clicked the survey link; 652 completed the survey, and 125 started but did not complete it. The primary researcher also posted the survey link on social media (Facebook, Twitter, and LinkedIn) and invited the public to the study. A total of 199 participants came from social media; 155 completed the survey, and 44 did not. The survey was managed using Qualtrics survey software. All data were collected anonymously from February 15 to March 24, 2021. Incentives were not offered. A one-time "Prevent Ballot Box Stuffing" function was used to prevent people from retaking the survey. Duplicate responses based on IP addresses were removed. The first entry from a unique IP address was considered the primary case, and others were removed from the sample. A total of 34 respondents were removed because of duplicated IP addresses. Participants who did not indicate consent (3 respondents), were younger than 18 years old (1) or older than 100 years old (1) or did not indicate agreement levels of scientific information (5) were removed. The study fulfilled the exemption requirement under the university Institutional Review Board's reviews (IRB Number: IRB2019-1036M).

A total of 763 responses were considered for the analysis. Most respondents were women (65%) and highly educated (53% held a graduate or professional degree); 91% were residents of the United States. Respondents' mean age was 43 (M = 42.65, SD = 16.82). Malhotra et al. (2014) noted that late respondents were more likely to misreport factual information. We compared early to late respondents to address possible non-response errors following the recommendation of Lindner et al. (2001). Respondents who completed the survey after the final reminder e-mail were considered late respondents (n = 45); others were identified as early respondents (n = 718). The independent sample t-test showed that no significant differences existed between early (M = 4.56, SD = 1.52) and late respondents (M = 4.58, SD = 1.71) when tested ($p < 0.5$) on agreement level of scientific findings related to organic foods; $t(761) = .070$, p = .944, d = .016, 95% CI [-0.44,0.48].

Survey Instrument

The survey instrument was developed based on the literature on science communication and audience perception of organic foods. It contained 20 questions corresponding to 19 factors. Willits et al. (2016) noted that single-item questions are more appropriate when asking respondents to provide overall evaluations on complex issues. Therefore, we used a single-item question to collect the respondents' views on religion, trust in science, politics, and preexisting attitudes toward organic foods. All questions and statements were worded positively to avoid low-reliability issues (Barnette, 2000; Chyung et al., 2018; Mike, 2017). Appendix B shows the original survey questions and the coding scheme used for analyses.

Independent Variables

Audience Beliefs

Trust in Science. Trust in science (*M* =4.22, *SD* = 1.02) was measured using one question that was adapted from the Science and Engineering Indicators 2018 (National Science Board, 2018). The question asked, “Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?” with the five response options: 5 = *benefits strongly outweigh harmful results*, 4 = *benefits slightly outweigh harmful results*, 3 = *benefits are about equal to harmful results*, 2 = *harmful results slightly outweigh benefits*, and 1 = *harmful results strongly outweigh benefits*.

Preexisting Attitude About Organic Foods. Preexisting attitudes toward organic foods are commonly measured by asking whether organic foods are healthier, tastier, and less risky and offer more benefits than conventional foods (Chen, 2009; Teng & Wang, 2015). In the present study, we wanted to separate perceptions of risks and benefits of organic foods from general attitudes about organic foods; therefore, participants were asked to indicate their food preferences (*M* = 2.53, *SD* = 1.57) from five options. The options were: 5 = *usually prefer organic foods*, 4 = *occasionally prefer organic foods*, 3 = *occasionally prefer conventionally grown foods*, 2 = *usually prefer conventionally grown foods*, or 1 = *prefer foods based on nutritional value rather than choosing only organic or conventional foods*. Pickens (2005) noted that behaviors are closely linked with people’s attitudes toward the situation or object; thus, we believed participants' food preferences illustrated their overall preexisting attitudes about organic foods.

Political and Religious Beliefs. Two items were used to collect information about respondents' political views. The first question was used to determine the level of interest in politics. Participants were asked to select one option from; 1) *I am favorable towards one political party regardless of their policy agenda* (5%), 2) *I am unfavorable towards one political party regardless of their policy agenda* (2%), 3) *My support of a political party is based on the policy agenda presented by the political party* (70%), 4) *I don't favor a political party* (18%), and 5) *I am not interested in politics* (9%). The second question measured the level of political views (M = 4.08, SD = 1.74) on the political spectrum on a 7-point scale (1 = *very conservative* to 7 = *very liberal*). Participants were asked to select their religious affiliation from eight religious' affiliations: (Christian (62%), Islam (1%), Judaism (1%), Hinduism (3%), Buddhism (7%), Atheist (9%), Agnostic (12%), and Other not included (5%)). For analysis, religious affiliation was collapsed into three categories: Christian, other religions, and atheist or agnostic. Religiosity (M = 4.24, SD = 2.03) was measured using a 7- point scale (1 = *not at all religious* to 7 = to *very religious*)

Risk and Benefit Perception of Organic Foods. Risk and benefit perception scores were calculated separately. The overall benefit perception score was calculated by adding ratings of four statements about the benefits of organic foods (M = 17.96, SD = 6.02). Similarly, the risk perception score was calculated by summing scores four statements about risks avoided by eating organic foods (M = 18.90, SD = 5.76). The statements were created based on previous literature (Forman & Silverstein, 2012; Jensen et al., 2019; Özfer Özc¸elik & Uçar, 2008; Truong Thien et al., 2012). We asked participants to rate the level of agreement with each statement using a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*). The benefits statements were organic foods: 1) are more nutritious than conventionally grown foods; 2) improve animal welfare; 3) reduce the environmental impact caused by conventionally grown foods, and 4) reduce health risks. Cronbach's alpha for the perception of the benefits construct was .90. The risk perception construct had four statements: organic foods help us to avoid: 1) synthetic chemical exposure such as pesticides, herbicides, and fertilizers; 2) products that contain antibiotic-resistant bacteria; 3) genetically modified foods; and 4) products that contain growth hormones. Cronbach's alpha for the risk perception construct was .85.

Socio-Demographics

Knowledge. We used the seven most often used questions in the Science and Engineering Indicators (National Science Board, 2018) to measure factual science knowledge levels (*M* = 6.07, *SD* = 1.11). We adapted modified wording that Kahan (2015) suggested to avoid measurement errors that resulted from culturally sensitive knowledge statements. We selected seven items because Willits et al.'s (2016) study noted that five, six, or seven statements are adequate to represent a construct. Response options were *yes* or *no*, each correct answer scored one, and the total number of correct answers determined the overall knowledge score. Example statements are "The center of the Earth is very hot" and "Lasers work by focusing sound waves." We used the "display answers in a random order" function in Qualtrics to avoid primacy and recency bias. Kuder-Richardson-21 reliability was .40, which is considered to be low reliability (Fraenkel et al., 2019)

Other Socio-Demographic. Measurement of socio-demographic variables included age, education levels, country of residence, self-reported income level (low (13%), middle (66%), and high (15%)), and gender. Participants were asked to indicate their birth year, and age, considered as a continuous variable, was calculated based on the year 2021. Gender and country of residence were coded as dichotomous variables with female (65% of respondents) and residence in the USA (91% participants) coded one, and all others coded zero.

Communication Source

The rings of public perception of science contains several factors under the communication theme. For this study, we chose information sources, communicators' credibility, and trust in scientists (trustworthiness) factors that possibly influence public's agreement with scientific information about organic foods. We asked participants to indicate their information sources for organic food to test the effect of the source. We used eight primary sources noted in Science & Engineering Indicators 2018 (National Science Board, 2018) to collect data. We divided internet sources into two categories: one with websites and online question and answer sites (Wikipedia, Q&A sites like Yahoo Answer) and another with social media (Facebook, Pinterest, Instagram, LinkedIn, Twitter, Snapchat, YouTube, Reddit). Internet (22%), social media (17%), and friends and family (15%) were the most selected categories. We created a dichotomous category for the information source internet, with internet (most popular) coded one and others coded zero.

Additionally, participants were asked to select the most credible communicator for receiving information about organic foods. We identified eight possible communicators about organic foods from previous studies (Ayoob et al., 2002; Teng & Wang, 2015). The eight communicator types were: 1) Journalists who report about organic foods, 2) Representatives from companies that sell certified organic foods, 3) Representatives from institutions certifying organic foods, 4) Politicians who support organic foods, 5) Nutritionists, 6) Scientists researching organic foods, 7) My friends who eat organic foods, and 8) My family members who eat organic foods. We displayed answers in a random order to avoid primacy or recency bias (Dillman et al., 2014) for information source and credibility source questions. Most of the respondents selected nutritionists or scientists as the most credible communicators (83%). We created a dichotomous category for the credibility of communicators, with nutritionists or scientists were coded one, and others were coded zero.

Trust in Scientists. Six statements were used to measure overall trust in scientists. We selected six statements covering content related to general attitudes toward scientists, trustworthiness, and expertise. "Scientific researchers are dedicated people who work for the good of humanity" and "Scientists are helping to solve challenging problems" were adapted from Science & Engineering Indicators 2018 (National Science Board, 2018). Three statements, 1) "We should trust scientists being honest in their work"; 2) "We should trust scientists being ethical in their work"; and 3)

"We can trust scientists to share their discoveries even if they don't like their findings" were adapted from the trust in science and scientists inventory (Nadelson et al., 2014). The statement "Scientists' training should be sufficient to make audiences trust them" was adapted from Palmer's (2018) study. Cronbach's alpha for the trust in scientists scale was .86. An aggregated score of trust in scientists was created, summing up ratings for all six statements (M = 31.91, SD = 6.63).

Environmental Factors

We measured the frequency of news exposure by asking participants to rate the exposure levels to news related to organic foods using a 5-point scale from 1 = *not at all*, 2 = *monthly or less*, 3 = *a few times a month*, 4 = *a few times a week*, and 5 = *daily*. We integrated the United States Department of Agriculture (USDA) definition of organic foods into the question to eliminate possible misinterpretation of organic foods. Forty-four percent were exposed to information related to organic foods monthly or less, 23% a few times a month, and 24% not at all exposed.

We used two items to measure the impacts of events on agreement levels with scientific information about organic foods. Participants indicated whether they started to eat organic foods or increased consumption of organic foods to strengthen the immune system because of COVID-19 using a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*). Cronbach's alpha for the event related to science was .92. Respondents who selected *somewhat agree*, *agree,* or *strongly agree* with either statement were considered as having been impacted by the events of COVID-19 and coded one (22%) and others coded zero (78%).

Dependent Variable

Agreement levels with scientific information about organic foods were measured by asking respondents to indicate how much they agree or disagree with the following statement:

> Several scientific studies have shown that organic foods have higher levels of bioactive compounds (e.g., polyphenols, vitamin C, and carotenoids) and lower levels of cadmium and other pesticides than conventionally grown foods. However, these higher levels of bioactive compounds and lower pesticide exposure levels have not been found to have a significant effect on human health.

Participants used a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*) to indicate agreement levels (M = 4.56, SD = 1.53). For the ordinal and multinomial regression analyses, *strongly disagree*, *disagree*, and *somewhat disagree* groups were collapsed into the "disagree" category, and *agree* and *strongly agree* were collapsed into the "agree" category to avoid a cell count of less than 5.

Data Analysis

Descriptive analyses were conducted for all perception factor variables. The number of missing cases was less than 2% per variable; thus, we excluded cases with missing values (Tabachnick & Fidell, 2013). The highest percentages of missing cases were for age (1.7%) and gender (1.3%). For analysis, we excluded cases listwise. Ordinal regression analysis using the cumulative logit model (SPSS PULM) was performed to identify factors associated with agreement levels with scientific information about organic foods. There was multicollinearity between total benefit score and total risk score, $r(760) = .72$, $p < .001$; thus, the total risk score was excluded from analysis, resulting in 18 factors. Evaluations of the adequacy of expected frequencies for categorical and nominal variables indicated that no cell had less than 5 expected frequencies. Additionally, we used multinomial logit regression and multiple linear regression to confirm the influence of significant factors on agreement levels. Statistical analyses were performed using IBM SPSS statistics version 27 software.

Results

The first study objective was to measure public levels of agreement with scientific information about organic foods. Our data suggest that 34% of respondents agreed with scientific information about organic foods, while 21% disagreed (*strongly disagree*, *disagree,* or *somewhat disagree*). A considerable portion (26%) neither agreed nor disagreed or only somewhat agreed (19%) with scientific information about organic foods.

Ordinal regression analysis with all 18 factors was performed to examine the relationship between levels of agreement with scientific information about organic foods and selected factors. The model produced a statistically significant outcome, χ^2 (28, N = 616) = 117.13, $p < .001$, Nagelkerke Pseudo $R^2 = .19$, indicating that the combined factors significantly predicted levels of agreement with scientific information about organic foods. Five factors showed a unique statistically significant relationship with agreement levels: benefit perception of organic foods, trust in scientists, trust in science, communicators' credibility, and events related to science. Table 3.1 shows the odds ratios and confidence intervals around the 18 factors.

Table 3.1

Ordinal Regression Coefficients of 18 Factors on Levels of Agreement with Scientific Information About Organic Foods

Factors	*B*	*SE*	*p*	95% CI for *B* *LL*	*UL*
Religiosity	0.02	0.06	.780	–0.09	0.12
Political ideology	0.07	0.06	.251	–0.05	0.18
Benefits of organic foods	–0.08	0.02	.000*	–0.12	–0.05
Knowledge	–0.11	0.08	.162	–0.27	0.04
Age	0.00	0.01	.653	–0.01	0.01
Trust in scientists	0.04	0.01	.003*	0.01	0.07
Trust in science (Benefits strongly outweigh harmful results)					
Harmful results slightly or strongly outweigh benefits	–0.67	0.33	.042*	–1.31	–0.02
Benefits are about equal to harmful results	–0.25	0.23	.276	–0.70	0.20
Benefits slightly outweigh harmful results	–0.10	0.20	.614	–0.49	0.29
Preexisting beliefs (usually prefer organic foods)					
Prefer foods based on nutrition value	0.22	0.25	.380	–0.27	0.70
Usually prefer conventionally grown foods	0.35	0.30	.251	–0.24	0.94
Occasionally prefer organic foods	–0.02	0.26	.926	–0.54	0.49
Religion (Atheist & Agnostic)					
Other religion	–0.53	0.30	.075	–1.12	0.05
Christian	–0.23	0.28	.399	–0.77	0.31
Interest in Politics (Favorable/unfavorable towards one political party)					
Don’t favor a political party/not interested in politics	0.42	0.37	.254	–0.30	1.14
Support for political party is based on the policy agenda	0.20	0.34	.565	–0.47	0.86
Gender (Female)	0.15	0.18	.398	–0.20	0.49

Table 3.1 Continued

Factors	*B*	*SE*	*p*	95% CI for *B*	
				LL	*UL*
Income (High)					
Low	–0.13	0.29	.651	–0.70	0.44
Middle	0.06	0.21	.786	–0.36	0.48
Country of residence (USA)	0.17	0.34	.611	–0.50	0.85
Education (Graduate or professional degree)					
Some college	–0.11	0.22	.607	–0.55	0.32
Bachelor's degree	0.07	0.20	.738	–0.32	0.45
Communicator credibility (Nutritionists/Scientists)	–0.68	0.23	.002*	–1.12	–0.24
Information sources (Internet)	0.18	0.16	.239	–0.12	0.49
Events related to science (Changed due to COVID-19)	0.49	0.21	.017*	0.09	0.90
Exposure to information (A few times a week or daily)					
Not at all	0.37	0.30	.222	–0.23	0.97
Monthly or less	0.11	0.28	.686	–0.43	0.66
A few times a month	0.40	0.29	.179	-0.18	0.97

Note. CI = Confidence interval, *LL* = lower limit, *UL* = upper limit; the parameters indicated inside of the brackets are the reference category

$*p < .05$.

Ordinal regression result shows that the proportional odds assumption was not met, $\chi^2(56, N = 616) = 93.19$, $p < .001$. The proportional odds assumption is rarely achieved when a large number of variables are included in a model and/or the model contains continuous explanatory variables (O'Connell, 2006). O'Connell (2006) recommended conducting separate logistic regression models in such a situation to test the overall model. We performed separate logistic regression using the cumulative odds descending approach (O'Connell, 2006) and compared odd ratios with ordinal regression. The comparison revealed that the binary logistic odds ratio pattern was not the same as the ordinal regression results. Thus, we performed a multinomial logit model, a less restrictive model considering the agreement levels as the discrete outcomes (Williams, 2016).

Multinomial logistic regression was performed for all 18 factors, considering the “agree” group as the reference. The “agree” group was selected as the reference category because the highest frequency in agreement level was recorded in this category. The results show that the model was significant compared with the model without any factors $\chi^2(84, N = 616) = 195.81$, $p < .001$. Overall, the classification of multinomial regression with 18 factors was unimpressive, with a rate of 46%. The model correctly classified 68% of the agreed category, 30% of the somewhat agreed category, 31% of neither, nor 43% of the disagreed category.

Multinomial regression results indicated that benefit perceptions of organic foods, trust in scientists, and credibility of scientists were significantly different among participants who agreed with scientific information and other categories (somewhat agree, neither, or disagreed). Table 3.2 shows the parameter estimate. The goodness-of-fit test indicated a nonsignificant result, which implied that the model could classify agreement levels based on 18 factorsχ^2 (1761, $N = 616$) = 1478.31, $p = 1.0$, Nagelkerke $R^2 = .29$.

Table 3.2

Results of Multinomial Logit Regression Analysis of Levels of Agreement with Scientific Information About Organic Foods

Variable (factor)	Disagree vs. agree		Neither agree or disagree vs agree		Somewhat agree vs agree	
	p	*Exp(B)*	*p*	*Exp(B)*	*p*	*Exp(B)*
Religiosity	.829	0.98	.999	1.00	.572	1.05
Political ideology	.126	0.86	.860	1.01	.332	0.92
Benefits of organic foods	.000*	1.14	.004*	1.07	.027*	1.06
Knowledge	.629	1.07	.251	1.15	.676	0.95
Age	.581	1.01	.282	0.99	.639	1.00
Trust in scientists	.007*	0.94	.007*	0.95	.004*	0.94
Trust in science (Benefits strongly outweigh harmful results)						
Harmful results slightly or strongly outweigh benefits	.071	2.71	.233	1.86	.598	1.36
Benefits are about equal to harmful results	.374	1.42	.396	1.35	.041*	2.06
Benefits slightly outweigh harmful results	.699	1.14	.446	1.25	.239	1.45
Preexisting beliefs (usually prefer organic foods)						
Prefer foods based on nutrition value	.274	0.66	.057	2.14	.541	1.30
Usually prefer conventionally grown foods	.099	0.43	.142	1.98	.978	1.01
Occasionally prefer organic foods	.935	1.03	.140	1.89	.147	1.90
Religion (Atheist & Agnostic)						
Other religion	.126	2.23	.017*	2.94	.108	2.27
Christian	.337	1.57	.720	1.15	.902	1.06

Table 3.2 Continued

Variable (factor)	Disagree vs. agree		Neither agree or disagree vs agree		Somewhat agree vs agree	
	p	*Exp(B)*	*p*	*Exp(B)*	*p*	*Exp(B)*
Political views (Favorable/unfavorable towards one political party)						
Don't favor a political party/not interested in politics	.184	0.44	.667	0.78	.505	0.69
Support for political party is based on the policy agenda	.308	0.56	.890	1.08	.186	0.50
Gender (Female)	.620	0.87	.083	0.63	.088	0.61
Income (High)						
Low	.215	1.84	.411	0.70	.590	0.77
Middle	.812	1.09	.273	0.71	.798	1.09
Country of residence (USA)	.969	0.98	.443	0.65	.974	1.02
Education (Graduate or professional degree)						
Some college	.529	1.27	.760	1.11	.665	1.16
Bachelor's degree	.434	0.77	.792	0.93	.058	0.54
Communicator credibility (Nutritionists/Scientists)	.024*	2.28	.263	1.47	.259	0.62
Information sources (Internet)	.165	0.69	.969	0.99	.857	1.05
Events related to science (Changed due to COVID-19)	.051	0.53	.250	0.69	.931	1.03
Exposure to information (A few times a week or daily)						
Not at all	.116	0.45	.885	1.07	.521	1.40
Monthly or less	.552	0.77	.592	1.25	.435	1.47
A few times a month	.203	0.55	.596	0.79	.809	1.13

Note. The parameters indicated inside of the brackets are reference categories.

*$p < .05$.

Additionally, the multinomial logit for participants affiliated with other religions was 1.079 units higher than that for those identified as atheists or agnostics. This indicates that participants from religions other than Christianity were more likely to neither agree nor disagree with scientific information about organic foods. Moreover, participants who believed that the benefits of scientific research were about equal to the harm that scientific research caused were more likely to somewhat agree with scientific information about organic foods than those who agreed. This result slightly differed from the ordinal regression findings, which showed that participants who believed that harmful results slightly or strongly outweigh benefits from science were more likely to disagree with scientific information.

Multinomial regression results did not show significant relationships between events related to science (i.e., COVID-19) and agreement levels with scientific information. However, ordinal regression analysis showed that participants who started eating or increased their consumption of organic foods to prevent COVID-19 were more likely to disagree with scientific information than those who did not change their habits in this regard. This finding may be explained in that those who disagreed with scientific information held strong beliefs that organic foods provided significant health benefits, which is contrary to scientific findings (Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012; Sobieralski et al., 2013). An independent paired *t*-test was performed to evaluate differences in benefit perception of organic foods to test our speculation. We found a statistically significant difference in benefit perceptions $t(347) = 10.95$, $p = <.001$, Cohen's $d = .82$ (two-tailed, equal variance not assumed). Those who ate more organic foods during COVID-19 (*M* =21.66, *SD* = 4.66) held more positive benefit perceptions than those who did not eat organic foods during COVID-19 (*M* = 16.85, *SD* = 6.36). The mean difference in benefit perception was 4.66, 95% CI [3.83,5.50].

We performed multiple linear regression considering the agreement level of scientific information as a scale measurement to identify the best predictors. Backward elimination was used to identify the best predictor model. The full multiple regression model $F(28,656) = 5.57$, p <.001, with an adjusted R^2 at .16, revealed that benefit perception of organic foods, trust in scientists, the credibility of communicators, events related to science (e.g., COVID-19), and preexisting beliefs were significant predictors of respondents' levels of agreement with scientific information about organic foods (see Table 3.3). The reduced model was significant $F(9,675) = 16.21$, p <.001, with an adjusted R^2 at .17 with medium effect (Cohen, 1988) f^2 = .20. Five significant predictors in the reduced model had small effect sizes: benefit perception (f^2 = .04), trust in scientists (f^2 =.02), credibility of scientists (f^2 = 01), preexisting beliefs (f^2 = 01), and events related to science (f^2 = 01).

Table 3.3

Results of Stepwise Multiple Regression for Levels of Agreement with Scientific Information about Organic Foods

Factors		95 % CI for *B*		*SE*		
	B	*LL*	*UL*	*B*	*β*	*p*
Full model [a]						
Constant	4.27	3.00	5.54	0.65		.000*
Benefits of organic foods	–0.06	–0.08	–0.03	0.01	–.22	.000*
Trust in scientists	0.03	0.01	0.05	0.01	.14	.001*
Communicator credibility (Nutritionists/Scientists)	0.55	0.25	0.85	0.15	.14	.000*
Events related to science (Changed due to COVID-19)	–0.25	–0.53	0.03	0.14	–.07	.076
Preexisting beliefs						
Prefer foods based on nutrition value	0.47	0.15	0.79	0.16	.16	.004*
Usually prefer conventionally grown foods	0.55	0.16	0.94	0.20	.15	.006*
Reduce model						
Constant	3.88	3.16	4.59	0.36		.000*
Benefits of organic foods	–0.06	–0.08	–0.04	0.01	–.24	.000*
Trust in scientists	0.04	0.02	0.05	0.01	.15	.000*
Communicator credibility (Nutritionists/Scientists)	0.52	0.24	0.81	0.15	.13	.000*
Events related to science (Changed due to COVID-19)	–0.28	–0.55	–0.02	0.14	–.08	.037*
Preexisting beliefs						
Prefer foods based on nutrition value	0.46	0.15	0.77	0.16	.15	.004*
Usually prefer conventionally grown foods	0.50	0.12	0.88	0.19	.13	.009*

Note. CI = Confidence interval, *LL* = lower limit, *UL* = upper limit.

[a] Nonsignificant predictors of the full model are not shown in this table. The parameters indicated inside of the brackets are reference categories.

$*p < .05$.

Overall analysis (i.e., ordinal, multinomial, and multiple regression) revealed three findings. First, an increase in benefit perceptions of organic foods would likely increase disagreement levels with scientific information about organic foods (see Figure 3.2). Second, an increase in trust in scientists would be expected to increase agreement with scientific information on organic foods (see Figure 3.2). Third, people who believe scientists and nutritionists are credible communicators would more likely agree with scientific information about organic foods than those who did not believe scientists and nutritionists were credible communicators (see Figure 3.3).

Figure 3.2

Mean Distribution of Benefit Perception and Trust in Scientists vs. Levels of Agreement

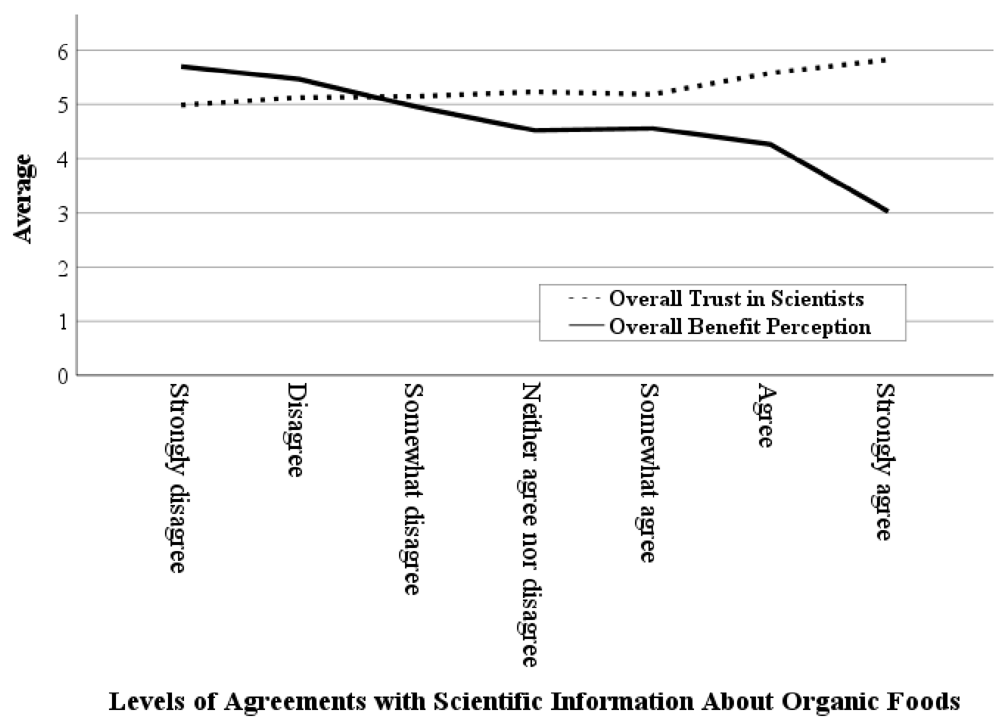
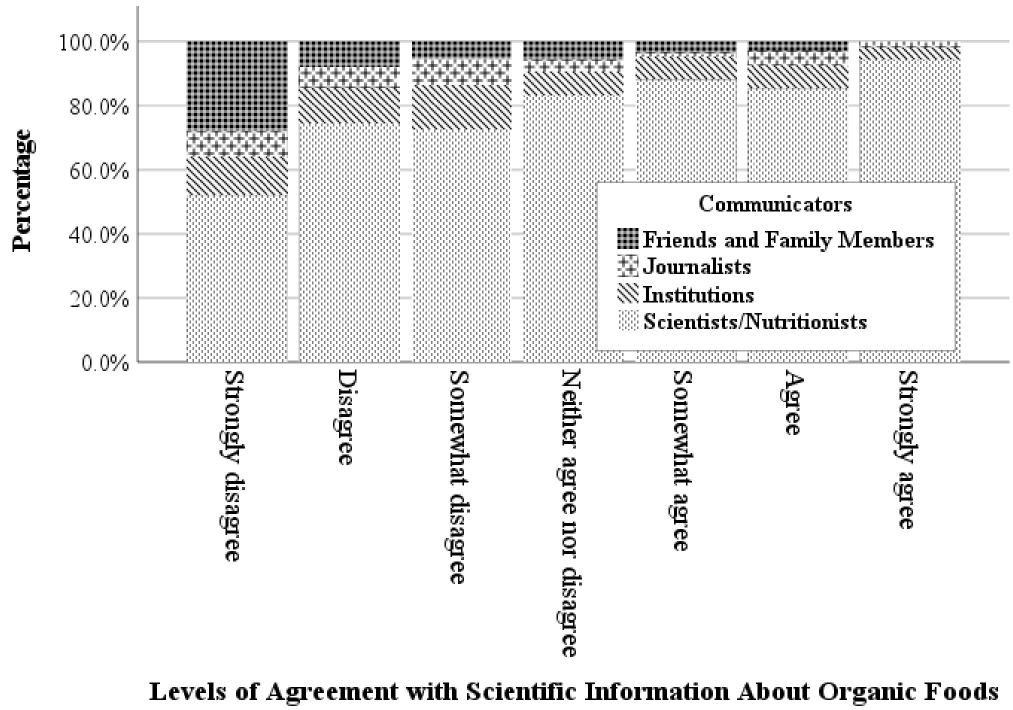


Figure 3.3

Credible Communicator According to Level of Agreements



Discussion

Although a majority of scientific studies have concluded that organic foods do not provide clinically significant health benefits (Brantsæter et al., 2017; Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012; Sobieralski et al., 2013), this study showed that one in five participants disagreed with scientific information and one in four neither agreed nor disagreed. We found three factors that predicted levels of agreement with scientific information about organic foods: 1) overall benefit perception, 2) trust in scientists, and 3) who is perceived to be a credible communicator (i.e., scientists/nutritionists). The relationships between levels of agreement with scientific information on organic foods and these three factors were significant in all three analyses. Graphical distributions of mean and percentages confirmed the relationship between the factors and agreement levels (see Figure 3.2 and Figure 3.3). Additionally, we found that preexisting attitudes about organic foods (measured as food preference), events related to science (COVID-19), overall trust in science, and religious affiliation were contributing factors. However, these factors could not be identified as best predictors because the relationships between agreement levels and these three factors were not significant in every analysis.

Best Predictors for Public Agreement with Scientific Information on Organic Foods

Benefit Perception

Overall benefit perception and level of agreement with scientific information were inversely related. When people perceived overall benefits from organic foods more positively, they viewed scientific information about organic foods more negatively, or they simply disregarded scientific information about organic foods when considering overall their benefits. These results are consistent with Olson's (2017) findings that commenters who disagreed with the Stanford meta-analysis review, which showed that organic foods did not provide significant health benefits, had strong positive beliefs about the health and safety benefits of organic foods. At the same time, commenters who agreed with the Stanford review held skeptical views about the benefits of organic foods (Olson, 2017). Likewise, Costanigro et al. (2014) observed that participants who had positive perceptions about organic foods considered only scientific facts regarding the pros of organic foods and disregarded those regarding the cons. Therefore, exploring how the level of perceived benefits of organic foods affects susceptibility to misconceptions and correcting the misconceptions surrounding organic foods would be useful.

Sometimes, correction of misconceptions generates reasons to support misconceptions (Chan et al., 2017), which is known as the backfire effect. Our study implies that people who positively perceived the benefits of organic foods disagreed with scientific information. Thus, future communication should be cautious about the possibility of backfire effects. Following the guidance of Lewandowsky et al. (2020) on debunking misconceptions, we recommend using inclusive language and explaining what is meant by clinically non-significant health benefits of organic foods rather than comparing organic and other foods.

Trust in Scientists' and Communicators' Credibility

We found that trust in scientists was positively associated with levels of agreement with scientific information about organic foods. Olson (2017) also found that those who disagree with scientific facts on organic foods question the trustworthiness of scientists who conducted the Stanford study. Moreover, a positive association between trust in scientists and agreement levels was also observed when communicating scientific findings on climate science (Hmielowski et al., 2013) and nanotechnology (Ho et al., 2010; Zhang et al., 2015). Therefore, we recommend engaging trusted scientists/nutritionists when communicating scientific facts about organic foods. Given that nearly 47% of the study sample disagreed or neither agreed nor disagreed with scientific information, engagement of trusted scientists/nutritionists would help to increase public agreement with scientific information about organic foods

Perceiving a scientist or nutritionist as a credible communicator was positively associated with levels of agreement with scientific information about organic foods. Additionally, we found that 42% of participants who believed that friends and family are credible communicators disagreed with scientific information, and past research on consumers'' purchase intention found that communication received from friends and family increased purchase intention (Anisimova et al., 2019; Teng & Wang, 2015). Therefore, we identified the need for carefully selecting the communicator based on the purpose of communication (either to promote purchase intention or to share scientific facts about organic foods). Vega-Zamora et al. (2019) also noted that communication activities related to organic foods should engage various communicators based on the intention of communication. For example, when health benefits are emphasized, health experts should be used, and when highlighting functional qualities of organic foods like taste and freshness, producers should be used.

Other Significant Predictors

Preexisting Beliefs

As we assumed, data suggested that participants who usually prefer organic foods are more likely to disagree with scientific information about organic foods than those who prefer conventional foods or foods based on nutritional value. This observation was consistent with the findings of Hoefkens et al. (2009), where a higher level of mismatch existed in consumer perception and scientific evidence among consumers who frequently consumed organic food. Likewise, other studies also found that a high level of preexisting beliefs reduces the impact of scientific information (Costanigro et al., 2014; Koswatta et al., 2022; Olson, 2017). However, we are cautious about our interpretation of preexisting beliefs because we measured the preexisting beliefs as food preference.

Trust in Science

The ordinal and multinomial regression results show that trust in science in general relates to how people agree or disagree with scientific information about organic foods. Therefore, it can be concluded that trust in science contributes to an agreement with scientific information about organic foods, consistent with Palmer’s (2018) observations. However, multiple regression results did not show a significant relationship between trust in science and agreement levels. Therefore, it cannot be assumed that people who have high trust in science will agree with scientific information about organic foods, but trust would help in the communication process.

Events Related to Science: COVID-19

We found that those who started to eat or increased consumption of organic foods during the COVID-19 pandemic had a higher level of disagreement with scientific information on organic foods. We speculated that this occurred for the following reason. People who hold positive benefit perceptions about organic foods despite contradictory scientific information (Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012; Sobieralski et al., 2013), believed that discomfort from COVID-19 can be overcome by eating or increasing consumption of organic foods. some people may develop more intense disbeliefs about scientific information if such information contradicts deep-seated beliefs about food, health, and/or other personal factors. For example, more than 12% market growth in organic foods was recorded in the United States during 2020, and the Organic Trade Association noted that an increase in growth occurred because people were seeking good and healthy food during the COVID-19 pandemic (McNeil, 2021). Overall, our findings demonstrated that events related to science have some influence on the levels of agreement with scientific information, as suggested by past research (Li et al., 2016; Suthanthangjai et al., 2013).

Religion

Our results suggested that level of religiosity does not have a relationship with the level of agreement with scientific findings. However, we found religion has an association, whereas past research has found that religiosity was not linked with attitudes toward organic foods in the United States (Larson, 2018). In particular, we found that participants affiliated with other religions (not Christians, atheists, or agnostics) were more likely to neither agree nor disagree with scientific information than agree with it. Minton et al. (2015) found that Buddhists practice more sustainable behaviors and consume more organic foods than Christians and atheists in the United States. Thus, we speculate that the weaker association between religion and agreement with scientific information about organic foods might arise from the perceived environmental benefits of organic foods.

Nonsignificant Factors

Although gender, age, income, and education have had an association with purchase intention of organic foods in past research (Curl et al., 2013; Larson, 2018), our results show that none of these demographic factors had an association with agreement level with scientific findings of organic foods. Lea and Worsley (2005) contended that Australian women believe organic foods have a higher level of vitamins and minerals than males do, but in our population, women did not differ from males in their level of agreement level with scientific information. These results are consistent with Hoefkens et al.'s (2009) findings that gender, education, and income level were not contributing factors that make a difference in consumer perceptions concerning scientific evidence about organic foods in Belgium. We also found no difference in levels of agreement with scientific information about organic foods for those who lived in the United States than those who lived elsewhere.

Past research has shown that knowledge about organic foods (correctly defining characteristics of organic foods) has a positive association with purchase intention (Mesías Díaz et al., 2012). However, we did not find an association between factual knowledge about science with agreement level of scientific information. One interpretation would be that participants held strong beliefs about the benefits of organic foods; thus, they assess information following their beliefs rather than following logical reasoning considering knowledge.

The results of the present study support the notion that political ideology (liberal/conservative) does not have a relationship with the agreement level of scientific information about organic foods. This pattern of results aligns with previous literature (Drummond & Fischhoff, 2020; Larson, 2018), where political preference was not associated with organic foods in the United States. Moreover, our results suggest that no association exist between interest in politics and agreement levels of scientific information on organic foods.

Our findings indicate a lack of association between the level of exposure to news on organic foods and agreement levels of scientific information on organic foods. In comparison, past research found an association with news exposure and beliefs about organic foods (Koswatta et al., 2022; Northup, 2017). Additionally, we did not find any association between information sources and agreement levels. However, our finding that the internet was the most common information source for receiving information about organic foods is consistent with Nasir and Nasir's (2017) findings, where the Internet was the most popular information source among East Europeans.

Limitations

This study has some limitations. First, the study sample was not nationally representative; a majority (80%) of respondents came from a Southwestern land grant university. Fifty-three percent of participants had a graduate or professional degree, only 3% had only a high school diploma, and none had less than a high school diploma. Because of this highly educated population, caution is warranted regarding the lack of relationship between knowledge and education. Therefore, we recommend replicating this study using a nationally representative sample to assess the lack of association between knowledge and education with levels of agreement with scientific information on organic foods. Second, the agreement levels with scientific information were measured based on the statement that explained nonsignificant health benefits about organic foods, exclusively, and not explains any other concerns related to organic foods. Third, the present study was based on self-reported data; thus, there are possible differences in actual behavior and reported data, particularly food preference (preexisting belief regarding organic foods) and news exposure. Third, despite using questions from the Science and Engineering Indicators (National Science Board, 2018) to measure factual knowledge about science, the Kuder-Richardson-21 reliability for the knowledge construct was .40, which is lower than the recommended level of .70 (Fraenkel et al., 2019). One possible explanation for this low reliability was that the Science and Engineering Indicator questions were too easy (Kahan, 2015) or the difficulty of all items was not the same for the study sample.

Conclusion

This study provides evidence that benefit perception of organic foods is a key contributing factor and has a negative relationship with levels of agreement with scientific information about organic foods. Disagreement with scientific information may be overcome by engaging trusted scientists or nutritionists when communicating scientific facts about organic foods. The results imply that factual knowledge or education does not have an association with agreement levels, but audience beliefs (benefits, trust in science, and food preference) do have an association with agreement levels. Therefore, the deficit model of science communication may not appropriate for communicating scientific information about organic foods. Results indicated that one in five participants among sample population disagree with scientific information about organic foods. Therefore, when communicating science related to organic foods, communicators should consider misconceptions surrounding the benefit perceptions of organic foods regarding nutrition and health.

We recommend designing science communication activities about organic foods following the mental models' approach, where audience beliefs and common misconceptions are considered in addition to audience members' knowledge. Furthermore, scientific communication about organic foods should consider steps in successfully debunking misconceptions. We recommend emphasizing selecting foods based on nutritional value, explaining what is meant by clinically non-significant benefits, and reinforcing scientific facts about organic foods multiple times.

Finally, we conclude that when people have positive benefit perceptions about a scientific topic and those perceptions contradict scientific information, their disagreement with scientific information increases. This disagreement will increase further when an event related to science has a closer connection with benefit perceptions.

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4. EFFECT OF MISINFORMATION ON PUBLIC PERCEPTION OF ORGANIC FOODS

Overview

Fake news is a threat to our society. Fake news, especially surrounding scientific controversies like the health benefits of organic foods, has led to changes in eating habits. Using a posttest-only control group design (N = 640), we tested how factual and nonfactual information influences public perception of organic foods. We randomly assigned participants from a southern land grant university to watch one video: factual, nonfactual, or control. Members in each group then indicated changes in perception about organic foods immediately after watching the video. We analyzed the data using one-way and two-way ANOVA tests. The nonfactual video had the highest influence on public perception of organic foods. Results confirmed that the effect of misinformation is higher for individuals who have preexisting beliefs consistent with the message communicated and people who have an average to a high level of exposure to health and diet news. These results suggest that to reduce the susceptibility to misinformation related to organic foods, communication activities should aim to increase healthy skepticism and design considering the audience's preexisting beliefs and frequency of health and diet news exposure. Additionally, we found that measuring changes in perception using two scales (a numerical rating and a summed scale) provides better insight into the influence of the message and helps to overcome the possible pitfalls of using one scale. Thus, we recommend using two scales on similar studies.

Introduction

The spread of nonfactual news (i.e. misleading news, fake news, misinformation) has affected public perception of science communication, limiting our ability to make decisions based on scientific facts. Barthel et al. (2016) found that 64% of American adults said fake news confused basic facts of current issues or events. However, the level of exposure to nonfactual information influenced audience perception differently based on their level of exposure(Allcott & Gentzkow, 2017; Balmas, 2014; Latré et al., 2018). For example, van der Linden et al. (2017) studied differences in respondents' perceptions of human-caused climate change after communicating scientific consensus messages, counter-messages (misinformation), and inoculate messages (messages that refute misinformation). They found that communicating a scientific consensus message significantly increased public perception of climate change, while nonfactual news undermined public perception of climate change (van der Linden et al., 2017).

Changes in public perception after exposure to nonfactual news on agriculture and food issues have been studied minimally. However, there is evidence that the spread of misinformation has impacted our eating habits (Koch et al., 2017; Mesnage et al., 2020; Rodman et al., 2014). Rodman et al. (2014) found that some people defined a healthy diet as the consumption of organic food, rather than food having nutritional value. Likewise, Winter and Katz (2011) reported that people limited their consumption of fruits and vegetables because of the perceived presence of pesticides, although scientists concluded that consuming conventionally grown foods did not pose a potential consumer risk for exposure to pesticides. The purpose of this study described herein was to understand how factual and nonfactual news stories affect public perception of science communication when reporting about agricultural controversies specifically related to organic and conventionally grown foods.

What Are Factual and Nonfactual News?

Different terms are used by scholars to define factual news (e.g., truthful, accurate, verifiable, and credible). Gualda and Rúas (2019) used credibility to discuss the factual nature of communication, as information with felt and perceived truth signified that facts. Sahu and Majumdar (2017) defined facts “as something that has occurred or is actually correct” (p. 2) and factual news articles as articles that reported “what actually happened and statements which claim to be true in nature” (p. 2).

Several terms can describe nonfactual news similarly (e.g., such as fake news, misinformation, misleading information, and false news). Allcott and Gentzkow (2017) defined fake news articles as “news articles that are intentionally and verifiably false and could mislead readers.” The presence of various definitions and terms for false news creates the need for selecting and defining what is meant by nonfactual news. Using definitions by Cook and Lewandowsky (2011) and Meinert et al. (2018), our study defines nonfactual information as any inaccurate or discredited information that diverts or deceives the audience about factual science-related communications of food- and agriculture-related controversies. Furthermore, the current study identifies nonfactual news as misinformation and factual news as food- and agriculture-related controversies based on scientific findings that are accepted by most scientists in relevant fields.

Communication Difference Between Factual and Nonfactual News

Factual and nonfactual news are communicated differently, and fake news detection techniques often use linguistic differences between factual and fake news to detect fake news (Horne & Adali, 2017; Meinert et al., 2018; Traylor et al., 2019; Zhou et al., 2018). Long et al. (2017) noted that factual news reports had more sentimental, sense-based words, and more other-oriented pronouns, but fewer self-oriented pronouns than did nonfactual news. Horne and Adali (2017) found that nonfactual news has short terms of content repetitive language, and less punctuation than factual news (Horne & Adali, 2017). Ahmed et al. (2018) compared the word usage of factual and fake reviews; they observed that factual reviews contained more nouns and adjectives, whereas fake reviews contained more filler/functional words (e.g., the, that, of) and content words (words that carry specific meaning for the fake reviews). Furthermore, significant differences existed between factual and nonfactual news titles as nonfactual news had longer titles, fewer stop words (e.g., the, is, on) and nouns, and more proper nouns than factual news (Horne & Adali, 2017).

Existing differences in communicating factual and nonfactual news and the influence of nonfactual news on perceptions of science signify a need for understanding how factual and nonfactual news reports affect public perception of science communications. The current study selected the popular misconceptions of the health benefits of organic foods over conventionally grown foods to test how public perception of science was affected by factual and nonfactual information. Several studies have concluded that eating organic foods does not provide significant health benefits over conventionally grown foods (Brantsæter et al., 2017a, 2017b; Forman & Silverstein, 2012; Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012; Sobieralski et al., 2013), but consumers believed organic foods were healthier than conventionally grown foods (Anghelcev et al., 2020; Guido et al., 2010; Pew Research Center, 2016; Rana & Paul, 2017). Rosen (2010) found that organizations promoted organic foods based on unreliable sources to support their claims. Thus, we believed that news stories that explain health benefits of organic foods would help us examine the effect of factual and nonfactual news stories on public perceptions of science. The primary research hypothesis was:

H_0: No differences exist in respondents' mean perceptions of organic foods after exposure to factual and nonfactual news videos.

H_1: Significant differences exist in respondents' mean perceptions of organic foods after exposure to factual and nonfactual news videos.

In addition to factual and nonfactual news, other factors such as knowledge (National Academies of Sciences, Engineering, and Medicine, 2017), exposure to news (Hart et al., 2015), education levels (Sarathchandra & McCright, 2017), and preexisting beliefs (Dixon, 2016) influence public perception of science communication. Thus, we examined the moderating effects of self-perceived knowledge, frequency of exposure to news about health effects of foods and drinks, education levels (measured as academic status), and preexisting beliefs on changes in perception levels after exposure to factual and nonfactual news stories.

Knowledge and Perception of Science

Takahashi and Tandoc (2016) showed that knowledge about science, scientific processes, and science institutions positively influenced public attitudes toward science. A National Academies of Sciences, Engineering, and Medicine (2017) report, *Communicating Science Effectively: A Research Agenda*, indicates that the relationship between knowledge and attitude toward science is not simple or direct. Knowledge interacts with other factors such as a person's characteristics, background, values and beliefs, and cues from mass media, which creates a more complex and combined influence on public perception about science (National Academies of Sciences, Engineering, and Medicine, 2017). For example, Bass (2016) found that factual knowledge of climate science overshadowed the political predisposition of citizens when they were asked to indicate their support to increase taxes on gasoline to reduce emissions.

Knowledge's impact on the public perception of science communication depends on the nature of the science being communicated (Koswatta et al., 2021). When communicating about genetically modified (GM) foods, knowledge influences the perception for Chinese consumers (Cui & Shoemaker, 2018) but not for U.S. consumers (Allum et al., 2008). However, knowledge did not impact audience perceptions in both China (Zhang et al., 2015) and the U.S. (Ho et al., 2010) when communicating about nanotechnology. Likewise, general knowledge in science was not associated with attitudes towards nuclear power and genetic medicine in the U.S. (Allum et al., 2008).

Additionally, knowledge influence in attitude about science varied by domains of knowledge such as general knowledge in science does not associate with GM foods, but specific knowledge in biology and genetics had an association with attitude towards GM foods (Allum et al., 2008). Connor and Siegrist (2010) also concluded that knowledge about basic biology, gene technology, or legal regulation of GM in Switzerland had either no or minimal impact on perception and acceptance of GM products. However, McPhetres et al. (2019) showed that increased knowledge of GM led to positive attitudes about GM foods, confirming the deficit model of communications (which predicts that more knowledgeable audiences are more likely to develop positive attitudes about science) for GM foods.

In the context of choosing organic or conventionally grown foods, several studies found relationships between knowledge and consumer attitudes toward organic foods (McReynolds et al., 2018; Mesías Díaz et al., 2012; Stanton & Cook, 2019; Yiridoe et al., 2005). Yiridoe et al. (2005) concluded that knowledge of organic products had an impact on consumers' attitudes, perceptions, and buying decisions. Stanton and Cook (2019) concluded that consumers with higher knowledge levels made rational choices when selecting organic foods, and McReynolds et al. (2018) found that higher knowledge levels correlated with higher levels of positive perceptions of organic foods among college students. Furthermore, Mesías Díaz et al. (2012) contended that knowledge about organic foods positively influenced the consumption and willingness to buy organic foods. However, Teng and Wang (2015) concluded that a higher level of perceived knowledge about organic foods did not lead to positive attitudes toward organic foods but created trust in organic foods. Dumortier et al. (2017) also concluded that knowledge of organic practices did not affect purchasing decisions. These studies confirmed associations between knowledge and consumer perception of organic foods. However, it is unclear how self-perceived knowledge mediates the effect of factual and nonfactual news stories on public perception of organic foods. Thus, the current study sought to examine relationships between self-perceived knowledge of nutritional value and changes in perceptions of organic foods after exposure to factual and nonfactual information.

> H_2: After exposure to factual and nonfactual information, participants' perceptions of organic foods will differ based on levels of self-perceived knowledge about nutritional value.

Exposure to Information

Prior research has found that exposure to information influences audience knowledge and perception of science (Hart et al., 2015; Nisbet et al., 2015; Southwell & Torres, 2006). Southwell and Torres (2006) found that exposure to television news increased viewers' ability to understand science. Corbett and Durfee (2004) found a significant difference in perceptions of scientific certainty about global warming among participants who read news stories on scientific claims versus participants who read stories about controversies about global warming. Sarathchandra and McCright (2017) observed that participants whose exposure to news, about the retraction of an article on eating GM foods linked to cancer, reversed their beliefs about the relative risk of GM foods. Those who were exposed to the original news article on eating GM foods linked to cancer did not reverse their beliefs (Sarathchandra & McCright, 2017).

In the context of communication about organic foods, scholars (Ma et al., 2020; McFadden & Huffman, 2017; Müller & Gaus, 2015) have investigated the effect of media exposure on consumers' purchasing behaviors. Müller and Gaus (2015) found that exposure to negative information about organic food production mediated respondents' behavioral intention to purchase organic products. Koch et al. (2017) observed that exposure to media reporting on pesticide residues in conventionally grown and organic foods increased consumers' knowledge about the legal limits of pesticide residues. However, Beaudreault (2009) concluded that the media did not influence college students' perception of organic foods. In summary, prior studies have shown possible effects of exposure to news on public perceptions of organic foods. However, minimal research has been conducted on associations between the frequency of exposure to news about the health effects of foods and drinks and changes in public perception levels of organic foods. Therefore, this study examined associations between the frequency of exposure to news about the health effects of foods and drinks and changes in participants' perception levels of organic foods after exposure to factual and nonfactual information on organic foods.

> H_3: After exposure to factual and nonfactual information, participants' perceptions of levels of organic foods will differ based on the frequency of exposure to news about the health effects of foods and drinks.

Academic Status

Cataldo et al. (2019) found that students' judgments of the credibility of science news resources differed across education levels. High school students followed a different judgment process to identify the credibility of science news than higher education students (community college students, undergraduates, and graduate students) (Cataldo et al., 2019). Kim et al. (2012) found that higher educated respondents are engaged in deliberate reasoning and better understand the potential consequences of GM foods than less-educated respondents. Similarly, Sarathchandra and McCright (2017) found that participants with lower educational attainment perceived GM foods were more dangerous than did participants with higher educational attainment.

In the context of organic foods, the credibility of information is considered an important factor because visual and sensorial differences between organic and conventionally grown foods are minimal, and consumers' trust depends on the credibility of information (Thorsøe, 2015). Dumortier et al. (2017) found that households that trusted media information on organic strawberries were more likely to purchase organic strawberries. Yet, in the same study, they found that trust in media information on organic tomatoes did not influence purchasing behavior (Dumortier et al., 2017). Dangi et al.'s (2020) review of organic food buying behavior noted that the consumer's ability to seek and process information about the quality of organic foods was influenced by education level. Larson (2018) identified education levels as a significant factor that influences attitudes about organic foods. Notably, several studies confirmed that consumers with high education levels consumed organic foods (Curl et al., 2013; Dimitri & Dettmann, 2012; Gwira Baumblatt et al., 2017; Rana & Paul, 2017). Thus, we were interested in identifying the impact of educational level (which was measured as academic status: undergraduate, graduate, faculty, or staff) on perception changes after exposure to factual and nonfactual videos:

> H_4: After exposure to factual and nonfactual information, participants' perceptions of organic foods will differ based on academic status.

Participants' Preexisting Beliefs About Organic and Conventional Foods

Knobloch-Westerwick et al. (2015) contended that online information users favored scientific information that matched their existing beliefs. The mental models' approach of science communication (Wong-Parodi & Bruine de Bruin, 2017) highlights audience interpretation of new scientific information based on preexisting beliefs. Koswatta et al. (2021) contended that preexisting beliefs are one of the strongest influencing factors affecting public perception of science. Several scholars have studied the relationships between preexisting beliefs and perceptions of science (Dixon, 2016; Landrum et al., 2018; Lewandowsky et al., 2013; Martins et al., 2018). Dixon (2016) observed different levels of influence based on levels of preexisting beliefs when communicating consensus messages on GM foods. The least influence was influenced were observed among respondents who had a low level of prior beliefs about GM foods (Dixon, 2016). Martins et al. (2018) demonstrated that, when preexisting beliefs matched the story communicated, the credibility of the communicator (journalists and scientists) increased.

Regarding organic and conventionally grown foods, Massey et al. (2018) and Yiridoe et al. (2005) identified that consumer beliefs about superior qualities of organic foods (i.e., safer, healthier, and then more environmentally friendly) over conventionally grown foods) were largely associated with intentions to purchase organic foods. Müller and Gaus (2015) found that attitude about organic foods moderately affected organic food purchasing intention. Furthermore, Costanigro et al. (2014) reported that presenting scientific evidence about the ambiguity of benefits for organic produce did not lead to significant changes in valuation decisions of organic products. They said that respondents interpreted scientific evidence based on preexisting beliefs, where high valuation participants paid attention to the pros, while low-valuation participants focused on the cons. (Costanigro et al., 2014). Thus, the current study examined changes in perception levels after exposure to factual and nonfactual news stories based on levels of preexisting beliefs about organic and/or conventionally grown foods. Hypotheses were:

H_5: Mean perception levels of participants with high levels of preexisting beliefs about organic foods were significantly lower than the mean perception levels of low and average beliefs groups after exposure to factual news stories about organic foods.

H_6: Mean perception levels of participants with high levels of preexisting beliefs about organic foods were significantly higher than mean perception levels of low and average beliefs groups after exposure to nonfactual news stories about organic foods.

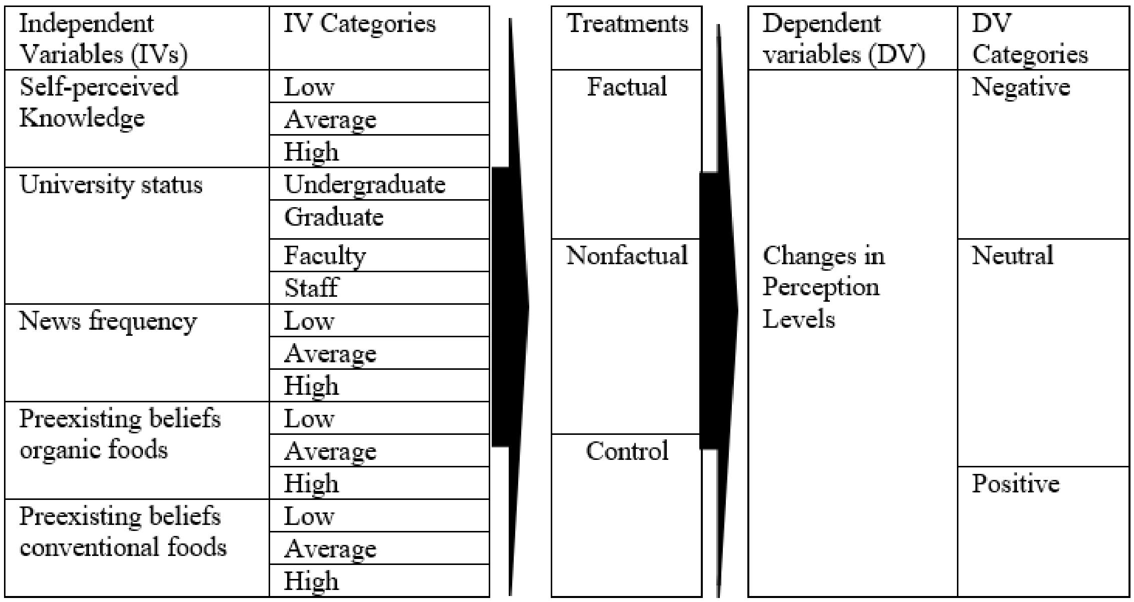
H_7: Mean perception levels of participants with high levels of preexisting beliefs about conventionally grown foods were significantly higher than mean perception levels of low and average beliefs groups after exposure to factual news stories about organic foods.

H_8: Mean changes in perception levels of participants with high levels of preexisting beliefs about conventionally grown foods were significantly lower than mean perception changes of low and average beliefs groups' exposure to nonfactual news stories about organic foods.

In summary, we assumed that self-perceived knowledge, education levels, frequencies of news exposure, and preexisting beliefs mediated perception changes after exposure to news stories presenting factual and nonfactual information on organic foods. Figure 4.1 illustrates the research framework, showing relationships between variables that we examined in the current study.

Figure 4.1

Research Framework: Relationships Between Interested Variables and Perception Differences



Methods

Study Design

A report from the *National Academies of Sciences, Engineering, and Medicine* (2017) noted the need for randomized controlled field experiments to assess changes in public perception from the impact of science communication. The posttest-only control group design is preferred over the pretest-post control group if the random assignment of subjects can be achieved (Campbell & Stanley, 1963; Fraenkel et al., 2019). Fraenkel et al. (2019) contended that if each group has at least 40 subjects, a post-test-only control group design is the best design to use in an experimental study. Thus, a randomized posttest-only control group design was used in an online experiment to assess how factual nonfactual news stories and news stories presenting misinformation affected public perceptions of organic foods.

Randomized posttest-only control provides strong control over subject characteristics, maturation, and regression, and some control over instrument decay, history, and mortality (Fraenkel et al., 2019). However, it has weaker control over threats to internal validity such as location, data collector characteristics, data collector bias, subjects' attitudes, and/or implementation (Fraenkel et al., 2019). This experiment overcame location, data collector characteristics, the Hawthorne effect, data collector bias, and implementation threats by using a one-time web survey to collect data. Subjects' attitudes, a threat to this experiment, were overcome by collecting more information on preexisting attitudes toward organic and conventionally grown food before exposing participants to the treatment conditions.

An overview of the experimental conditions and the number of participants per condition are indicated in Table 4.1. Three YouTube videos with factual or nonfactual information were used for two treatments and a control. The videos were selected from a pool of English-language YouTube videos that were less than two minutes and contained information about organic and conventionally grown foods. The research team and agricultural communications experts analyzed the videos and selected those that matched the purpose of the study.

Table 4.1

Overview of Experimental Design

Sample	Random Assignment	Experimental conditions	Post-test
	R	X	O
	229 participants to treatment 1	Factual video on organic foods	Changes in perception of organic foods.
	R	Y	O
n = 640	184 participants to treatment 2	Nonfactual video on organic foods	Changes in perception of organic foods.
	R	C	O
	227 participants to control group	Food safety video	Changes in perception of organic foods.

Study Participants

Population

The target population was a university population at a southwestern land grant university, whereabout 54% were male. Furthermore, the university population (73,687 in Fall 2019) was characterized as White (57%), Hispanic (21%), and Black or African American (4%) (Table 2). The accessible population was students and employees (56,851) who subscribed to the university employee and students email list in Spring 2020, resulting in a 77% coverage rate of the population of interest. To ensure that each member had an equal chance of being volunteering for the current study, the invitation was sent using the bulk email service to all subscribers. Participants were selected using convenience sampling techniques (Fraenkel et al., 2019; Mike, 2017). Subscribers (n = 1167) who opened the invitation and clicked on the survey URL were considered as the study sample. Subscribers who did not open the invitation emails (*n* = 35,414) and subscribers who opened the invitation but did not click the survey URL (*n* = 20,268), were not considered a part of the sample.

Table 4.2

Socio-demographic Characteristics of Participants

Variables	Categories	Target Population [a]		Research Sample	
		N = 73,687	%	*n* = 638	%
Gender					
	Male	39,408	53.5	212	33.2
	Female	34,278	46.5	415	64.9
	Other			3	0.5
	Prefer not to respond	1	0	9	1.4
Ethnicity					
	White	41,786	56.7	424	66.5
	Hispanic	15,276	20.7	63	9.9
	Black	2,625	3.6	32	5.0
	Multiple ethnicities	1,642	2.2	33	5.2
	Asian	5,852	7.9	54	8.5
	Native Hawaiian	44	0.1	3	0.5
	American Indian/Alaska native	143	0.2		
	Other			6	0.9
	Prefer not to respond	452	0.6	23	3.6
	Unknown	283	0.4		
Status					
	Undergraduate	51,625	70.1	152	23.6
	Graduate	11,619	15.8	111	17.4
	Faculty member	3,409	4.6	86	13.5
	Staff member	7,034	9.5	261	40.8
	Other			30	4.7

Note. [a] Population Texas A&M University data was calculated using students and staff demographics from the Texas A&M University accountability report 2019 (Texas A&M University Accountability, 2020) and faculty demographics from the Texas A&M University faculty profile (Office of Data and Research Services, 2019). Percentages may not equal 100% because of rounding errors and/or non-response.

Sample

The required sample size was determined using Dillman et al. (2014) formula (Equation 1) with a finite population correction for a simple random sample survey. Dillman et al. (2014) stated that using a finite population correction helps to achieve a greater share of the population. As the target population was a university population where the majority are students; who are considered as homogenous compared to the general public (Peterson, 2001),the variation in perception was assumed to be smaller than that in the general population. Therefore, we used 80/20 split to calculate the sample size. A 95% confidence interval was used because it is a commonly used confidence interval in social and behavioral science research (Hancock et al., 2018) and the predetermined alpha value was 0.05 for testing research hypotheses of the current study. We intended to obtain 400 completed responses and selected a $\pm$5% desired margin of sampling error, the maximum sampling error for a sample of 400 responses (Marsden & Wright, 2010). The calculation shows a total sample size of 245 was required to meet population generalizability.

$$n = \frac{(N * p * q)}{\left\{(N-1) * \left(\frac{MoE}{z}\right)^2 + (p * q)\right\}} \tag{1}$$

The required sample size was further confirmed using G*Power 3.1.9.7 (Faul et al., 2007) to test mean differences between the three groups using one-way ANOVA fixed effect test, medium effect (*d* = .25),α = 05, and β = .80. The result showed that a total sample of 252 participants with a minimum of 16 cases per group was required for group mean comparison.

Survey Implementation

Survey implementation and management followed the five-contact e-mail strategy suggested by Dillman et al. (2014). The survey invitation and reminders were sent using the university bulk email service. Incentives were not offered for completing the study. Data were collected from March 31 to May 1, 2020. The study fulfilled the exemption requirement under the university Institutional Review Board’s reviews (IRB Number: IRB2019-1036M).

Response Rate

Dillman et al. (2014) emphasized the importance of following standard definitions of the American Association for Public Opinion Research (AAPOR) to describe the response rate. This study adopted the standardized classification system for sample cases of internet surveys of specifically named persons and response rate formula one (known as RR1) to calculate the response rate (American Association for Public Opinion Research, 2016). The AAPOR RR1 formula is indicated in Equation 2. AAPOR case codes and the number of respondents used for calculation are shown in Table 4.3

$$RR1 = \frac{(I)}{(I+P)+(R+NC+O)+(UH+UO)} \qquad (2)$$

Non-contact [NC], other [O], unknown eligibility [UH], and unknown other [UO] were zero for this study; thus, the modified response rate formula (Equation 3) is:

$$Response\ rate\ = \frac{(I)}{(I+P)+R} \tag{3}$$

Table 4.3

AAPOR Final Disposition Case Codes

Case codes	*n*
Target Population	73,687
Accessible Population (Subscribers of the student and employee email listserv)	56,851
Population not contacted [OOS] (Subscribers who did not open the emails)	35,414
Population contacted [OSS] (Opened invitation, but not the survey URL)	20,268
Sample (Participants who clicked the survey URL)	1,169
Refusal [R] (Opened the survey URL, but did not complete any items)	277
Data set	
Complete [I] (100% completed, including 18 who disagreed on the informed consent)	658
Partial [P] (Started, but did not provide 100% completion) [a]	234

Note. AAPOR abbreviations are indicated inside of square brackets and research-specific definitions are indicated inside the parenthesis. [a] Partially completed responses were not considered in the data analysis of the current study because respondents need to be exposed to treatments and complete the post-test to be considered as an eligible response.

A total of 640 participants completed the survey, all anonymously with a 55.6% response rate. Malhotra et al. (2014) found that multiple attempts can lead to measurement error because late respondents are more likely to misreport factual information. Therefore, it is recommended to limit the non-response bias rather than achieving a high response rate (Nishimura et al., 2016). The current study examined nonresponse error by comparing early and late respondents following the recommendation of Lindner et al. (2001), where respondents to the final reminder were identified as late respondents (n = 79) and others were identified as early respondents (n = 561). The independent sample t test showed no significant differences between early (M = 7.07, SD = 1.60) and late respondents (M = 6.96, SD = 1.63) when tested ($p < 0.5$) on knowledge about nutritional value of food, $t(638) = 0.54$, $p = .589$, $d = 0.08$, 95% CI [–0.27,0.48]. Likewise, no significant difference was found between early (M = 0.25, SD = 1.53) and late (M = 0.32, SD = 1.67) respondents when tested ($p < 0.5$) on changes in perception levels after exposure to treatments, $t(638) = –0.378$, $p = .706$, $d = –0.06$, 95% CI [-0.44,0.30].

The sample included students, faculty, and staff members at southwestern land grant university. Based on self-identified race and ethnicity data, about 65% were female, 67% identified as White, 10% Hispanic, and 5% Black. The sociodemographic profile of the sample population is shown in Table 4.2. Comparison between the sample and population sociodemographic shows the sample is not a representative sample of a population, despite achieving the required sample size for population generalizability. The sampling error was 3%, calculated by using the formula (Equation 4) for sampling error (Dillman et al., 2014) at a 95% confidence interval with an 80/20 split.

$$MoE = z * \sqrt{\frac{(p * q)}{n}} \; 4 \tag{4}$$

We acknowledge a sampling error exists and do not attempt to generalize the findings to the population.

The Experimental Protocol

Allgaier (2019) stated that people prefer to use YouTube to find scientific information because other web-based textual information requires high reading levels. About 73% of American adults and 94% of younger Americans (18–24 years old) use YouTube (Pew Research Center, 2018), suggesting its acceptability as a common form of communications media. Therefore, we selected three YouTube videos as experimental manipulation to examine the changes in perception levels based on facts presented in the videos.

A video produced by WebMD (2017), “Truth About Organic Food,” was used as a factual news story (1 min 29 s). “Why Eat Organic Food? Our Top 5 Reasons to Change to this Healthy Lifestyle“ by Organic Roost (2016) was used as a nonfactual video (2 min 12 s)., and “Top 5 Food Safety Tips to Keep Your Family Safe | Food Hygiene“ by Howdini (2014) was used as the control (1 min 37 s). The three videos were approximately the same length (i.e., average 1min 45 s viewing time). Participants who agreed to participate in the study were randomly assigned to watch one video through the Qualtrics randomization feature. Each group of participants answered the same pre-questionnaires on preexisting attitudes and watched the video, then completed the post-questionnaires. We informed participants that the purpose of the study was to measure perceptions of scientific news stories about foods, but they were not made aware of randomized assignments (factual, nonfactual, and control videos) in the experiment.

Research Instrument

The research instrument was developed by adapting the study *The New Food Fights: U.S. Public Divides Over Food Science,* conducted between May–June 2016 by the Pew Research Center (Pew Research Center, 2016). The wordings of selected questions were changed to increase clarity and readability. Additional questions were used to measure knowledge about nutritional value, perform an experimental manipulation check, and determine changes in perception levels. The research instrument contained 11 constructs including nine specific constructs to measure participants' perceptions of organic and conventionally grown foods (see Appendix C).

Frequency of News Exposure

Because we aimed to examine how communication type affects perception of organic foods, the first construct measured levels of exposure to information on health effects of food and drinks using six questions. The first two questions measured the frequency of hearing and reading news stories about the health effect of foods and drinks using a 5-point scale (1 = *not at all* to 5 = *daily*). The other two questions measured the frequency of exposure to news reports that conflict with earlier reports that the audience had heard or read about the health effects of foods and drinks. The response options ranged from 1 (*not at all*) to 4 (*all the time*). These four questions were developed based on questions in the Pew Research Survey on *The New Food Fights* (Pew Research Center, 2016). We modified the wording of questions to match the purpose of the current study and developed four questions to separate hearing and reading news. The Cronbach's alpha for the frequency of news exposure was .72.

Selective Exposure

To reduce participants' misinterpretations of the terms "organic foods" and "conventional foods, "we developed new questions using the United States Department of Agriculture's (USDA) definition of organic and conventionally grown foods. We asked participants to rate the news exposure level to specific news. Participants used a 4-point scale ranging from 1 (*not at all*) to 4 (*very closely*) to indicate the exposure level.

Knowledge

The knowledge construct contained one question to measure self-perceived knowledge about the nutritional value of foods. A scale from 1 (*no knowledge*) to 10 (*high knowledge*) was used to quantify self-perceived knowledge.

Participants' Preexisting Beliefs About Organic and Conventionally Grown Foods

To measure preexisting beliefs, we used 24 statements (12 statements per organic and 12 statements per conventional) divided into four matrix-type questions. Participants used a 4-point Likert-type scale (1 = *strongly disagree* to 4 = *strongly agree)* to state their agreement levels with each statement. We performed reliability tests using all 12 items, and selected items with a corrected item-total correlation higher than .30 to determine overall beliefs about organic and conventional foods. The "Preexisting Beliefs of Organic Foods" and "Preexisting Beliefs of Conventionally Grown Foods" constructs contained statements that describe the taste, health benefits, pesticide exposure, and whether the foods were grown naturally. We adapted taste and health benefits statements for “Preexisting Beliefs of Organic Foods” from the Pew Research Center survey on *The New Food* Fights (Pew Research Center, 2016). The “Preexisting Beliefs of Conventionally Grown Foods” construct followed the same wording except it asked whether conventionally grown foods were better, worse, or neither better nor worse than organic foods.

To determine overall beliefs about organic foods, we created an aggregated score of six statements (6–24 score range). We reverse-coded two negatively worded statements. Those statements were “neither better nor worse for one’s health than conventionally grown foods” and “neither better-tasting nor worse tasting than conventionally grown foods.” Cronbach’s alpha for the selected six statements on organic food beliefs was .82. The “Preexisting Beliefs of Conventionally Grown Foods” construct also contained six statements, and an aggregated score (6–24 score range) was used to determine overall beliefs about conventional foods. We reverse coded negatively worded statements “worse for one’s health than organic foods,” “worse tasting than organic foods,” and “increase exposure to commercial pesticide residues” before calculating the overall score. The selected six statements on conventional-grown food beliefs constructs had Cronbach’s alpha of .81.

Exposure to Treatments (Attention Check)

The instrument contained three sets of post-question blocks to verify the efficiency of the treatment effects. We assigned participants to each attention check based on video exposure type. Each set of attention checks contained five statements and used 4-point Likert-type scales (1 = *strongly disagree* to 4 = *strongly agree*). Groups who viewed factual or nonfactual video received five statements that contained statements such as "the video was based on factual science," "the video was not based on factual science," and "according to the video, there is no difference in quality between conventionally grown and organic foods." The group who viewed the control video received three statements: "the video shared information about organic foods," "the video did not share information about organic foods," and "the video shared information about food safety tips." To reduce acquiescence bias (Cronbach, 1950; Dillman et al., 2014), attention check constructs contained statements that agreed and disagreed with exposure statements. We reversed coded statements that disagreed with the exposure treatment for reliability analysis. Cronbach's alpha for exposure to factual treatments was .71, exposure to nonfactual treatment was .73, and exposure to control was .74. These alpha levels were deemed reliable for the purposes of the current study.

Changes in Perception Levels

Participants were asked to indicate how watching the videos influenced their perception of organic foods. Changes in perception were measured using an 11-point scale, ranging from –5 (*negatively influenced*) to +5 (*positively influenced*). The 11-point scale was used to reduce extremely unfavorable ratings (Preston & Colman, 2000). Analysis using 11-point scale data is referred to as numerical rating scale hereafter. In addition to using a numerical rating scale, we used five statements based on the latent content of the video message to measure changes in perception levels to get an in-depth understanding of treatments' influence. A 4-point, Likert-type scale (1 = *strongly disagree* to 4= *strongly agree*) with a *not applicable* option was used to collect the responses. The five statements were: “the video makes me feel more confident about eating conventionally grown foods,” “the video makes me feel more confident about eating organic foods,” “the video makes me feel more anxious about eating conventionally grown foods,” “the video makes me feel more anxious about eating organic foods,” and “the video makes me think more about the nutritional value of the food than whether to select organic or conventionally grown foods.” We reverse coded statements that disagreed with the exposure treatment before calculating the aggregated score (range 5–20) of changes in perception levels. Analysis using the aggregated score is reported as summed scale hereafter.

We coded *not applicable* responses for the “Changes in Perception Levels” construct based on experimental conditions. For treatment conditions, selecting *not applicable* meant no effect of treatments; thus, we coded *not applicable* responses as zero. Treating *not applicable* as zero was appropriate in this situation because the respondent put themselves on the lower end of the scale by indicating no treatment effects (Huggins-Manley et al., 2018; Welch, 2013). Selecting *not applicable* for the control condition cannot be considered as the lower end of the latent trait because *not applicable* was the correct response describing the control condition. For example, for the statement, “The video makes me feel more confident about eating conventionally grown foods,” a respondent may have chosen *strongly disagree* or *not applicable* to convey their disagreement. Moreover, the *not applicable* option was added to the survey based on the feedback from pilot test participants who noted that *strongly disagree* did not describe their situation. Therefore, we coded both *not applicable* and *strongly disagree* responses as four for the control condition.

Assigning four to the *not applicable* for control condition responses was appropriate following Huggins-Manley et al.'s (2018) recommendations when a *not applicable* response is a true indicator explaining the situation of a respondent. Holman et al. (2004) noted that replacing the *not applicable* response with a pre-determined value (cold-deck approach) reduces variability. Thus, we reported results from the numerical rating scale and summed scale separately. Cronbach's alpha for the changes in perception was measured per each experimental condition (factual .73, nonfactual .76, and control .89) as well as the overall construct, which was .84. At the end of the survey, the group who viewed the nonfactual video received an additional statement about recent findings that no significant health benefits were derived from eating organic foods (Hurtado-Barroso et al., 2019; Smith-Spangler et al., 2012).

Based on our interpretation of summed scale, if a respondent scored 20 in the experimental condition, it reflected: 1) Participants agreed that scientific facts explaining nutritional values of foods were more important than selecting organic or conventionally grown foods (factual group); 2) Participants agreed that organic foods were superior to conventionally grown foods regardless of nutritional value (nonfactual group); or 3) Participants agreed that video about food safety did not influence their views about nutritional values of organic foods (control group).

Instrument Validity and Reliability

The instrument was pilot tested using a purposive sample (n = 29), which included undergraduate students, graduate students, faculty members, and staff members. Four researchers (who were not involved in developing the study but have expertise in developing web surveys) and graduate committee members evaluated the instrument for content-related evidence validity (Fraenkel et al., 2019). Based on the feedback, the wording and format were changed to achieve an adequate representation of the content.

Internal consistency was measured using Cronbach's alpha. All constructs reported in this manuscript had five or six items per construct. Each construct achieved Cronbach's alpha value of more than .7 and a mean inter-item correlation value between .2 and .4. Briggs and Cheek (1986) noted: "the optimal level of homogeneity occurs when the mean inter-item correlation is in the range .2 to .4 range" (p. 115). Streiner (2003) noted Cronbach's alpha values between .7 and .8 produce acceptable reliability for basic research. The reliability scores and mean inter-item correlation of each construct are indicated in Table 4.4, and Appendix C shows the wordings of original questions and coding used for analysis.

Table 4.4

Reliability Score for Each Construct of Questionnaires

Constructs	Sample Statements	α	Mean inter-item correlation
Frequency of news Exposure	How often do you hear news stories about the health effects of what people eat and drink? How often do you hear news stories that conflict with earlier reports about the health effects of what people eat and drink?	.72	.41
Preexisting beliefs of organic foods	Do you believe organic foods are: Better for one's health than conventionally grown foods. Reduce exposure to commercial pesticide residues.	.82	.43
Preexisting beliefs of conventional foods	Do you believe conventionally grown foods are: Neither better tasting nor worse tasting than organic foods Increase exposure to commercial pesticide residues.	.81	.42
Exposure - factual treatments	According to the video, there is no difference in quality between conventionally grown and organic foods.	.71	.33
Exposure - nonfactual treatments	According to the video, organic foods are better than conventionally grown foods	.73	.36
Exposure - control	The video shared information about food safety tips.	.74	.36
Changes in perception	The video makes me feel more confident about eating conventionally grown foods. The video makes me feel more anxious about eating conventionally grown foods.	.84	.32

Data Analysis

Analyses included sample characteristics and descriptive statistics for preexisting beliefs and changes in perceptions. An analysis of variance (ANOVA) test was performed to examine the primary hypothesis (H_1) of the changes in perception levels after exposure to factual, nonfactual, and control videos. The independent variable was participants' exposure to different videos (factual, nonfactual, or control); the dependent variable was differences in perception levels. Summed scale and numerical rating scale data on influence were non-normally distributed with unequal variance. However, we performed a parametric test because we had a relatively larger sample size (n = 626). Scholars have concluded that parametric tests can be used for unequal and non-normally distributed Likert data without fear of making an incorrect conclusion (Carifio & Perla, 2008; Norman, 2010). We performed a non-parametric test (*Kruskal-Wallis*) to avoid making incorrect conclusions and reported the results separately.

We examined the moderating effects (H_2 to H_8) of self-perceived knowledge, frequency of exposure to news about the health effects of foods and drinks, academic status, and preexisting beliefs on changes in perception levels after exposure to treatments using two-way between-groups analysis of variance (two-way ANOVA). Even though we had non-normally distributed data, we performed the two-way ANOVA tests following the recommendation of Toothaker and Newman (1994). Toothaker and Newman (1994) noted that if the sample size large enough with a slight deviation from a normal distribution, two-way ANOVA performs better than non-parametric tests.

Additionally, we tested whether changes in perception exist based on gender and ethnicity using two-way ANOVA.

Participants who did not watch the videos nor indicate changes in perception levels after watching videos were considered invalid responses and remove from the analysis. Analyses were based on 100% of completed responses. Missing values were treated as missing for analysis. We considered aggregated scores of each construct as interval data for all analyses (Carifio & Perla, 2008; Norman, 2010).

Results

Before testing hypotheses, we performed a manipulation check to confirm the treatments' effectiveness. An aggregate score (range 9–20) of the attention check construct (M = 15.92, SD = 2.43) was used to identify participants who received treatment (watched the video) and who did not receive treatment (did not watch the video). Participants who scored equal to or greater than 11 were labeled "treatment-received" and those who scored equal to or less than 10 were labeled "treatment-not-received." The cutoff score of 10 was based on the premise that if a participant selected incorrect choices for all five statements, the maximum score would be 10. Thirteen participants were identified as treatment-not-received.

Effects of Factual and Nonfactual News

Using numerical rating scale and summed scale data, two one-way ANOVA tests were conducted to compare the mean differences in perception of organic foods after exposure to factual, nonfactual, and control videos. Before conducting the ANOVAs, we identified extreme outliers in each experimental group. Standardized z-score values of changes in perception levels not in the range of −3 to +3 were considered indicative of extreme outliers (Osborne & Overbay, 2004; Pituch & Stevens, 2015). Outliers constituted less than 2% of the total sample and did not result from errors in recording or measurement. In such situations, Pituch and Stevens (2015) recommend not omitting such outliers from the analysis. We recomputed the group's mean removing outliers and found a small difference in the factual group's means (numerical rating scale 0.02 and summed scale 0.44), but not in the means of the nonfactual or control groups. Similarly, the computation of ANOVAs with and without outliers did not change the study findings. The analysis without outliers is reported in Tables 4.5 and 4.6.

Table 4.5

Results of One-way ANOVA Test for Changes in Perception of Organic Foods

Scale	Factual		Nonfactual		Control				
	M	*SD*	*M*	*SD*	*M*	*SD*	*F* ratio	*df*	*p*
NR [a]	0.18	1.18	0.63	2.26	0.00	0.15	9.90	2,610	< .001*
SS [b]	14.13	2.18	11.80	4.13	17.44	2.88	169.27	2,615	< .001*

Note. NR = Numerical Ratings: SS = Summed Scale. ANOVA= analysis of variance. [a] Numerical rating score ranged from –5 to +5. [b] Summed scale ranges from 0 to 20.

**p* < .05.

Table 4.6

Results of Kruskal–Wallis Test for Changes in Perception of Organic Foods

Scale	Factual	Nonfactual	Control		
	Md	*Md*	*Md*	*H*(2)	*p*
Numerical rating	0	0	0	32.86	< .001*
Summed scale	14	13	19	231.70	< .001*

*$p < .05$.

The primary hypothesis (H_1) was fully supported by the results of both parametric and nonparametric tests. These results showed significant differences between participants' mean perception levels of organic foods after exposure to factual and nonfactual news. However, effect size differed based on scale. Results from the numerical rating scale showed a small effect ($\eta_p^2 = .03$), but those from the summed scale showed a larger effect ($\eta_p^2 = .36$).

Post hoc comparisons were conducted using the *Games–Howell* procedure, when population variance is uncertain and sample sizes are unequal (Field, 2013). The post hoc *Games–Howell* test indicated a significant difference in changes in perception levels between the a) nonfactual and control group (numerical ratings: $p = <.001$, $M_{diff} = .62$, summed scale: $p < .001$ $M_{diff} = -5.64$), and b) factual and nonfactual group (numerical ratings: $p = .047$, $M_{diff} = -.45$, summed scale: $p < .001$, $M_{diff} = 2.33$). Summed scale analysis showed a significant difference in perception levels between the factual and control groups for parametric ($p < .001$, $M_{diff} = -3.31$) and nonparametric analysis ($p <$

.001, r = .48). However, numerical rating analysis showed no statistically significant difference in perception levels between factual and control groups for parametric (p = .073, M_{diff} = .18) and nonparametric tests (p = .203, r = −.06).

Self-Perceived Knowledge of the Nutritional Value of Foods

Before conducting a two-way ANOVA to examine the possible moderating effect of self-perceived knowledge, we identified three self-perceived knowledge groups based on quartile values on the self-reported knowledge scale (numerical rating scale range from 1–10 with integers). One group consisted of individuals in the first quartile (low), another those in the second quartile (average), and the last those in the third quartile (high). There was a nonsignificant interaction effect between type of video exposure and knowledge groups for both numerical rating, $F(4, 618) = 2.05$, $p = .806$, and summed, $F(2, 617) = 1.11$, $p = .353$, scales analysis. Thus, our second hypothesis (H_2) was not supported by the data. Self-perceived knowledge levels did not have a moderating effect on change in perception levels after exposure to factual and nonfactual information.

Frequency of News Exposure

A total score of news exposure was computed combining the rating of exposure to news about health effects of foods and drinks and conflicting news (news that conflicts with earlier reports that heard or read). The frequency of news exposure groups was based on first, second, and third quartile values (interval scale range from 4-18 with integers) of the total score of news exposure. The 25th percentile value was 10; participants who scored 10 or less were in the low exposure group. Those who scored

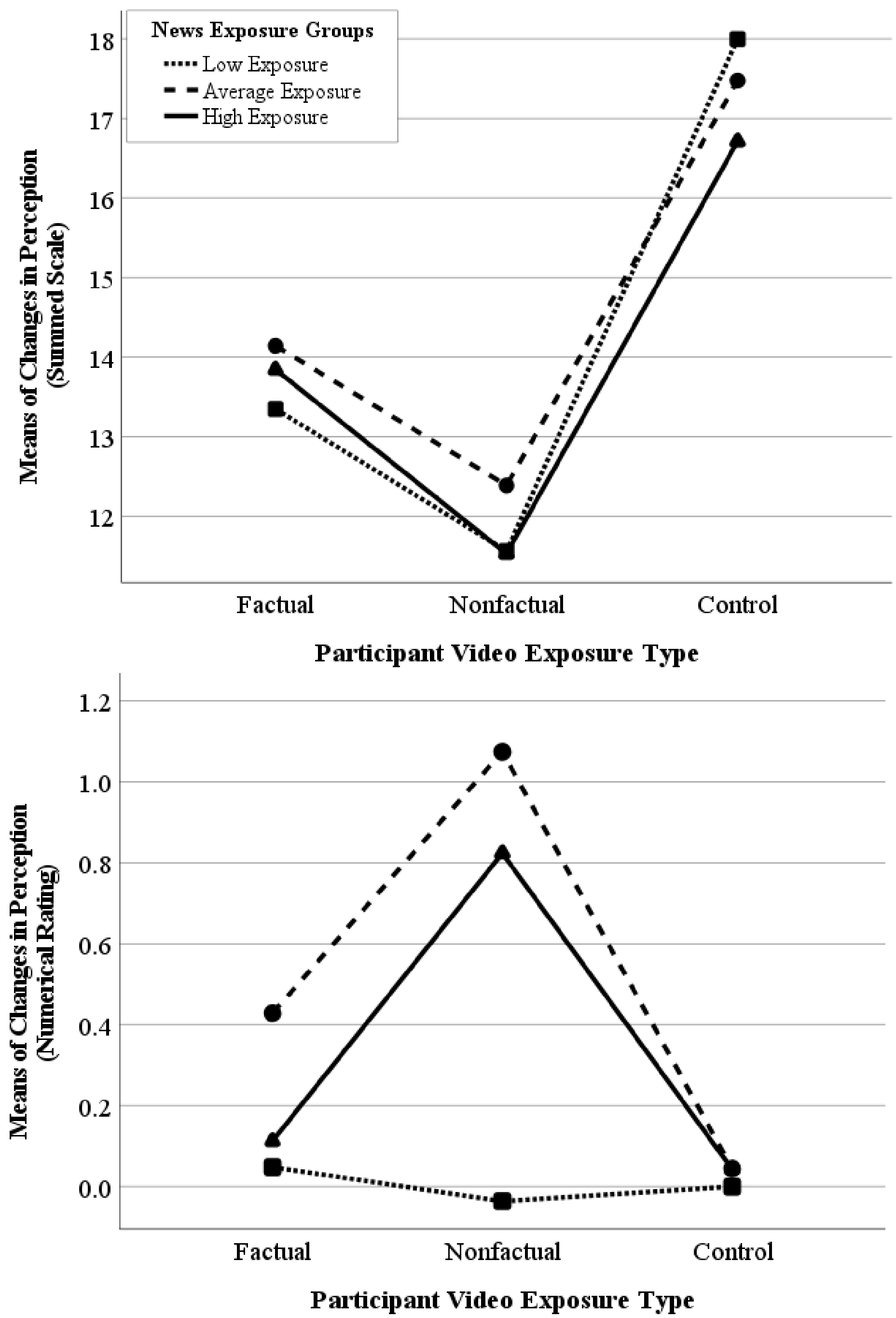
11–12 were in the average exposure group, with the median of 11. Participants who scored 13 or more were in the high exposure group.

A significant main effect based on the frequency of news exposure groups was found in the numerical rating analysis. We performed post hoc comparisons using the *Gabriel* pairwise test because it has greater power if sample sizes are slightly different (Field, 2013) compared to other post hoc tests. *Gabriel's* test indicated that the mean changes in perception levels differed significantly between average and low exposure groups (M_{diff} = .47, p = .006). The high exposure group did not differ significantly from the low (M_{diff} = .31, p = .097) or average exposure (M_{diff} = –.16, p = .667) groups.

The interaction effect between video exposure types and the frequency of news exposure was significant only with the numerical rating scale $F(4, 617) = 2.47$, $p = .044$, $\eta_p^2 = .02$. Results were nonsignificant with the summed scale $F(4, 616) = 1.75$, $p = .138$, $\eta_p^2 = .01$. The significant interaction effect supported the third research hypothesis (H_3) that frequency of exposure moderate changes in perception levels. Specifically, pairwise comparisons with Bonferroni adjustments showed those with low levels of news exposure (M_{diff} = −0.04, SE = 0.26) did not experience significant changes in their perception levels of organic foods after watching the nonfactual video, compared with the control group. Participants with average (M_{diff} = 1.03, SE = 0.28, p = .001) or high level (M_{diff} = 0.78, SE = 0.26, p = .008) news exposure, positively changed their perceptions about organic foods after watching the nonfactual news video. Figure 4.2 shows changes in perception for each news exposure group.

Figure 4.2

Interaction Plot of Changes in Perception vs. Participants Video Exposure Type for Each News Exposure Group



Selective Exposure

We tested whether selective exposure to organic and conventional foods news had a moderating effect on changes in perception. Levels of selective exposure were based on self-reported interest in following news about organic and conventional foods. Twenty-three percent of participants did not follow organic news stories; 51% not very closely, 22% somewhat closely, and 4% very closely. Similarly, 21% noted they did not follow news stories about conventional foods; 46% followed it not very closely, 28% somewhat closely, and 5% very closely.

We combined participants who followed the news *very closely* and *somewhat closely* into a new group, labeled as "closely" before testing the moderative effect of selective exposure. A two-way ANOVA indicated a nonsignificant interaction between selective exposure to organic news and video exposure types for the numerical rating score $F(4, 618) = 0.35$, $p = .845$, and summed scale score $F(4, 617) = 1.46$, $p = .214$, for organic foods. Similarly, the interaction effect between selective exposure to conventional food news and experimental groups was not significant for neither scale; numerical rating score $F(4, 618) = 0.98$, $p = .471$, and summed scale score $F(4, 617) = 1.90$, $p = .110$.

Academic Status

Two-way ANOVA was conducted to examine the mean changes in perception levels based on academic status. Academic status groups were undergraduate students, graduate students, faculty, staff, and others. There were non-significant interaction effects between experimental conditions and academic status for both numerical rating

F(8,612) = 0.89, p = .52, and summed scale F(8,611) = 0.85, p = .56. Thus, the fourth hypothesis (H_4) was not supported, academic status did not moderate changes in subjects' perception of organic foods after exposure to treatments.

Participants' Preexisting Beliefs About Organic Foods

The moderating effects of participants' preexisting beliefs about organic foods were tested. Three groups were formed, based on first, second, and third quartile values of the total beliefs construct score (an integer scale of 2–24). The 25th percentile value was 12.5; those who scored 12.5 or less did not have strong opinions about organic foods. They constituted the "low organic beliefs" group. The median was 15; those scoring between 12.6 and 16 were the "average organic beliefs" group. The third quartile value was 17; participants who scored 17 or more were the "high organic beliefs" group.

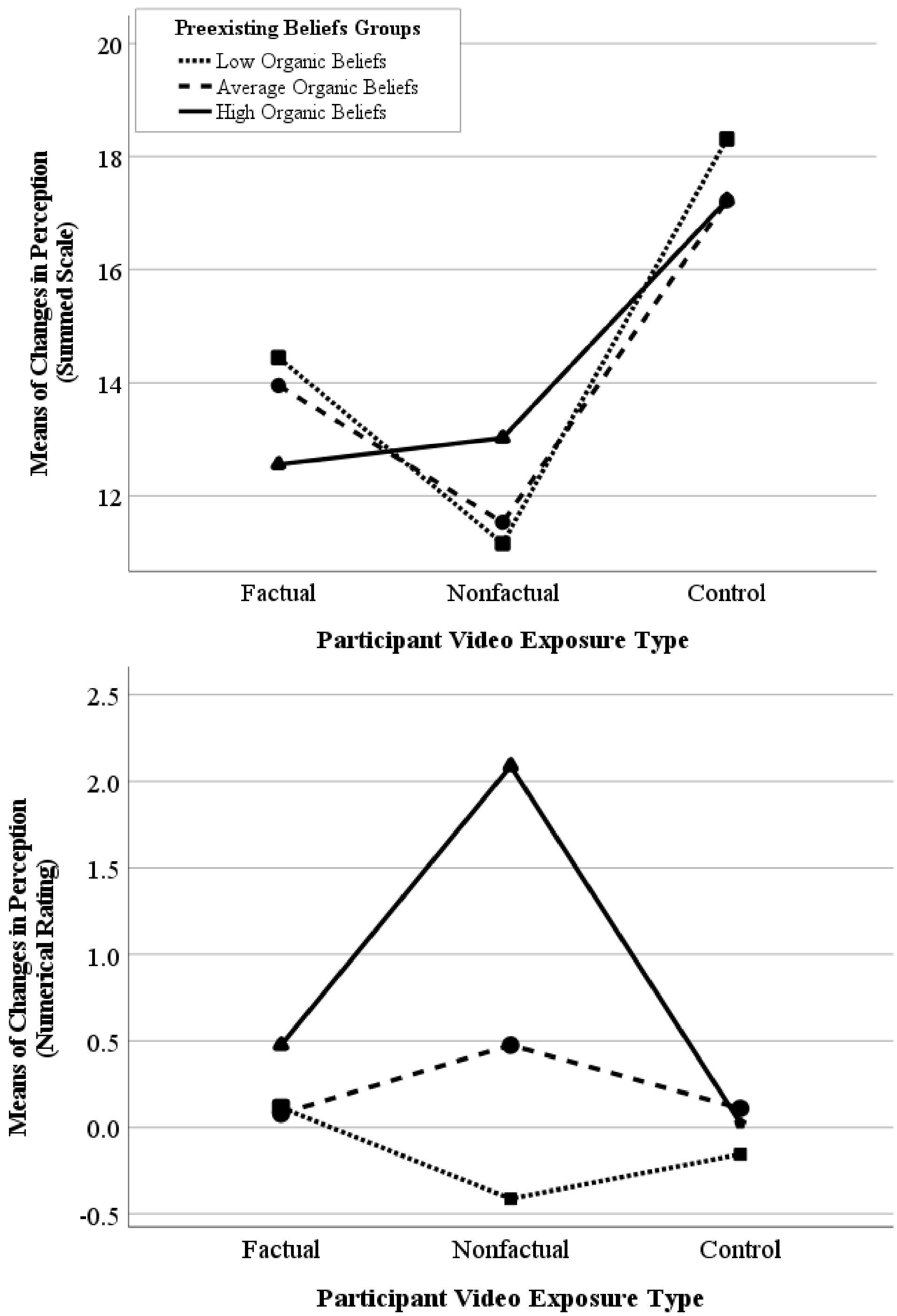
There was a statistically significant main effect for preexisting organic foods beliefs based on numerical rating score $F(2, 618) = 20.86$, $p = < .001$, $\eta_p^2 = .06$, but not with the summed scale score $F(2, 617) = 0.80$ $p = .451$, $\eta_p^2 = .00$. Pairwise comparisons (with Bonferroni adjustment) for the main effect using the numerical rating score showed a significant difference in perception changes by beliefs groups. The "high organic beliefs" group had significantly greater level of changes in perception than "low organic beliefs" (M_{diff} = 1.01, SE = 0.16, p = <.001) and "average organic beliefs" (M_{diff} = 0.64, SE = 0.14, p = <.001) groups after exposure to treatments.

The interaction effect between experimental groups and preexisting beliefs about organic foods was significant for both scales: numerical rating scale with medium effect $F(4, 618) = 11.13$, $p = < .001$, $\eta_p^2 = .07$, and summed scale with small effect F(4, 617) =

5.30, p = <.001, η_p^2 = .03. Figure 4.3 shows two-away ANOVA interaction plots for changes in perception versus participant video exposure types for each organic foods' beliefs group. The interaction effect for both numerical rating and summed scales analysis indicated that changes in perception varied by levels of preexisting beliefs about organic foods.

Figure 4.3

Interaction Plot of Changes in Perception vs. Participant Video Exposure Types for Each Organic Foods Beliefs Group



Participants With Favorable Beliefs About Organic Foods

Using pairwise comparisons (with Bonferroni adjustment for multiple comparisons), we tested whether participants with high-organic beliefs (i.e., favorable beliefs about organic foods) had statistically significant changes in their perception of organic foods after exposure to factual and nonfactual videos (see Table 4.7). For summed scale results, the “high organic beliefs” group had significantly lower perception change (i.e., lower total scores for change in perception) after exposure to a factual video about organic foods than the “low organic beliefs” and “average organic beliefs” groups. We did not find similar effects from the numerical rating scale analysis. The fifth hypothesis (H_5) was partially supported by the summed scale data: the “high organic beliefs” group was least influenced by the factual video, which explained that organic foods did not provide significant health benefits over conventionally grown foods.

Table 4.7

Pairwise Comparisons for Organic Beliefs Groups

	Level of organic beliefs						Pairwise comparisons [a]			
	Low		Average		High		High vs Low		High vs Average	
	M	*SD*	*M*	*SD*	*M*	*SD*	M_{diff}	*p*	M_{diff}	*p*
F										
NR	0.11	1.28	0.08	1.43	0.48	1.40	0.36	.509	0.40	.275
SS	14.44	3.03	13.95	2.77	12.56	3.58	–1.89	.005*	–1.40	.028*
NF										
NR	–0.41	2.50	0.48	1.95	2.09	1.74	2.50	<.001*	1.61	<.001*
SS	11.16	3.52	11.53	4.32	13.02	4.27	1.87	.019*	1.49	.049*

Note. F = Factual group; NF = Nonfactual group; NR = Numerical ratings; SS= Summed Scale. [a] With Bonferroni Adjustment for Multiple Comparisons

$*p < .05$.

The sixth hypothesis (H_6) stated that after exposure to a nonfactual video "high organic beliefs" group would have more positive perceptions of organic foods than would low and average groups. H_6 was supported with both numerical rating and summed scale analysis. The "high organic beliefs" group reinforced existing opinions after exposure to the nonfactual video and perceived organic foods provide significant benefits over conventionally grown foods than were "low organic beliefs" and "average organic beliefs" groups.

Participants' Preexisting Beliefs About Conventionally Grown Foods

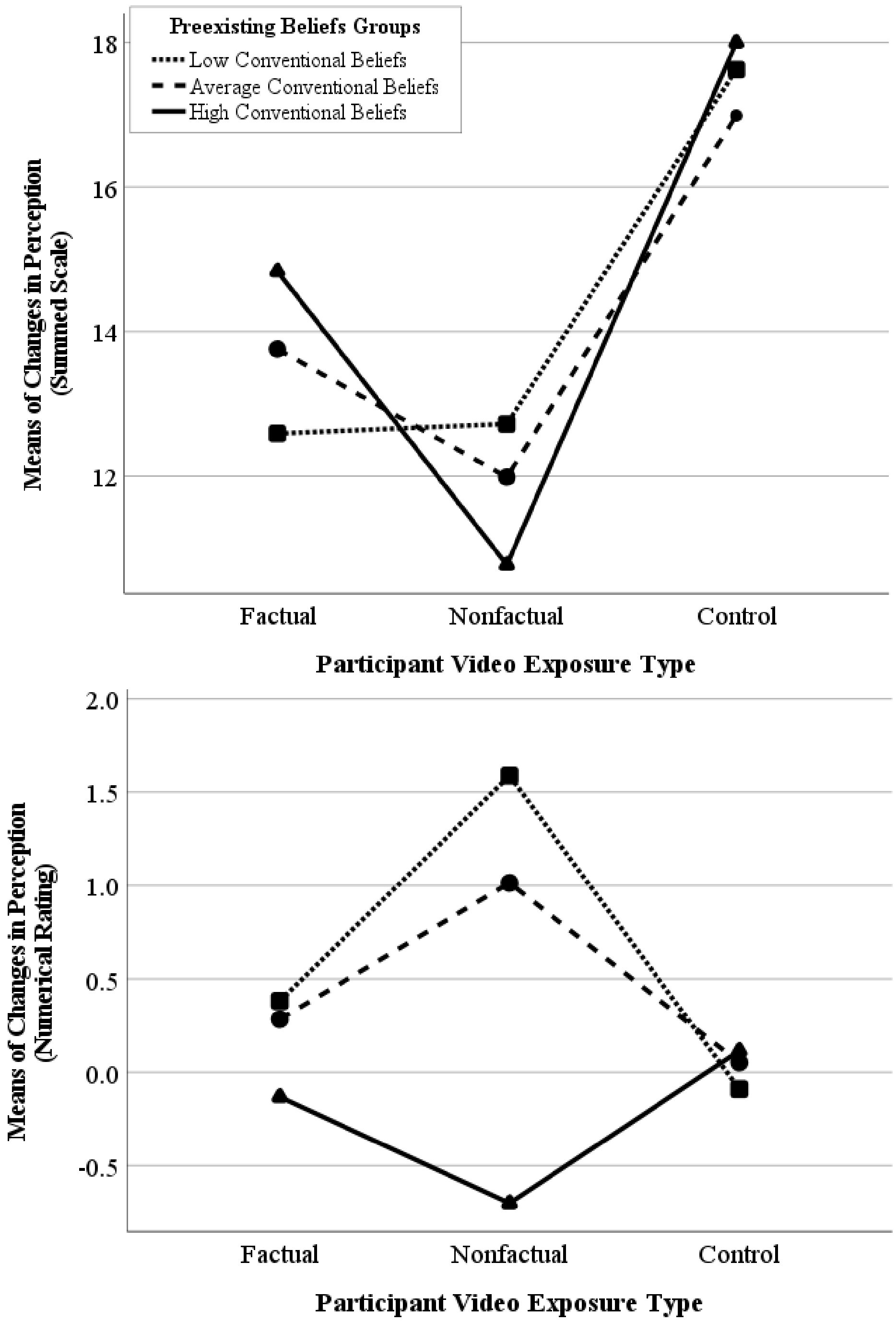
Two-way ANOVA was conducted to test the moderating effect of preexisting beliefs about conventionally grown food on changes in perception. We grouped participants based on their preexisting beliefs about conventionally grown foods. These groups were based on first, second, and third quartile values of the total score (an integer scale of 5–24) for preexisting beliefs of the conventionally grown foods construct. The "low conventional beliefs" group constituted of individuals in the first quartile (scoring ≤14), "average conventional beliefs" in the second quartiles (scoring 15–17), and "high conventional beliefs" in the third quartile (scoring ≥18).

A significant main effect for preexisting beliefs about conventionally grown foods was found for the numerical rating scale analysis $F(2, 616) = 18.10$, $p = < .001$ $\eta_p^2 = .05$, but not for summed scale scores $F(2, 615) = 0.42$, $p = .656$, $\eta_p^2 = .00$. Pairwise comparisons for main effect (with Bonferroni adjustment using numerical rating scale) showed "high conventional belief" group had significantly lower total scores for change in perception, compared with participants with low ($M_{diff} = -0.87$, $SE = 0.15$, $p = <.001$) or average ($M_{diff} = –0.69$, $SE = 0.14$, $p = <.001$) conventional beliefs group.

The interaction effect between experimental groups and participants' preexisting beliefs about conventionally grown foods was significant both on the numerical rating scale $F(4, 616) = 11.99$, $p = <.001$, $\eta_p^2 = .07$ and summed scale scores $F(4, 615) = 6.67$, $p = <.001$, $\eta_p^2 = .04$. Figure 4.4 shows the mean plots of changes in perception versus experimental groups for each conventional beliefs group. The interaction effect in both numerical rating and summed scale scores indicated that subjects' perception changes differed according to their level of preexisting beliefs about conventionally grown foods.

Figure 4.4

Interaction Plot of Changes in Perception vs. Participants Video Exposure Type for Each Conventional Beliefs Group



Participants With Favorable Beliefs About Conventional Grown Foods

To test whether the "high conventional beliefs" group had significant changes in perceptions after watching the factual and nonfactual videos, we performed pairwise comparisons (with Bonferroni adjustment for multiple comparisons) (See Table 4.8). The seventh hypothesis (H_7) was not supported by numerical rating scale analysis, which showed after exposure to the factual video, the "high conventional beliefs" group did not significantly change their perception about organic foods compared with low and average groups. However, according to the summed scale analysis, "high conventional beliefs" and "low conventional beliefs" groups differed significantly after exposure to the factual video.

Table 4.8

Pairwise Comparisons for Conventional Beliefs Groups

	Conventional Beliefs Groups						Pairwise comparisons [a]			
	Low		Average		High		High vs Low		High vs Average	
	M	*SD*	*M*	*SD*	*M*	*SD*	M_{diff}	*p*	M_{diff}	*p*
F										
NR	0.38	1.53	0.28	1.49	–0.13	0.97	–0.51	.140	–0.42	.251
SS	12.59	3.82	13.76	2.66	14.84	2.65	2.25	<.001*	1.08	.144
NF										
NR	1.59	1.99	1.01	2.00	–0.70	2.21	–2.29	<.001*	–1.72	<.001*
SS	12.72	4.37	11.99	3.90	10.77	4.05	–1.95	.008*	–1.21	.122

Note. F = Factual group; NF = Nonfactual group; NR = Numerical Ratings; SS = Summed Scale. [a] With Bonferroni Adjustment for Multiple Comparisons

**p* < .05.

The eighth hypothesis (H_8) was tested after exposure to the nonfactual video, the "high conventional beliefs" group has a lower level of changes in perception compared with low and average beliefs groups. From both numerical rating and summed scale analysis, the eighth hypothesis (H_8) was supported; the "high conventional beliefs" group significantly differs from the "low conventional beliefs" group. However, according to summed scale analysis, changes in perception of the "high conventional beliefs' group were not statistically different from those of average-conventional beliefs groups.

Gender and Ethnicity

In addition to testing our hypotheses, we tested whether subjects' gender and ethnicity were associated with the change in perceptions after exposure to factual and nonfactual videos. No significant interactions existed between gender (female or male) and video exposure types for their numerical rating $F(2, 615) = 1.95$, $p = .143$ or summed scale scores $F(2, 614) = 1.04$, $p = .363$. Similarly, no significant interactions existed between ethnicity (White or non-White) and video exposure types for either numerical rating $F(2, 619) = 1.67$, $p = .189$ or summed scale $F(2, 618) = 1.12$, $p = .326$. However, based on numerical rating scale analysis, we found a main effect for race $F(1, 619) = 7.64$, $p = .006$, $\eta_p^2 = .01$. Pairwise comparisons showed non-Whites' mean changes in perceptions were significantly higher than were Whites ($M_{diff} = -.36$, $SE = 0.13$, $p = .006$).

Discussion

The effect of factual and nonfactual news stories on public perceptions of organic food was examined using a randomized posttest-only control experiment and our results showed that nonfactual information had the most influence on public perception of organic foods. Changes in perception varied by level of preexisting attitudes about organic and/or conventionally grown foods, as well as the frequency of exposure to news about the health effects of foods and drinks. We did not find changes in perceptions based on self-perceived knowledge of the nutritional value of foods, selective exposure, academic status, sex, or race.

In addition, we discovered the following two challenges for nutritionists and other communicators when communicating scientific information about organic foods. First, participants with average to high frequencies of news exposure tended to believe nonfactual information more than did those with low frequencies of news exposure. Second, participants were more susceptible to nonfactual information when their preexisting beliefs matched with the content of the nonfactual video. Inversely, when nonfactual information was inconsistent with their preexisting beliefs, participants showed less susceptibility to misinformation.

Changes in Perception After Exposure to Videos

Prior research on misinformation often tested the effects of nonfactual information on public perception of science using politically sensitive topics such as climate change (Drummond et al., 2020; Hart & Nisbet, 2012; van der Linden et al., 2017). Our study provides evidence regarding the effects of nonfactual information on changes in public perception of organic foods, which is considered a politically not polarized topic. We found that the factual video convinced participants about scientific facts. However, numerical rating score analysis did not detect a significant change in perception levels between the factual and control group. A possible reason could be that the factual video's message was not strong enough to change overall opinion, similar way to the nonfactual video that changed participants' perception about organic foods. Perhaps participants' preexisting beliefs on organic foods were stronger and the video's message could not negate these beliefs' impact because the message did not agree with the participants' preexisting beliefs. Future research is needed to identify possible negating effects based on the level of preexisting beliefs by presenting factual videos covering diverse topics (topics that coincide with preexisting beliefs and topics that do not) and measuring the changes in perceptions.

The significant interaction effect between preexisting beliefs on organic foods and types of video exposure showed that participants who had a high level of preexisting beliefs about organic foods did not change their perception after exposure to the factual video. This observation further supported our assumption that the influence made from the factual video not strong enough to change participants' preexisting beliefs about organic foods. Costanigro et al. (2014) observed similar results when measuring changes in valuation decisions after presenting scientific evidence on the ambiguity of the benefits of organic produce. Participants interpreted scientific evidence based on their preexisting beliefs and they did not change their overall valuation decisions of organic products (Costanigro et al., 2014). Therefore, we agree that nutrition communicators face challenges when communicating scientific facts in media environments with fake and highly exaggerated news (Rowe & Alexander, 2017). However, our findings from summed scale analysis demonstrate that although the factual video did not persuade participants at the same level as the nonfactual video, communicating factual messages helps improve people's understanding of scientific facts on controversial issues.

Self-Perceived Knowledge

Self-perceived knowledge of nutrition value did not influence the changes in perceptions of organic foods after exposure to factual and nonfactual videos. Our results aligned those with Teng and Wang (2015), who found that perceived knowledge does not lead to positive attitudes toward organic foods, because attitudes are influenced by knowledge only when trust is built. Our findings have a limitation because most of our sample had at least an undergraduate education and a lack of representation of people with less than undergraduate education. This homogenous nature of the sample might result in nonsignificant findings between self-perceived knowledge groups. However, analysis based on academic status (undergraduate, graduate, faculty, and staff) also showed nonsignificant results. We did not find a difference in perception between undergraduate and graduate students. Thus, we conclude that self-perceived knowledge does not influence changes in perception of organic foods after exposure to factual and nonfactual videos.

Frequency of News Exposure

We found that people with an average to a high frequency of news exposure to health effects of food and drinks were more vulnerable to nonfactual information on organic foods than were those with low frequencies of exposure. When people are repeatedly exposed to information they are more likely to believe in the information regardless if it is true or false (Lewandowsky et al., 2020). Similarly, Pennycook et al. (2018) indicated that prior exposure increases the perceived accuracy of fake news. Therefore, we speculated that participants with a high frequency of exposure may have been exposed to news that was like nonfactual news that was presented in this current study. The nonfactual video explained organic foods as significantly better than conventionally grown foods; similar to news that exaggerates the benefits of organic foods. Cahill et al. (2010) contended that news media often exaggerates the health and environmental benefits of organic foods in the United States. Therefore, participants with average or high frequencies of news exposure increased their perceptions of organic foods after watching the nonfactual video because prior exposure influenced their perceived accuracy of nonfactual information.

We identified levels of exposure by combining frequencies of exposure to news that discuss the health effects of foods and drinks as well as exposure to news that report conflicting information. Northup (2017) found that those who were exposed to contradictory news about health and diet had fatalistic views (i.e., confused views about the difference in nutritional benefits of organic and conventional foods), more so than those who did not read contradictory information. Nagler (2014) found that those exposed to contradictory news had greater levels of nutrition confusion, which was negatively associated with engaging in healthy lifestyle behaviors. Thus, results imply that participants with average to high frequencies of exposure held more fatalistic views of organic foods than did low-exposure participants.

These fatalistic views might negatively impact the lifestyle of some people (Nagler, 2014) or people may perceive pesticide-related risks of conventionally grown foods is greater than any public health hazards encountered in daily life (Williams & Hammitt, 2001). Therefore, it is worth devoting resources to clarifying the confusion view about the difference in nutritional benefits of organic and conventionally grown foods. Such clarification would help consumers with limited financial resources to seek foods based on nutritional value rather than spending more resources to buy organic foods (assuming it has significant health benefits) or reduce the fear of consuming conventionally grown foods due to pesticide-related risk.

We did not find significant differences in perceptions based on organic or conventional food news followership (closely vs. not at all). Our results confirmed that exposure to conflicting news about the health effects of foods and drinks might be associated with increased susceptibility to nonfactual information. However, due to the small interaction effect, as well as analysis based on self-reported news exposure, we are cautious about our findings. We suggest using experimental studies in future research to examine how exposure to conflicting news about the health effects of foods and drinks increases one’s susceptibility to fake news.

Preexisting Beliefs

Consistent with prior work (Dixon, 2016; Landrum et al., 2018; Lewandowsky et al., 2013; Martins et al., 2018), our findings indicate that preexisting beliefs had a moderating effect on changes in perception. We found different levels of change in perception based on preexisting beliefs about organic and conventionally grown foods. Participants with low levels of preexisting beliefs (i.e., less favorable beliefs) about organic foods were the least influenced by the nonfactual video. Our findings aligned with those of Dixon (2016); participants with low levels of prior beliefs about GM foods were least influenced by consensus messages. Our findings showed that participants with high levels of beliefs (i.e. more favorable views) about organic foods were not persuaded by scientific facts. Costanigro et al. (2014) and Olson (2017) also found similar effects, in that high-organic believers were resisted accepting scientific facts on the ambiguity of health benefits of organic foods.

We found that participants with high levels of beliefs about conventionally grown foods were not persuaded by the nonfactual video (i.e., the video stating that organic foods provide significant health benefits over conventionally grown foods). This finding concurred with those of previous research (Lewandowsky et al., 2012; Thorson, 2016; Walter & Tukachinsky, 2019), which demonstrated that counter-attitudinal misinformation had minimal influence because messages were not aligned with participants' beliefs. Overall, we concluded that when participants' preexisting beliefs are aligned with nonfactual information, participants become more vulnerable to nonfactual information and tend to consider it true.

Findings from the current study raise two questions. First, how can communicators mitigate susceptibility to misinformation (believing nonfactual news as true) among average- to high-exposure groups? Second, how can communicators reduce the susceptibility of misinformation when participants have strong opinions toward misinformation? These two questions can be answered by designing a communication plan using the mental models' approach (Bruine de Bruin & Bostrom, 2013) and promoting healthy skepticism (Lewandowsky et al., 2012). Particularly, Rosen (2010) found that organic food producers often rely on noncredible sources to promote their products therefore, by promoting healthy skepticism would help to induce distrust of misinformation (Lewandowsky et al., 2012) about organic foods.

We suggest nutritionists and health communicators follow the mental models' approach when communicating ambiguity of the health benefits of organic foods for three reasons. First, our findings showed that knowledge does not moderate changes in the perception of organic foods, while preexisting beliefs do moderate perception changes. The mental models' approach is an effective communication strategy that encourages message recipients to make informed decisions and closely consider audiences' beliefs, rather than knowledge (Bruine de Bruin & Bostrom, 2013; Walter & Tukachinsky, 2019; Wong-Parodi & Bruine de Bruin, 2017). Second, our study shows that participants with average or high exposure to news about the health effects of food and drinks were more susceptible to nonfactual information and had fatalistic views about the health benefits of organic foods. The mental models' approach compares audience understanding of the message and accuracy of communicated information with domain experts (Bruine de Bruin & Bostrom, 2013). Thus, confirming message accuracy and understanding can help reduce audience's fatalistic views. Third, the mental models' approach has been applied successfully to communicating scientific controversies such as climate change (Wong-Parodi & Bruine de Bruin, 2017). We believe that designing communication with the mental models' approach would help the intended audience make informed decisions about organic foods.

Theoretical Contribution

An unexpected finding was the advantages of using two scales (measuring the changes in perception using numerical rating and an aggregated score of multiple statements). We recommend using two scales for future such research for three reasons. First, using multiple statements helps identify specific message influences when the message does not change participants' overall opinions. This is especially applicable when the audience has strong opinions about nonscientific information, rather than scientific information, about controversial issues.

Second, using an aggregated score based on multiple statements helps to identify small changes in perception caused by the communicated message. For example, our analysis using numerical rating yielded small and larger partial eta-squared values for the summed scale. The summed scale detected higher variation between experimental groups because it measured message impact using several statements (agreement levels for specific statements based on the understanding of communicated message). Converting overall change in perception to numerical ratings may reveal a small effect because participants' preexisting beliefs lessened the impact of the communicated message. As a result, a small variation was found between groups based on the numerical rating.

Third, summed scales help neutralize possible impacts of cultural differences by using numerical ratings. We found non-White participants indicated high-level changes in perception when using numerical ratings (choosing a number from -5 to +5), but not with summed scales. In other words, White and non-White participants had similar agreement levels of changes in perception when they evaluated the impact of video using a Likert scale. Lee et al. (2002) observed cultural differences in choosing midpoints when expressing positive feelings. Furthermore, they noted that "some cultural groups may be reluctant to endorse items that suggest that they ever experience negative feelings" (Lee et al., 2002, p. 305). We believe that using both numerical and aggregated scores help minimize possible errors resulting from either scale. Moreover, we propose future studies using nationally representative samples to examine whether non-White participants are more susceptible to nonfactual information about organic foods.

Limitations

The study described herein has limitations. First, despite achieving an adequate sample size to generalize the findings, we used a convenience sample (university population); therefore, our ability to generalizing the findings beyond the study population is limited. Second, summed scale analysis showed that the factual video had some influence on participants' perception of organic foods, which might be because the sample was from a university, where scientific findings are evaluated more favorably than they might be elsewhere.

Third, when we calculated summed score of changes in perception, we coded *not applicable* choices using pre-determined values. The use of pre-determined values reduces the variance in mean values (Holman et al., 2004). Thus, we suggest future research to examine differences in aggregated perception change scores without the *not applicable* option.

Fourth, we selected videos (i.e., manipulation treatments) available on YouTube, which limited control of presenters, visuals, video quality, and other variables that might influence perceptions. The factual video was produced by WebMD, a reputable trusted medical information provider. The source of this video might have influenced participants' perceptions. However, we believe that a factual video from a trusted organization represented a real-world situation.

Fifth, we measured changes in perception immediately after treatments; therefore, we do not know whether there were longer-term effects. Future research should investigate how perception changes over time after exposure to nonfactual information, particularly how longitudinal effects of nonfactual information vary by levels of preexisting beliefs about organic and conventionally grown foods. Finally, this experiment was conducted in Spring 2020, when the COVID-19 pandemic hit the United States. Recent findings indicate that public trust in science has changed during the COVID-19 pandemic (Kreps & Kriner, 2020). Thus, participants' evaluation of scientific findings might differ from the present state.

Conclusion

The research described herein expands upon prior work on the effect of misinformation on public perception of science. It provides evidence that politically neutral topics, such as organic foods, are affected by nonfactual information. Effects of nonfactual information are heightened in those whose preexisting beliefs align with the nonfactual information and in those with high frequencies of exposure to news about the health effects of food and drinks. Thus, we need to increase audience awareness of trustworthy communicators to reduce susceptibility to nonfactual information about organic foods. Because organic and conventionally grown foods have only minimal visual and other sensorial differences, the audience relies more on outside information on this topic than it does about some others.

We see a crucial need for promoting healthy skepticism and relying on scientific facts when communicating scientific information about organic foods. We recommend that communicators follow the mental models' approach to design communication content that promotes healthy skepticism about organic foods' ambiguous health benefits. Following the mental models' approach would help to reduce believing nonfactual information related to organic foods as true. Although this approach would require considerable resources, time commitment, and collaboration with experts to confirm the accuracy of the message, it could help to reduce the audience's confusion about the nutritional benefits of organic and conventionally grown foods. In summary, following the mental models approach we recommend health communicators highlight the need for selecting foods based on nutritional value rather than explaining differences between organic versus conventionally grown foods. Explain what mean by clinically nonsignificant health benefits. Evaluate the effectiveness of communication by confirming the accuracy of audience understanding. Finally, our research provides useful insight into the advantages of using two scales (numerical ratings and aggregated scores of multiple statements) to measure changes in perception of controversial scientific topics.

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5. CONCLUSIONS

Multiple factors influenced the public's perception of science. It was difficult to identify all factors, given the changing landscape of scientific research and the ways in which scientific information is communicated. The first study identified factors affecting public perceptions of science in the presence of misinformation. We proposed a conceptual framework, *Rings of Public Perception of Science*, illustrating how these factors combine to influence public perception. The type of science is a fundamental factor determining the level of influence of other factors, and audience's beliefs was the most influential factor. We identified a need for a holistic approach to examining the factors that influence public perception of science because these factors act as confounding and/or mediating variables that prevent separation of single factors.

Further, we identified the need for research on emerging factors because of changing communication infrastructures, particularly with the increased use of social media. For example, how active engagement in social network sites (such as following groups and sharing content related to science) influences perceptions about the science. We suggest conducting qualitative studies to identify context-specific factors. Most studies reviewed were conducted in developed countries; thus, we identified the need for research in developing countries to understand whether these factors will exert influence in the same manner in different cultural contexts. Additionally, the proposed rings can be used to design communication strategies by identifying the most influential factors and addressing those factors when communicating about controversial scientific issues.

The second study used the *Rings of Public Perception of Science* to examine associations between factors and levels of agreement with scientific information about organic foods. We found that the benefit perception of organic foods was a key contributing factor predicting agreement levels. It was inversely related to agreement levels. When people perceive benefits of science that contradict scientific findings, their disagreement with scientific information increases. However, we also found that disagreement with scientific information can be overcome by enhancing trust toward scientists. In the context of organic foods, communicating scientific information by engaging credible communicators, such as scientists or nutritionists, was more likely to increase agreement with scientific information. Increasing levels of agreement with scientific information will help create awareness of the differences between organic and conventionally grown foods and improve the audience's understanding of foods based on nutritional values. Additionally, we found that socio-demographic variables, including knowledge and education, did not predict levels of agreement with scientific information. Moreover, we recognized a need for future research examining how perceived benefits of organic foods influence audiences believing factual and nonfactual information related to organic foods.

The third study examined changes in perception of organic foods after exposure to factual and nonfactual information on organic foods. We found a nonfactual video had a greater influence on participants' perceptions than did a factual video. This result confirmed the second study that participants were reluctant to accept factual information based on scientific facts about organic foods. Moreover, we found the effect of the nonfactual video became greater when participants had high levels of preexisting positive beliefs (i.e., favorable opinions) about organic foods. This finding also confirmed the second study's results that the audience's beliefs about the benefits of organic foods were a key factor influencing public perceptions about organic foods. Furthermore, we found that a high frequency of exposure to news about the health effects of food and drinks increased susceptibility to nonfactual information, i.e., people with average to high frequency of news exposure were more likely to believe organic foods provided significant health benefits over conventionally grown foods.

Overall, the current studies suggest that consideration should be given to audience beliefs and common misconceptions when communicating scientific facts about organic foods rather than increasing audience knowledge. We recommend following the mental models' approach for communicating scientific information about organic foods. The mental models' approach prioritizes the beliefs of audiences and considers misconceptions about scientific issues (Bruine de Bruin & Bostrom, 2013). Furthermore, such communication may follow strategies or steps recommending for debunking misconceptions. Following the debunking steps that Lewandowsky et al. (2020) suggested would help to avoid any reconfirmation of misconceptions that might occur due to a high level of perceived benefits about organic foods.

Future communication about organic foods should highlight the need for selecting foods based on nutritional value, explain what is meant by clinically nonsignificant health benefits, and reinforce scientific facts about organic foods multiple times rather than comparing organic foods with their counterparts. Additionally, compared with other controversial issues, the organic foods controversy is unique due to its politically neutral nature and the minimal visual and sensorial differences between organic and conventionally grown foods. Thus, there is a crucial need for promoting healthy skepticism and helping people to identify trustworthy and credible communicators. People with limited financial resources to purchase foods based on nutritional values, rather than having organic food labels, assuming those are healthier than conventional foods.

This study provides a theoretical contribution to communication research by illustrating the advantages of using two scales (numerical ratings and aggregated scores of multiple statements) to measure changes in perceptions of controversial scientific topics. When people have strong beliefs about the possible benefit of items that contradict scientific findings, the numerical rating is minimally sensitive in identifying the overall influence of a message. In other words, a high level of benefit perception overrides the effect of the message; thus, numerical ratings do not show a small influence exerted by a message, while multiple statements help identify these changes. Furthermore, using both scales help identify if there are differences in using numerical ratings by culture (i.e., White vs. non-White).

Finally, we concluded that when people had positive benefit perceptions about scientific topics and those perceptions contradicted scientific information, their disagreement with the scientific information increased. Disagreement will further increase when an event related to science has a closer connection with benefit perceptions, as well as when people are frequently exposed to nonfactual information that is consistent with their preexisting beliefs about positive benefits.

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APPENDIX A

A Summary of Key Findings of Reviewed Articles

The following table summarizes the key findings from reviewed articles about factors that affect public perception of science.

Themes	Subthemes	Articles	Key Findings
Audience beliefs	Religious beliefs	Morin (2018)	It is difficult to persuade individuals when a scientific subject becomes religiously polarized.
		Ho et al. (2010)	Highly religious individuals were less supportive of nanotechnology research funding than less religious individuals. Elaborative processing of scientific news was positively associated with public funding support.
		Bass (2016)	Religious beliefs did not influence citizens' views about climate change.
		(Kahan, 2015a, and Kahan, 2015b, as cited in Bonney, 2018)	When ordinary science intelligence increased, respondents who have above average religious views worsen their understanding of evolution.
	Political beliefs	(Kahan, 2015a, and Kahan, 2015b, as cited in Bonney, 2018)	Very conservative/strong republican participants are less likely to hold the correct beliefs in science.

Themes	Subthemes	Articles	Key Findings
		Bass (2016)	Political predispositions are strongly associated with citizens' views about climate change and their support for policy solutions for global warming.
		Morin (2018)	Increasingly difficult to persuade individuals when a scientific subject becomes politically polarized.
	Trust in science	Ho et al. (2010)	Respondents who are high deference for scientific authority were more supportive of funding of the emerging technology than those low in deference.
		Palmer (2018)	Trust in science creates both beneficial and detrimental effects on the conspiratorial beliefs of participants. Participants with a high level of trust in science believe in scientific content more than those with low-level trust. Participants with a high level of trust in science tend to disseminate conspiratorial information if scientific news contains scientific evidence.
		Howell et al. (2018)	A significant reduction in societal risk perceptions of GMOs among respondents who least likely trust the scientific consensus report.
		Sonntag et al. (2019).	Lack of trust in modern poultry farming systems had a major influence on the perception of poultry farming systems.

Themes	Subthemes	Articles	Key Findings
	Perceived risks and benefits	Ho et al. (2010)	Perceived risks and benefits of nanotechnology associated with public support for nanotechnology funding.
		Cui and Shoemaker (2018)	Perceived risk of GM food (safety concern) is noticed by more than half of the respondents.
		Nawaz et al. (2019)	A positive effect was observed between ‘Benefits Perceived’ (BP) over ‘Willingness to Consume’ (WoC).
	Preexisting attitudes	Zhang et al. (2015)	Support for nanotechnology was associated with beliefs about the technology rather than knowledge.
		Lefevere et al. (2011)	The effect of popular exemplars strengthens with pre-existing attitudes.
		Martins et al. (2018)	Pre-existing beliefs did have a significant effect on the credibility of journalists and scientists. Journalist’s credibility increased if the stories are matched with preexisting beliefs of readers, decreased when stories are mismatched.
		Landrum et al. (2018)	Pre-existing attitudes toward the safety, risks, and benefits of GMOs were associated with the perceived trustworthiness of agricultural biotechnology organizations.

Themes	Subthemes	Articles	Key Findings
		Dixon (2016)	Respondents with low prior support for GM foods are less affected by a consensus message.
		Nagy et al. (2018)	Pre-existing belief in the Frankenstein myth has evolved into a stigma where it creates negative reactions toward certain sciences and scientific practices.
		Lewandowsky et al. (2013)	The perception that a previous environmental problem has been resolved is negatively associated with the acceptance of climate science.
		Bass (2016)	Pre-existing beliefs about the causes of climate change predicted people's support for climate mitigation policies.
Audiences' Socio-demographics	Age	Cui and Shoemaker (2018)	Respondents' attitudes toward GM foods were correlated with age. Negative attitudes toward GM foods were more frequent among those respondents born before 1969 (59.3%).
	Income level	Cui and Shoemaker (2018)	Respondent's attitudes toward GM foods were correlated to their income. Negative attitudes toward GM foods were highly correlated with those who reported an annual household income above one million Chinese Yuan (RMB) compared to those with an annual household income below 80,000 RMB.

Themes	Subthemes	Articles	Key Findings
		Ruth et al. (2018)	Most respondents who had a positive attitude toward GM science earned more than $75,000 annually.
	Occupation	Mnaranara et al. (2017)	Academicians and regulatory authorities had stronger positive perceptions of GM foods, whereas farmers and media had a negative perception (concerned about risk and safety of GM foods).
	Gender	Cui and Shoemaker (2018)	Gender was not found to be a factor in shaping attitudes toward GM food.
		Ruth et al. (2018)	Gender was related to attitude toward GM science. Most males have a positive attitude, while most females have a negative attitude toward GM.
		Zhang et al. (2015)	Men are more likely to support nanotechnology development than women.
	Knowledge	Cui and Shoemaker (2018)	The lower the understanding of GM technology, the more hesitant the respondents were to accept GM food. A positive correlation was observed between supporting GM with respondents who “know a lot” about GM. There was a negative correlation between opposing GM with respondents who “know a lot”

Themes	Subthemes	Articles	Key Findings
		Nawaz et al. (2019)	The knowledge about GM foods was the strongest predictor of perceived health concerns on GM foods.
		Zhang et al. (2015)	Support for nanotechnology was less based on knowledge but more on beliefs.
		Bass (2016)	Factual knowledge of climate science overshadowed the political predisposition of citizens when they were asked to indicate their support to increase taxes on gasoline to reduce emissions. However, the same effect was not seen for policies that did not have a direct impact on citizens.
		Ho et al. (2010)	Factual scientific knowledge had no significant association with public support for federal funding of nanotechnology.
		Lakomý et al. (2019)	Science literacy has a weak, but positive association with science. Public engagement in science is determined by public knowledge and perception of science.
		Smith et al. (2011)	The audience perceived astronomic images differently based on their knowledge levels of astronomy.
		Cataldo et al. (2019)	A difference in credibility judgment in science news was observed between educational stages. High school students and graduate students judged the credibility of science news differently.

Themes	Subthemes	Articles	Key Findings
Communication sources	Expertise	Lefevere et al. (2011)	Popular exemplars have significantly more impact than experts.
	Credibility and trustworthiness	Martins et al. (2018)	Scientists' and journalists' credibility positively correlated with the belief change.
	Credibility	Osman et al. (2018)	The source of credibility is an influencing factor that affects public perception of science. The public perceives scientists as more credible than governmental groups to share scientific claims on behavioral intervention. Credibility influence on perception was varied by the type of science communicated.
	Credibility	Sarathchandra and Haltinner (2019)	The skeptical public sees scientists as less credible when communicating climate science.
	Scientists 'trustworthiness	Ho et al. (2010)	Public trust in scientists associated with support for nanotechnology funding.
	Scientists 'trustworthiness	Zhang et al. (2015)	Trust in researchers is a significant factor that determines the support for nanotechnology.
	News organization's trustworthiness	Wilner (2018)	Participants who had a positive opinion about a news organization were more likely to consider news coming from those organizations as credible than those who do not have a positive opinion.

Themes	Subthemes	Articles	Key Findings
	Organizational trustworthiness	Landrum et al. (2018)	Perception of GMO safety was positively associated with ratings of organization trustworthiness.
	Format Debate	Morin (2018)	Scientific certainty about evolution and GMO significantly higher after exposure to debate. How people modify personal beliefs after exposure to debate is varied by the issue being discussed.
	Fact-checking videos	Young et al. (2017)	Fact-checking videos were successful in reducing misperceptions, increasing message attention, and reducing confusion related to the topic discussed.
	Satirical television news	Brewer (2013)	Satirical television news programs such as *The Daily Show* contributed to public understanding of science by reporting scientific consensus, encouraging the audience to critically evaluate scientific facts following deliberate reasoning.
	Satirical television news	Brewer and McKnight (2015)	Satirical television news programs influenced viewers' climate change perceptions.
	Satirical television news	Brewer and McKnight (2017)	After watching a segment of satirical television news, viewers increased their own beliefs of global warming.
	Tone Balance norm	Martins et al. (2018)	Following a balance norm (reflecting information from contradictory sources) decreased the perceived credibility of scientists.

Themes	Subthemes	Articles	Key Findings
	Moralized tone	Capurro et al. (2018)	Highly moralized tone used in news reporting changed the risk perception of the public and led to mandatory vaccinations.
	Framing (ethical and risk)	Kastenhofer (2009)	Framing influences policymakers and society's perception. In the early phase of technology, ethical concerns are the dominant framing, when moved to market risk framings become dominant.
	Ambiguous message	Brewer and McKnight (2015)	The presenter's ambiguous message on controversial issues affects the viewer's interpretation of scientific information.
	Consensus message	Dixon (2016)	Consensus messages' effect on audience perception varied based on the audience's prior beliefs.
		Brewer and McKnight (2017)	Consensus messages about climate change increased viewers' own belief in global warming and perceptions of most scientists believe in global warming. The belief change was stronger among participants with low interest compared to high-interest participants.
		Lewandowsky et al. (2013)	The perceived scientific consensus is associated with the acceptance of science.

Themes	Subthemes	Articles	Key Findings
	Use of visual images	Gruber and Dickerson (2012)	Images appear to have an equal or no impact on perceived credibility and reasonableness of popular science news about neuroscience of reading dreams.
	Visual format and interactivity	Li et al. (2018)	Visual format and interactivity were not related to the perception of data credibility.
Environment	Exposure to Information	Clayton et al. (2019)	When participants were exposed to ambiguous but false information, they perceived false statements as accurate.
	Type of exposure	Gesser-Edelsburg et al. (2017)	A moderate correlation was found between the online platforms and the type of information sources used to report the scientific facts. News websites tend to use health officials as the source of scientific facts rather than other online platforms (Facebook, forums, and blogs). News websites used different types of sources to report scientific facts and the quality of information varies across websites.
		Zoukas (2019)	Climate science blog readers perceived blogs as a medium to receive unbiased factual information about climate science.
	Social bot	Ross et al. (2019)	In a highly polarized setting, 2-4% participation of social bot was sufficient to overturn the opinions of users.

Themes	Subthemes	Articles	Key Findings
	Events Related to Science Geographic proximity	Li et al. (2016)	Twitter users who were geographically closer to the accident site showed evoked concerns about the nuclear accident than those who were not closer to the accident.
	When the event happened	Li et al. (2016)	Twitter users were pessimistic about nuclear power soon after the accident. Overall sentiment toward nuclear power becomes neutral and uncertain over time.
		Suthanthangjai et al. (2013)	Changes in respondents' perceptions over an extended period were not statistically significant for environmental concerns in New Zealand. People's environmental perceptions on certain issues can be resistant to information and events. Short-term variability in perceptions was observed after the events.

APPENDIX B

Questionnaire and Coding of Descriptive Study

This appendix shows the description of variables and their coding for ordinal, multinomial, and multiple linear regression analyses that were used for Chapter 3.

Categories	Question asked in the survey	Coding for analysis [a]
Dependent variable		
Agreement level of scientific evidence about organic foods	How much do you agree or disagree with these statements? (1 = *Strongly disagree* to 7 = *Strongly agree*)	Strongly disagree (1) Disagree (1) Somewhat disagree (1) Neither agree nor disagree (2) Somewhat agree (3) Agree (4) Strongly agree (4)
Independent variable		
Trust in science	People have frequently noted that scientific research has produced benefits and harmful results. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results or have the harmful results of scientific research been greater than its benefits?	Benefits strongly outweigh harmful results (4) Benefits slightly outweigh harmful results (3) Benefits are about equal to harmful results (2) Harmful results slightly outweigh benefits (1) Harmful results strongly outweigh benefits (1)

Categories	Question asked in the survey	Coding for analysis [a]
Preexisting attitude	Select the statement that best describes your food preferences.	I usually prefer organic foods (4) I occasionally prefer organic foods (3) I occasionally prefer conventionally grown foods (2) I usually prefer conventionally grown foods (2) I prefer foods based on nutrition value rather than choosing only organic or conventionally grown foods (1)
Religion	With which religious affiliation do you most closely identify?	Christian (1) Islam (0) Judaism (0) Hinduism (0) Buddhism (0) Atheist (2) Agnostic (2) Other not included (0)
Religiosity	In general, how would you rate your religious beliefs on a scale from not at all religious or very religious? (1 = *Not at all Religious* to 7= *Very Religious*)	Scale

Categories	Question asked in the survey	Coding for analysis [a]
Political views	In general, would you describe your political views as...	I am favorable towards one political party regardless of their policy agenda. (3) I am unfavorable towards one political party regardless of their policy agenda. (3) My support of a political party is based on the policy agenda presented by the political party. (2) I don't favor a political party. (1) I am not interested in politics (1)
Political ideology	In general, would you describe your political views on the political spectrum? (1 = *Very Conservative* to 7= *Very Liberal*)	Scale
Benefits of Organic foods	We would like to know your views about the risks and benefits of organic foods. Rate your level of agreement for each of these statements from "strongly disagree" to "strongly agree." (1 = *Strongly disagree* to 7 = *Strongly agree*) Organic foods. 1. are more nutritious than conventionally grown foods. 2. improve animal welfare. 3. reduce environmental impact caused by conventionally grown foods. 4. reduce health risks.	An aggregated score of four items as a scale

Categories	Question asked in the survey	Coding for analysis [a]
Risks of organic foods	Organic foods help us avoid: (1 = *Strongly disagree* to 7 = *Strongly agree*) 1. synthetic chemical exposure such as pesticides, herbicides, and fertilizers. 2. products that contain antibiotic-resistant bacteria. 3. genetically modified foods. 4. products that contain growth hormones. 5.	An aggregated score of four items as a scale. Removed in the analysis due to multicollinearity with benefits score
Gender	What is your gender identity? Male, female, other, and decline to answer	Male (0) Female (1) Others and decline to answer (missing)
Knowledge	Please answer the following questions according to your beliefs. (*True* or *false*) 1. The center of the Earth is very hot. 2. The continents have been moving and will continue moving their locations for millions of years. 3. All radioactivity is man-made. 4. Lasers work by focusing sound waves. 5. According to astronomers, the universe began with a huge explosion. 6. It is the father's gene that decides whether a baby is a boy or a girl. 7. According to the theory of evolution, human beings, as we know them today, developed from earlier species of animals.	Scale (A summed scale of seven items. The correct answers were coded 1, and the incorrect answers were coded (0).

Categories	Question asked in the survey	Coding for analysis [a]
Age	What year were you born? (e.g., 1980)	Scale (calculated ages as of 2021)
Income	Considering your country of residence, how do you describe your income level	Low income (1) Middle income (2) High income (3) Decline to answer (missing)
Country of residence	Indicate your country of residence (the country where you are currently living in).	USA (1) Outside of USA (0)
Education	What is your highest level of education?	Less than high school diploma (missing) High school diploma (missing) Some college (1) Bachelor's degree (2) Graduate or professional degree (3)
Information source	Indicate your primary source(s) for receiving news about organic foods (click all that apply): Television, Internet, social media, Newspaper, Radio Magazine, Books, Government, Friends, and family or colleagues	Who selected the internet as an information source (1) and others (0)

Categories	Question asked in the survey	Coding for analysis [a]
Trust in scientists	Rank your level of agreement for each statement using the scale (1 = *Strongly disagree* to 7 = *Strongly agree*) 1. Scientific researchers are dedicated people who work for the good of humanity. 2. Scientists are helping to solve challenging problems. 3. We should trust scientists being honest in their work. 4. We should trust scientists being ethical in their work. 5. We can trust scientists to share their discoveries even if they don't like their findings. 6. Scientists' training should be sufficient to make audiences trust them.	Scale aggregated score of six statements
Credibility	Who do you believe is most credible when providing information about organic foods? 1. Journalists who report about organic foods 2. Representatives from companies that sell certified organic foods. 3. Representatives from institutions certifying organic foods. 4. Politicians who support organic foods. 5. Nutritionists. 6. Scientists researching organic foods. 7. My friends who eat organic foods. 8. My family members who eat organic foods.	Journalists (0) Companies (0) Institutions (0) Politicians (0) Nutritionists (1) Scientists (1) Friends (0) Family members (0)

Categories	Question asked in the survey	Coding for analysis [a]
Exposure to information	The United States Department of Agriculture (USDA) defines organic food as “produce that was certified as grown on soil that had no prohibited substances applied for three years prior to harvest. Prohibited substances include most synthetic fertilizers and pesticides.” Given this definition, how often do you hear or read news stories about organic food production?	Not at all (1) Monthly or less (2) A few times a month (2) A few times a week (3) Daily (3)
Events related to science	Many of us adopted our lifestyles and eating patterns because of COVID-19. Considering any changes made to your eating habits because of COVID-19, please indicate your level of agreement with each statement. (1 = *Strongly disagree* to 7 = *Strongly agree*) 1. I started eating more organic foods, rather than conventionally grown foods. 2. I started eating more organic foods to strengthen my immune system.	Strongly disagree (0) Disagree (0) Somewhat disagree (0) Neither agree nor disagree (0) Somewhat agree (1) Agree (1) Strongly agree (1)

Note. The value indicated in brackets is used for analysis.

[a] Categorical and nominal variables were dummy coded with zero and one for multiple linear regression analysis.

APPENDIX C

Questionnaire and Coding of Experimental Study

This appendix shows the description of variables and their coding for one-way and two-way ANOVA analyses that were used for Chapter 4.

Categories	Question asked in the survey	Coding for analysis			
Dependent variable Change in perception (Rating scale)	Was your opinion about organic foods influenced by watching the video? (-5 = *negatively influenced*, 0 = *not influenced*, and 5 = *positively influenced*)	Scale (-5 to +5)			
Change in perception (Summed scale)	After watching the video, how much do you agree or disagree with each of the following items?	An aggregated score of five statements. Each statement was coded based on the participants' video type exposure.			
	1. The video makes me feel more **confident** about eating **organic foods**		F	NF	C
		Strongly disagree	(1)	(4)	(4)
		Disagree	(2)	(3)	(3)
		Agree	(3)	(2)	(2)
		Strongly agree	(4)	(1)	(1)
		Not applicable	(0)	(0)	(4)
	2. The video makes me feel more **confident** about eating **conventionally grown foods.**		F	NF	C
		Strongly disagree	(4)	(1)	(4)
		Disagree	(3)	(2)	(3)
		Agree	(2)	(3)	(2)
		Strongly agree	(1)	(4)	(1)
		Not applicable	(0)	(0)	(4)

Categories	Question asked in the survey	Coding for analysis			
	3. The video makes me feel more **anxious** about eating **conventionally grown** foods.		F	NF	C
		Strongly disagree	(4)	(1)	(4)
		Disagree	(3)	(2)	(3)
		Agree	(2)	(3)	(2)
		Strongly agree	(1)	(4)	(1)
		Not applicable	(0)	(0)	(4)
	4. The video makes me feel more **anxious** about eating **organic** **foods.**		F	NF	C
		Strongly disagree	(4)	(4)	(4)
		Disagree	(3)	(3)	(3)
		Agree	(2)	(2)	(2)
		Strongly agree	(1)	(1)	(1)
		Not applicable	(0)	(0)	(4)
	5. The video makes me think more about the **nutritional value** of the food than whether to select organic or conventionally grown foods.		F	NF	C
		Strongly disagree	(1)	(4)	(4)
		Disagree	(2)	(3)	(3)
		Agree	(3)	(2)	(2)
		Strongly agree	(4)	(1)	(1)
		Not applicable	(0)	(0)	(4)
Independent Variables					
News exposure		An aggregated score of four statements			
	1. How often do you hear news stories about the health effects of what people eat and drink?	Not at all (1)			
		Monthly or less (2)			
	2. How often do you read news stories about the health effects of what people eat and drink?	A few times a month (3)			
		A few times a week (4)			
		Daily (5)			

Categories	Question asked in the survey	Coding for analysis
	3. How often do you hear news stories that CONFLICT with earlier reports about the health effects of what people eat and drink? 4. How often do you read news stories that CONFLICT with earlier reports about the health effects of what people eat and drink?	Not at all (1) Not very often (2) Fairly often (3) All the time (4)
Knowledge	Rate your understanding of the nutritional value of foods on the scale below. (0 = *no knowledge* to 10 = *high knowledge*)	Scale (0– no knowledge to 10 – high knowledge)
Selective exposure Organic foods news	The United States Department of Agriculture (USDA) defines organic food as produce that was certified as grown on soil that had no prohibited substances applied for three years prior to harvest. Prohibited substances include most synthetic fertilizers and pesticides. Given this definition, how closely do you follow news stories about **organic food** production?	Not at all (1)-low Not very closely (2)-average Somewhat closely (3)- high Very closely (3)-high
Selective exposure Conventionally grown food news	Conventionally grown food news According to the USDA, conventional farming is the use of seeds that have been genetically altered using a variety of traditional breeding methods, excluding biotechnology, and are not certified as organic. Given this definition, how closely do you follow news stories about conventional food production	Not at all (1) -low Not very closely (2)-average Somewhat closely (3) -high Very closely (3)- high

Categories	Question asked in the survey	Coding for analysis
Preexisting Beliefs of Organic Foods [b]	Do you believe **organic foods** are 1. Better for one's health than conventionally grown foods. 2. Neither better nor worse for one's health than conventionally grown foods. [a] 3. Better tasting than conventionally grown foods. 4. Neither better tasting nor worse tasting than conventionally grown foods. [a] 5. Reduce exposure to commercial pesticide residues 6. Are safe to eat because they are naturally grown foods	An aggregated score of six statements Strongly Disagree (1) Disagree (2) Agree (3) Strongly Agree (4)
Preexisting Beliefs of Conventionally Grown Foods [b]	Do you believe conventionally grown foods: 1. Worse for one's health than organic foods [a] 2. Neither better nor worse for one's health than organic foods. 3. Worse tasting than organic foods.[a] 4. Neither better tasting nor worse tasting than organic foods. 5. Increase exposure to commercial pesticide residues. [a] 6. Are safe to eat because they are grown to government standards.	An aggregated score of six statements Strongly Disagree (1) Disagree (2) Agree (3) Strongly Agree (4)

Categories	Question asked in the survey	Coding for analysis
Manipulative check-Factual	After watching the video, how much do you agree or disagree with each of the following items? 1. The video was based on factual science. 2. The video was not based on factual science. [a] 3. According to the video, organic foods are better than conventionally grown foods. [a] 4. According to the video, conventionally grown foods are better than organic foods. [a] 5. According to the video, there is no difference in quality between conventionally grown and organic foods.	An aggregated score of five statements Strongly Disagree (1) Disagree (2) Agree (3) Strongly Agree (4)
Manipulative check-Nonfactual	After watching the video, how much do you agree or disagree with each of the following items? 1. The video was based on factual science. [a] 2. The video was not based on factual science. 3. According to the video, organic foods are better than conventionally grown foods. 4. According to the video, conventionally grown foods are better than organic foods. [a] 5. According to the video, there is no difference in quality between conventionally grown and organic foods. [a]	An aggregated score of five statements Strongly Disagree (1) Disagree (2) Agree (3) Strongly Agree (4)

Categories	Question asked in the survey	Coding for analysis
Manipulative check-Control	After watching the video, how much do you agree or disagree with each of the following items? 1. The video was based on factual science. 2. The video was not based on factual science. [a] 3. The video shared information about organic foods. [a] 4. The video did not share information about organic foods. 5. The video shared information about food safety tips.	An aggregated score of five statements Strongly Disagree (1) Disagree (2) Agree (3) Strongly Agree (4)
Academic Status	Which of these groups identifies your current status?	Undergraduate student (1) Graduate student (2) Faculty member (3) University staff member (4) Other (5)
Gender	What is your gender identity?	Male (1) Female (2) Other (missing) Prefer to not respond (missing)

Categories	Question asked in the survey	Coding for analysis
Ethnicity	What is your ethnicity? You may choose more than one response. 1. American Indian or Alaska Native 2. Asian 3. Black or African American 4. Hispanic 5. Native Hawaiian or Other Pacific Islander 6. White 7. Other 8. Prefer to not respond	Nonwhite (0) White (1) Recode values American Indian or Alaska Native (0) Asian (0) Black or African American (0) Hispanic (0) Native Hawaiian or Other Pacific Islander (0) White (1) Multiple ethnicities (missing) Other (missing) Prefer to not respond (missing)

Note. Participants video type exposure F = Factual; NF = Nonfactual; C = Control. The value indicated in brackets is used for analysis. [a] Reverse coded items. [b] Statements that were considered for analysis are indicated here, the original survey contained 12 statements for preexisting beliefs about organic foods and 12 statements for preexisting beliefs about conventionally grown foods.