Introduction

Scientific innovation provides countless benefits to society; however, it can also foster suspicion and distrust from consumers (Lang, 2013). A Pew Research Center sponsored study found 35% of Americans have “a great deal” (para. 2) of trust in scientists, but many are concerned about “scientists’ competence, credibility and concern for the public interest” (Funk, Johnson, & Hefferon, 2019, para. 3). Trust in science and technology impacts consumer attitudes, especially when many consumers primarily rely on their trust in science when making purchasing decisions due to their lack of knowledge (Critchley, 2008; Marques, Critchley & Walsche, 2014; Ruth & Rumble, 2017; Siegrist, 2000). Lack of trust in science is further exemplified depending on the type of science being presented. For example, levels of trust in science vary more considerably with contentious topics such as climate change, genetic modification (GM) science, and childhood vaccines (Funk, 2017).

The unknowns associated with scientific innovations in agriculture, such as precision agriculture and climate-smart crops, has resulted in a strained relationship between consumers and farmers (Rumble & Irani, 2016). The strained relationship creates little to no support for solutions, including technological innovations addressing agricultural issues (Lang & Hallman, 2005). The relationship between public trust in science and acceptance of agricultural innovation is further strained when it concerns GM science; especially when it comes to food (Lang, 2013). Lang and Hallman (2005) found consumers “do not trust many of the organizations that have the greatest resources and responsibilities for ensuring the safety of GM food” (p. 1249). Consumer trust in scientists and organizations that conduct scientific research is fundamental to consumers accepting GM science (Marques et al., 2014). This disconnect between consumers and trust in GM science may be influenced by the fact that current agricultural communication practices may not be developing lasting impacts with consumers (Rumble & Irani, 2016; Whitaker & Dyer, 2000; Zimbelman, Wilson, Bennett, & Curtis, 1995).

Effective communication is imperative in fostering consumer trust in GM science. Many consumers receive information from the media, which can be biased and incomplete, causing misunderstandings (Bickford, Posa, Qie, Campos-Arceiz, & Kudavidanage, 2012; Coyle, 2005; Ladle, Jepson, & Whittaker, 2005). When unbiased GM science is not presented in a logical and easily attainable and understandable manner, consumers rely on their emotions rather than facts and logic to form opinions regarding the purchasing and consumption of GM foods (Mahgoub, 2016). Communicating scientific information in an effective manner may allow consumers to make logic-based decisions about GM science (Bickford et al., 2012; Sunderland, Sunderland-Groves, Shanley, & Campbell, 2009).

Infographics, or informational graphics, are an increasingly popular form of communication that reach a large audience (Afify, 2018; Atkinson & Lazard, 2015) and may be beneficial in effectively communicating GM science to consumers. Infographics are designed to deliver complex information in a simple form through the use of graphic drawings and text (Atkinson & Lazard, 2015; Hiroyuki, 2010). There are various types of infographics, but the two most prominent are static and animated (Afify, 2018). Static infographics do not include motion or animations and are typically found in print media or online (Hassan, 2016). Animated infographics include motion or animations, and are presented on video screens such as YouTube, TV ads, or other video media channels (Hassan, 2016).

Afify (2018) found infographics to be effective at communicating information, especially when the communication tool includes something educational. Thus, infographics have the potential to effectively communicate science with consumers and increase consumer trust in science (Card, Mackinlay, & Shneiderman, 1999; Tu, Tu, & Wang, 2018), however, the effectiveness of infographics on communicating agricultural concepts has not been widely studied (Burnett, 2018). This study aimed to discover the influence of GM science-focused infographics on consumer trust in science, attitudes toward GM, and the attitudes they perceive others have toward GM. Identifying the role infographics play in improving attitudes or building consumer trust in science may help agricultural communicators develop materials that result in well-informed consumer choices regarding agricultural scientific innovations.

Literature Review

Research on consumer attitudes has a long history in the field of social psychology (Maio & Haddock, 2010; McGuire, 1985; Prislin & Crano, 2008). Heddy, Danielson, Sinatra, and Graham (2016) defined attitude as "an overall evaluation of an object, person, or event" (p. 516), which also can be described as a consumer liking or disliking an object, person, or event (Holbrook, Berent, Krosnick, Visser, & Boninger, 2005). If a consumer likes or dislikes of an object, person, or event; their attitudes also changes (Maio & Haddock, 2010).

Attitude influences consumer learning (Maio & Hadcock, 2010) and is most salient when discussing controversial scientific topics, including GM science (Heddy et al., 2016). Previous studies have found public attitudes toward science and technology vary based on demographic characteristics including gender, education, income, and age (Ellis & Tucker, 2009; Roberts, Reid, Schroeder, & Norris, 2013). Typically, consumers who are more educated, male, and of higher socioeconomic status have more positive attitudes about science and technology (Roberts et al., 2013).

Attitudes toward science are also impacted by media portrayals of science. Since the 1970s, consumers have primarily sourced their scientific information from television (Dudo et al., 2010). However, there has been a shift to consumers sourcing their scientific information from other types of media, including social media and the internet (Dudo et al., 2010). Social media has created a space for companies to advertise and affect consumers' attitudes toward products (Boateng & Okoe, 2015). Infographics are being used in this space as an emerging way of communicating large amounts of data in a simplified format that is easily understood (Smiciklas, 2012).

Consumers on social media tend to perceive attitudes of other users on social media inaccurately (Baldassarri & Bearman, 2007; Gelman, Park, Shor, Bafumi, & Cortina, 2008; Robbins & Krueger, 2005), which may be problematic as social media users' attitudes are impacted by one another (Chou & Edge, 2012). Often, a larger diversity in opinion exists among social media users than the user themselves believes to exist (Bishop, 2008; Sunstein, 2009). Goel, Mason, and Watts (2010) found social media users based their judgement of other social media users' attitudes from stereotypes and attempted to align their personal views to other users' opinions they valued. In addition, social media users may be interested in avoiding conflict, which can create discrepancies in other users perceived and actual attitudes (Goel et al., 2010). The discrepancy in social media users' perceived and actual attitudes may pose a challenge when communicating with consumers about science, especially when using infographics to supply factual data in a visual manner, because consumers may be less willing to focus on facts when their opposing attitude on a topic is widely accepted (Fowler & Christakis, 2008). Therefore, whether or not they trust scientific information will also have an impact on their consumption of information and ultimately their purchasing decisions.

The concept of trust is complex and has been defined in many ways. Previous research (Myers et al., 2017; Poortinga & Pidgeon, 2003) has suggested a widely accepted definition for trust as “a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another” (Rousseau, Sitkin, Burt, & Camerer, 1998, p. 395). Paltrinieri and Spillare (2018) found consumer trust in agricultural science has become more reflexive due to the ever-increasing amount of scientific information being presented and consumer awareness of risks (Bildtgard, 2008). Therefore, trust in science cannot be ignored when studying how to communicate with consumers about agricultural science topics such as GM.

Consumers are constantly introduced to agricultural innovations and unknowns and must decide whether or not they trust science when obtaining information and forming attitudes (Goodwin, 2013; Tschannen-Moran & Hoy, 2000). Hendriks, Kienhues, and Bromme (2016) found “the public mostly trusts scientists to produce reliable knowledge of good quality, not biased, and adhering to scientific principles” (p. 149). In general, consumers who are interested in science and technology will be more willing to trust scientific innovation that comes from a scientist (Roberts et al., 2013; Rumble et al., 2019). However, increased public trust in science does not guarantee increased trust in specific scientific concepts, such as GM science (National Science Board, 2018) even when they are broken down into simple concepts in an infographic format that should be easily understood (Smiciklas, 2012).

Effective science communication facilitates literacy, trust in science, attitudes toward science, and relationships between consumers and innovation (Rumble et al., 2019; Ruth & Rumble, 2017). In the agricultural industry, public trust in “food production may lead to supportive consumption behaviors, and thus sustain technological advances” (Rumble et al., 2019, p. 4). Unfortunately, the disconnect between the public and the farm has resulted in the emergence of agricultural innovation without public awareness contributing to a perceived societal negative attitude toward the agricultural industry (Meijboom, Visak, & Brom, 2006). In addition, recent scandals and food recalls have forged a large gap between consumers’ acceptance of GM and the agricultural industry’s use of GM science (Jokinen, Kupsala, & Vinnari, 2012). Given infographics are an increasingly popular way to share information about science (Atkinson & Lazard, 2015; Smiciklas, 2012) their use may help agricultural communicators moderate the negative GM information consumers are receiving from the media, increase their level of trust in science and positively impact their attitudes (Burnett, Holt, Borron, & Wojdynski, 2019). However, little is known about the role different types of infographics play in communicating agricultural science and their impact on trust in science, attitudes and perceived attitudes of others.

Purpose and Objectives

The purpose of this study was to examine if static or animated infographics sharing current societal perceptions of GM science in the U.S. influenced consumers’ trust in science, personal attitudes toward GM, and perceived attitudes of others toward GM over those not receiving an infographic. The purpose was addressed through the following objectives:

RO1. Identify respondents' level of trust in science, personal attitudes toward GM, and perceived attitudes of others toward GM after receiving a static infographic, animated infographic, or no infographic.

RO2. Determine if differences existed in respondents' trust in science, personal attitudes toward GM, and perceived attitudes of others toward GM, based on whether they viewed a static infographic, animated infographic, or no infographic.

H1: Respondents' level of trust in science, personal attitudes toward GM and perceived attitudes of others toward GM will be higher when they receive an infographic.

H2: Respondents' level of trust in science, personal attitudes toward GM and perceived attitudes of others toward GM will be the highest among the group receiving the animated infographic.

Methods

The researchers executed an experimental design to fulfill the research objectives and test the hypotheses. The study was part of a larger research effort being conducted to identify how to communicate with U.S. consumers about GM science as a solution to citrus greening disease. Therefore, the population of interest was U.S. citizens age 18 or older. The research focused on three sections of the survey instrument: level of trust in science, personal attitudes toward GM, and perceived attitudes of others toward GM. The United States Department of Agriculture, National Institute of Food and Agriculture, funded the research through the Specialty Crops Research Initiative/Citrus Disease Research and Extension under Award No. 2015-70016-23028. Research findings previously obtained as part of the larger research project detailing public sentiment toward GM were used in the development of the infographic (e.g. Ruth, Rumble, Lamm, Irani, & Ellis, 2018). The source of the information was not provided to the respondents to reduce bias.

Respondents were randomly assigned to one of three treatment groups: 1) control, 2) static infographic, or 3) animated infographic. Figure 1 displays the static version of the infographic. The infographics viewed by the static and animated treatment groups were identical except for the visual effects introduced in the animated version. Animations included graphs and charts with a single, continuous flow to visualize data in movement, data points to create an animated scene of the graph, single, continuous animation to draw the eye down the infographic, and a moving object to draw attention and contextualize data presented (Afify, 2018).

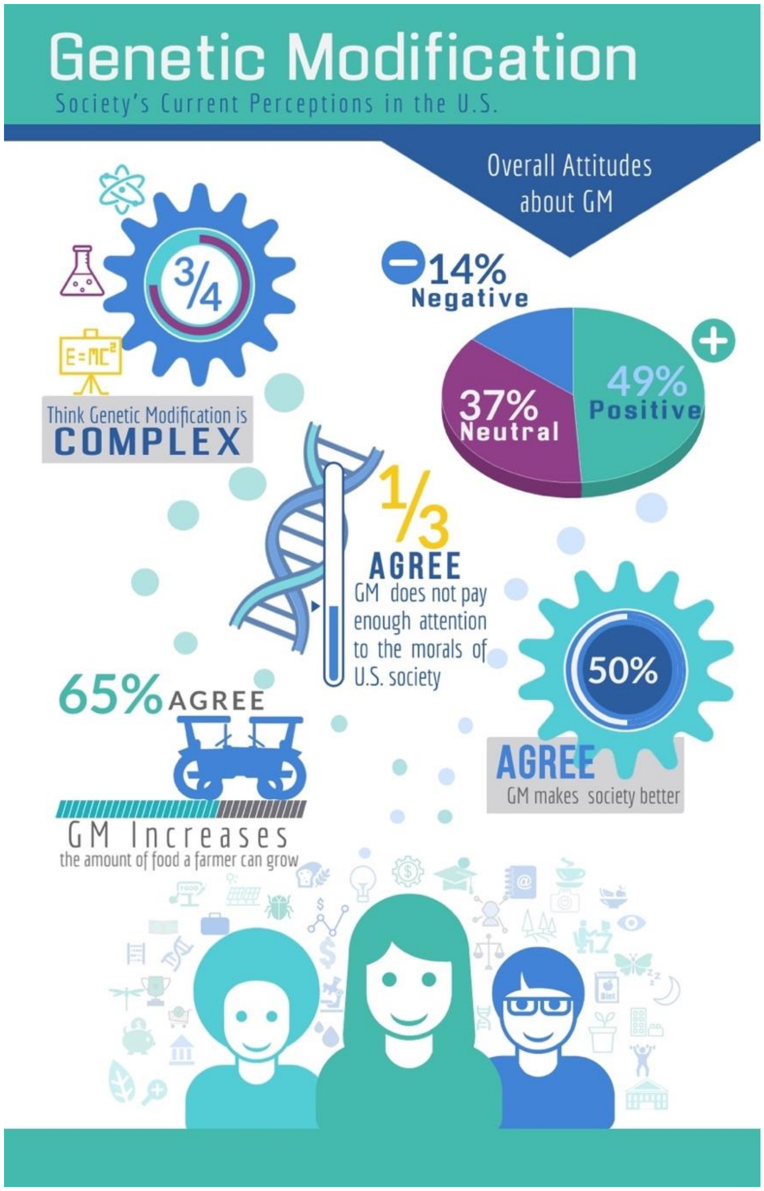

Figure 1. Static infographic design

If a respondent received one of the infographic treatments, he or she was timed to ensure they spent at least 20 seconds (a predetermined minimum necessary amount of time based on cognitive interviews conducted prior to data collection) was spent viewing the infographic. Respondents were then asked what information was presented at the bottom of the infographic to ensure they viewed the treatment. If the respondents did not indicate the only correct response, then they were sent to the end of the survey and were not included in the analysis. Those answering correctly progressed into the survey questions. Respondents in the control group went straight into the questions without awareness of a potential intervention. All three treatment groups (control, static, and animated) answered the same sets of questions.

Level of trust in science was measured using a 10-item scale adapted from the National Science Board's (2018) Science and Engineering Indicators Report. Respondents were asked to indicate their level of agreement or disagreement on a five-point Likert-type scale (1 = *Strongly*

Disagree, 2 = *Disagree*, 3 = *Neither agree nor disagree*, 4 = *Agree*, 5 = *Strongly Agree*). Reponses to the 10 items were averaged to create a trust in science score. Reliability was calculated *ex post facto* ($\alpha = .78$).

Personal attitude toward GM was measured using an eight-item, five-point semantic differential scale developed by Lamm, Taylor, Rumble & Ellis (2019). Respondents were asked to respond by marking the circle that best represented their thoughts about GM science between two opposing adjectives. The adjective pairs were: good/bad, positive/negative, beneficial/not beneficial, acceptable/unacceptable, necessary/unnecessary, important/unimportant, essential/not essential, and crucial/trivial. Responses to the eight items were averaged to create a personal attitude toward GM score. Reliability was calculated *ex post facto* ($\alpha = .95$).

Perceived attitudes of others toward GM was measured using the same scale as the one for personal attitude toward GM. The difference was the stem asked respondents to respond by marking the circle that best represents what the majority of U.S. citizens think about GM science. Responses to the eight items were averaged to create a perceived attitude of others toward GM score. Reliability was calculated *ex post facto* ($\alpha = .96$).

An expert panel was used to review the survey for content accuracy, face validity, and survey design. The expert panel included an Assistant Professor of Agricultural Communication at the University of Nebraska that has done extensive work on communicating about GM science, an Assistant Professor of Science Communication at Iowa State University, and an Assistant Professor at the University of Florida with a background in survey design and construction. Institutional Review Board approval was obtained prior to distribution.

Non-probability opt-in sampling was used to obtain a representative sample of the U.S. public. Qualtrics, a public opinion research company, obtained the sample. Non-probability sampling has become an accepted form of sampling when testing communication materials on public audiences (Baker et al., 2013; Lamm & Lamm, 2019). Random assignment to treatment groups diminished the typical need for adjustments that come with non-probability samples. However, non-probability samples that use weighting techniques are known to be more accurate (Abate, 1998; Twyman, 2008; Vavreck & Rivers, 2008); therefore, post-stratification methods were used *post hoc* to ensure the validity of the results (Kalton & Flores-Cervantes, 2003). The 2010 Census data were used because it is the most recent record of U.S. demographics. Data were analyzed descriptively, using frequencies and means, and inferentially using ANOVAs to address the research objectives and test the hypotheses using SPSS26 (Field, 2013). Prior to inferential analysis the variables of interest were tested for homogeneity of variance and normality of distribution using skewness and kurtosis. All assumptions were met based on the results from the Levene's test and Kolmogorov-Smirnov test.

Results

A total of 1,000 responses was obtained. The demographic profile of the respondents is in Table 1. There were more female (53.7%) than male (46.3%) respondents. There were a variety of ages represented with the largest group (20.4%) being between the ages of 40-49 years. All races were represented by the respondents with the majority being White (76.9%). Ethnicity was measured in addition to race; 9.9% identified as Hispanic.

Table 1
Demographics of Respondents (N = 1,000)

	n	%
Sex		
Female	536	53.7
Male	462	46.3
Age		
18-19 years	37	3.7
20-29 years	194	19.3
30-39 years	197	19.6
40-49 years	205	20.4
50-59 years	132	13.1
60-69 years	151	15.0
70-79 years	83	8.3
80+ years	5	.5
Race		
White	768	76.9
Black	131	13.1
Asian	52	5.2
Multiracial	21	2.1
Other	21	2.1
American Indian or Alaska Native	6	.6
Hispanic Ethnicity	99	9.9

Respondents were randomly assigned to three groups: a control, a group that viewed a static infographic, and a group that viewed an animated infographic. Mean responses to the trust in science, personal attitude toward GM, and perceived attitudes of others toward GM within each group are in Table 2. The animated group had the highest mean trust in science and the control group had the most positive attitude toward GM and the most positive perceived attitudes of others toward GM.

Table 2

Respondent levels of trust in science, personal attitudes toward GM and perceived attitudes of others toward GM by treatment group (N = 1,000)

	Control (n = 347)		Static (n = 347)		Animated (n = 306)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Trust in science[a]	3.53	.67	3.58	.65	3.64	.67
Personal attitude toward GM[b]	2.60	1.00	2.46	1.00	2.47	.98
Perceived attitude of others toward GM[b]	2.82	1.06	2.68	1.02	2.54	.96

Note. [a]Scale: 1 = low level of trust, 5 = high level of trust; [b]Scale: 1 = negative attitude, 5 = positive attitude.

Differences in trust in science, personal attitudes toward GM, and perceived attitudes of others toward GM based on treatment group

A series of ANOVAs were used to identify any significant differences among the two treatment groups and the control. The results are in Table 3. The only statistically significant difference was in the perceived attitudes of others toward GM. A Bonferonni test was conducted *post hoc* to discern more specific differences. The test revealed the significant difference was between with control and animated treatment group with the control group having a more positive perceived attitudes of others toward GM than the animated treatment group. As a result, both hypotheses (H1and H2) were rejected.

Table 3
Differences in trust in science, personal attitudes toward GM, and perceived attitudes of others toward GM based on treatment group

	df	*F*	*p*	n_p^2
Trust in science	2	2.37	.09	.01
Personal attitude toward GM	2	2.31	.10	.01
Perceived attitudes of others toward GM	2	5.97	.00**	.01

Note. ***p* < .01

Discussion

This study sought to understand how consumers' trust in science, personal attitudes toward GM science, and perceived attitudes of others toward GM science would be affected by viewing either a static or animated infographic. The study was exploratory in nature given the lack of literature examining the effects of animating infographics. Therefore, it must be acknowledged a single infographic viewed for 20 seconds may not lead to a difference in attitudes and is a limitation of the study. In addition, consumers' uncertainty surrounding the science of GM foods is widely acknowledged as a contentious issue with attitudes toward GM difficult to alter (Funk, 2017; Lang, 2013; Lang & Hallman, 2005). Acknowledging all of this, the findings do add to the literature as a starting place for measuring consumers' trust in science when no infographic was presented, when a static infographic was presented, and when an animated infographic was presented. The findings have the potential to lead to further research examining the role infographics play in communicating about agricultural science broadly.

First, the findings revealed no significant difference in respondents' trust in science or their perceived attitude toward GM science; however, the group of respondents who received no infographic indicated a statistically significant different perception of others' attitudes of GM science. While this finding is significant, as it provides insight into how others perceive GM science, it somewhat contradicts previous research that reported a strained or negative relationship between the general population and science acceptance (Lang, 2013; Lang & Hallman, 2005; National Science Board, 2018). The infographic portrayed how others viewed GM science and all of the data graphically represented a positive to neutral attitude toward GM science. With previous research reporting a potentially negative relationship between society and science, the opposite finding would be expected. Therefore, this finding bears further inquiry to identify what specific information presented in the infographic may or may not have contributed to the respondents' perceptions of society's attitude toward GM science.

Additionally, the infographics' lack of impact on respondents' trust or attitude toward GM science somewhat contradicts previous research related to respondents' increased attitude and elaboration of agricultural issues (Burnett et al., 2019). Additional research should be conducted to test the scales of trust and attitude in different contexts and with different treatments to further understand how the constructs are being interpreted by respondents. Future research should explore the type of content and data included in infographics and how that affects respondents' processing on information and attitudes of science-based issues.

This research did not focus on the source of GM science information presented to respondents. Previous research suggests consumers' attitudes and trust in scientific information can be influenced by the organization and how that information is delivered to consumers (Myers et al., 2017). With the public being inundated with information about science through various media channels (Rumble et al., 2019), infographics, more specifically animated infographics, are more uncommon to the public as a form of sharing science information on a regular basis and may have led the respondents to question the validity of the information presented. This finding bears further investigation to understand consumer acceptance and trust of science information delivered through infographics and animated media. Understanding biased information foisted upon consumers through digital and print media channels can create gaps in knowledge of science (Bickford et al., 2012; Coyle, 2005; Ladle et al., 2005), research should continue to understand how to bridge consumer gaps in science literacy through the most effective media channels.

Finally, science technology and communication media channels will continue to advance; therefore, future research should examine the relationship between how individuals search for and process information related to GM science, as it relates to communication channels and their impact on consumer attitudes and perceptions. Food concerns will continue to be of paramount importance for consumers in years to come and researchers need to help scientists and communicators in the food and fiber industry share relevant and research-based information with the public.

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