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The international agricultural and extension education field is fairly infantile in its research approach with descriptive, exploratory and process-oriented research taking the forefront over the introduction and testing of theoretical models that strive to answer complex questions. In a time when the world is facing a myriad of global challenges directly related to the agricultural and natural resource system (e.g. food security, climate change, infectious disease management) the discipline must be bold, innovative, and discovery-driven. The research presented here tests a theoretical model that combines two well-known theories, Diffusion of Innovations and Spiral of Silence, in the context of examining public willingness to expose attitudes about genetic modification (GM) in the United States. Structural equation modeling is used to determine the direct and indirect effects theoretical variables can have in a complex decision-making environment. Perceptions of diffusion characteristics of an innovation were found to directly and indirectly effect perceived opinions of others, perceived future trends in attitudes toward GM, and attitude toward GM but they did not have a significant direct or indirect effect on willingness to expose attitudes about GM. The findings revealed the ongoing complexity associated with systems-thinking and the research approaches necessary to answer complex questions. It also showcased that when thoroughly vetted theoretical explanations are tested, they will not always have the expected result

Keywords

systems thinking;decision-making;diffusion;spiral of silence

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Testing a Model to Explain how the Public Makes Decisions about Genetic Modification

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Abstract

The international agricultural and extension education field is fairly infantile in its research approach with descriptive, exploratory and process-oriented research taking the forefront over the introduction and testing of theoretical models that strive to answer complex questions. In a time when the world is facing a myriad of global challenges directly related to the agricultural and natural resource system (e.g. food security, climate change, infectious disease management) the discipline must be bold, innovative, and discovery-driven. The research presented here tests a theoretical model that combines two well-known theories, Diffusion of Innovations and Spiral of Silence, in the context of examining public willingness to expose attitudes about genetic modification (GM) in the United States. Structural equation modeling is used to determine the direct and indirect effects theoretical variables can have in a complex decision-making environment. Perceptions of diffusion characteristics of an innovation were found to directly and indirectly effect perceived opinions of others, perceived future trends in attitudes toward GM, and attitude toward GM but they did not have a significant direct or indirect effect on willingness to expose attitudes about GM. The findings revealed the ongoing complexity associated with systems-thinking and the research approaches necessary to answer complex questions. It also showcased that when thoroughly vetted theoretical explanations are tested, they will not always have the expected result.

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Introduction

Scholars in the international agricultural education, communication, extension, and leadership disciplines have been examining decision making, trust in science, and consumer perceptions in the context of agricultural and natural resources for some time (e.g. Lamm, Warner, Taylor, & Martin, 2017; McKee, Lamm, & Bunch, 2017; Sanok, Stripling, Stephens, Griffith, 2015; Rumble, Chiarelli, Culbertson, & Irani, 2014; Rumble et al., 2019). While many of these studies add to the literature given the ANR context, they often fail to create and test proposed theories and models (Irani & Doerfert, 2013). The young and evolving nature of the discipline, in comparison with parent disciplines like education, psychology, and sociology, has been reflected in common descriptive, exploratory, and process-oriented research (Irani & Doerfert, 2013). The applied nature of our field also creates an environment suitable for simpler research processes (Irani & Doerfert, 2013; Lindner, 2018). However, as ANR issues become more complex and controversial, there is a need for our discipline to become more innovative, collaborative, and discovery-driven in our approaches to research (Irani & Doerfert, 2013). In this manuscript, we seek to make advances in the testing and validation of a theoretical model to help explain and predict decision making on complex ANR issues. A model of this nature could aid in the development of effective education, communication, and outreach approaches for complex ANR issues.

Globally, discussion has focused on grand challenges (United Nations, n.d.). "Grand challenges are ambitious but achievable goals that harness science, technology, and innovation to solve important national or global problems and that have the potential to capture the public's imagination" (Office of Science and Technology Policy, n.d., para. 1). Many grand challenges, such as food security, rural development, sustainability, climate change, and infectious disease management, intersect the agricultural and natural resource disciplines. Furthermore, grand challenges can benefit from social, human, and leadership capacity offered by disciplines such as ours (Linder, 2018). For example, we know that public decision making about agricultural and natural resource issues is complex and multi-dimensional (Trowler, 2012). Understanding the emotion, ethics, morals, and politics that impact personal decision making (Cook, Pieri, & Robbins, 2004) becomes integral to translating scientific solutions to real-world solutions that are accepted by the public.

Genetic modification (GM) is one agricultural breakthrough that scientifically could have positive implications for the grand challenge of food security (Maghoub, 2016). The implications and success of GM, however, have been hindered throughout the world by regulatory and consumer acceptance challenges (Lusk, Jamal, Kurlander, Roucan, & Taulman, 2005; Maghoub, 2016). Numerous studies have documented negative attitudes and lack of acceptance toward GM food (Funk & Rainie, 2015; Maghoub, 2016). Also well documented are the arguments against and concerns surrounding GM (Mahgoub, 2016), but missing from the literature is a scientific and tested understanding of why individuals have made decisions against GM. Several studies have attributed lack of acceptance to perceptions of risks (Boccaletti & Moro, 2000; Chen & Li, 2007; Curtis & Moeltner, 2006; Lusk & Coble, 2005; Mahgoub, 2016; Rosati & Saba, 2000; Scholdere et al., 1999) but depth of understanding related to the decision-making process is missing. In this study, we seek to not only test a theoretical model to help explain and predict decision making on complex ANR issues, but also understand specifically how the model explains decision making related to GM. Understanding decision making of this controversial issue will provide communicators, leaders, and educators with information to help build capacity around the next innovation and lead to scientific and social success in addressing grand challenges.

Conceptual Framework

Ruth, Rumble, Lamm, Irani, and Ellis (2018) introduced a conceptual model for decision-making about ANR science and technology, combining the Theory of Diffusion (Rogers, 2003), the Spiral of Silence (Noelle-Neumann, 1974), and the Elaboration-Likelihood Model (Cacioppo & Petty, 1984; Perloff, 2014). The model (Figure 1) outlines a framework for examining how individuals enmeshed in the complexities that arise from navigating complex and often competing sources of information about ANR science and technology make sense of and express their views, and how these views can be modulated through persuasive messaging. The Ruth et al. (2018) model posits that individuals establish perceptions of a given ANR science or technology and its attributes through Roger's five characteristics of an innovation: (a) relative advantage, (b) compatibility, (c) complexity, (d) triailability, and (e) observability. Each factor can have a different impact on an individual's attitude toward a given technology; for example, Ruth et al. (2016) noted compatibility was the only factor that explained a group of college students' willingness to consume genetically modified citrus. Which factors explain perception and attitude toward a given ANR technology vary based on several demographic and cultural factors: gender, race, age, socio-economic status, and culture of origin (Weick & Walchi, 2002). The Ruth et al. (2018) model in turn treats each factor as a separate explanatory variable and their interactions as related, but not linked to one another.

Social and cultural factors, expressed through and in tandem with the five characteristics of an innovation outlined by Rogers (2003), influence how individuals approach their larger social world and make sense of which forms of discourse are acceptable within a given group in society and which ones are not acceptable. Following Noelle-Neumann's Spiral of Silence (1974) theory of public opinion formation, the ANR model outlined by Ruth et al. (2018) posits that two of the three key factors of the spiral of silence, perceived opinions of others and perceived future trends of others' attitudes, are formed in conversation with how an individual situates personal views within their immediate social groups and the self-perceived majority. Individuals within a given society must navigate how their personal views align with the shared imperative of maintaining cohesion, or risk social isolation (Noelle-Neumann, 1974). Media packages play a critical role in creating and reinforcing the spiral of self-confirming views, or what Scheufele, Hardy, Brossard, Waismel-Manor and Nisbet (2006) called the echo chamber. This phenomenon has become more pronounced as the wealth of media options enables individuals to find social groups in alignment with their viewpoints that do not necessarily reflect national priorities and values (Glynn & Park, 1997; Slater, 2007). Individual viewpoints, mediated through perceptions of future attitudes and existing attitudes of others within their social groups, shape an individual's attitude and his or her willingness to expose said attitude to others.

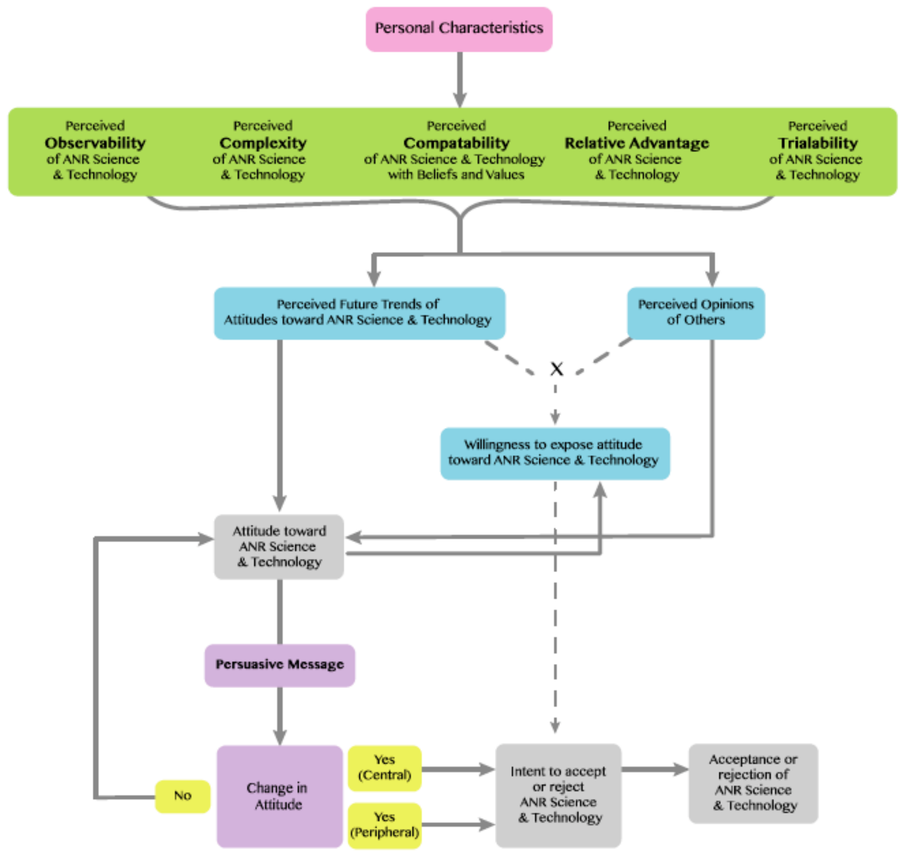

Figure 1. Decision-Making Model for ANR Science and Technology (Ruth et al., 2018).

An attitude, however, is not an immobile object within the model but rather a place where discourse can begin between an individual mediated in his or her social milieu and alternative messaging. Drawing on persuasive communications theory, the model of Decision-Making for ANR Science and Technology finds the Elaboration-Likelihood Model (ELM; Petty et al., 1995) provides an effective framework to explain how messaging interacts with existing attitudes and willingness to expose such attitudes in shaping how an individual analyzes new information and comes to either the same, or a different, conclusion. Elaboration-likelihood is a process-probability model: the framework rests on explicating when an individual will carefully explore the implications of new messaging or rely on existing knowledge and social norms/values (Perloff, 2014).

Individuals presented with new messaging who explore and examine the new message and its implications within their existing knowledge and value systems carefully weigh the quality of messaging, who is providing the message, and the social forces that are influencing their expressed viewpoint (Bhattacherjee & Sanford, 2006). Individuals who experience a change in attitude through careful examination of messages experience what Petty et al. (1995) call a “central” change or core shift in viewpoint. Such “central route” transformations in attitude create the conditions by which sustained change in behavior is possible. By contrast, those who do not explore and examine new messages in depth – what the ELM model refers to as "peripheral route" processing (Perloff, 2014) – tend to rely on manifestly less issue-focused factors, such as the likeability of the person providing a message, or other factors not immediately related to the message itself. Changes in attitude through peripheral route processing are not as easily sustained.

Ruth et al. (2018) note the Decision-Making Model for ANR Science and Technology can play an important role in improving the processes and practices through which agricultural education can facilitate the adoption of new technologies. However, the model has yet to be formally tested and validated. While models are imperfect representations of reality couched in complex assumptions, the experience of researchers, and the shared knowledge of a community of practice, it is crucial such models are tested and their limits identified (McQuail & Windahl, 2013). This study seeks to address how two of the interacting components within the Ruth et al. (2018) model, diffusion of innovations and spiral of silence, explain a person's willingness to express his or her views on ANR science and technology. To accomplish this, we turn to a highly visible and polarizing arena of discourse: the application of GM technologies to agriculture, or GM crops. Perceptions of GM agriculture vary considerably in different social and cultural contexts: according to Frewer et al. (2013), individuals' perceptions vary based on their specific socio-cultural context(s). Finucane (2002) argued that tailoring communication strategies to a specific group's views on risk, trust, new technologies, and the world at large is necessary to achieve a fuller understanding of the role GM agriculture can play globally.

Testing the Decision-Making Model for ANR science and technology with attention to an individual's willingness to expose attitude toward GM requires a few clarifying modifications to the original model. The five characteristics of diffusion adopted from Rogers (2003) should have separate causal relationships (Figure 2).

While the original model treated each factor as separate and proposed using quantitative and qualitative measures, in this study we argue it is crucial our model makes clear interdependencies or a lack thereof to maximize replicability, especially since it is only using quantitative measures. Similarly, Attitude toward ANR science and technology is now situated between the two Spiral of Silence factors – Perceived Future Trends and Perceived Opinions of Others. This modification achieves a better representation of the relationship between perception and willingness expressed in the original Spiral of Silence theory. Finally, as our analysis focuses on an individual's willingness to expose attitudes toward ANR science and technology specifically GM, the Willingness to Expose Attitudes variable has been moved down between individual attitude and the interaction variable marked by an "X" in Figure 1.

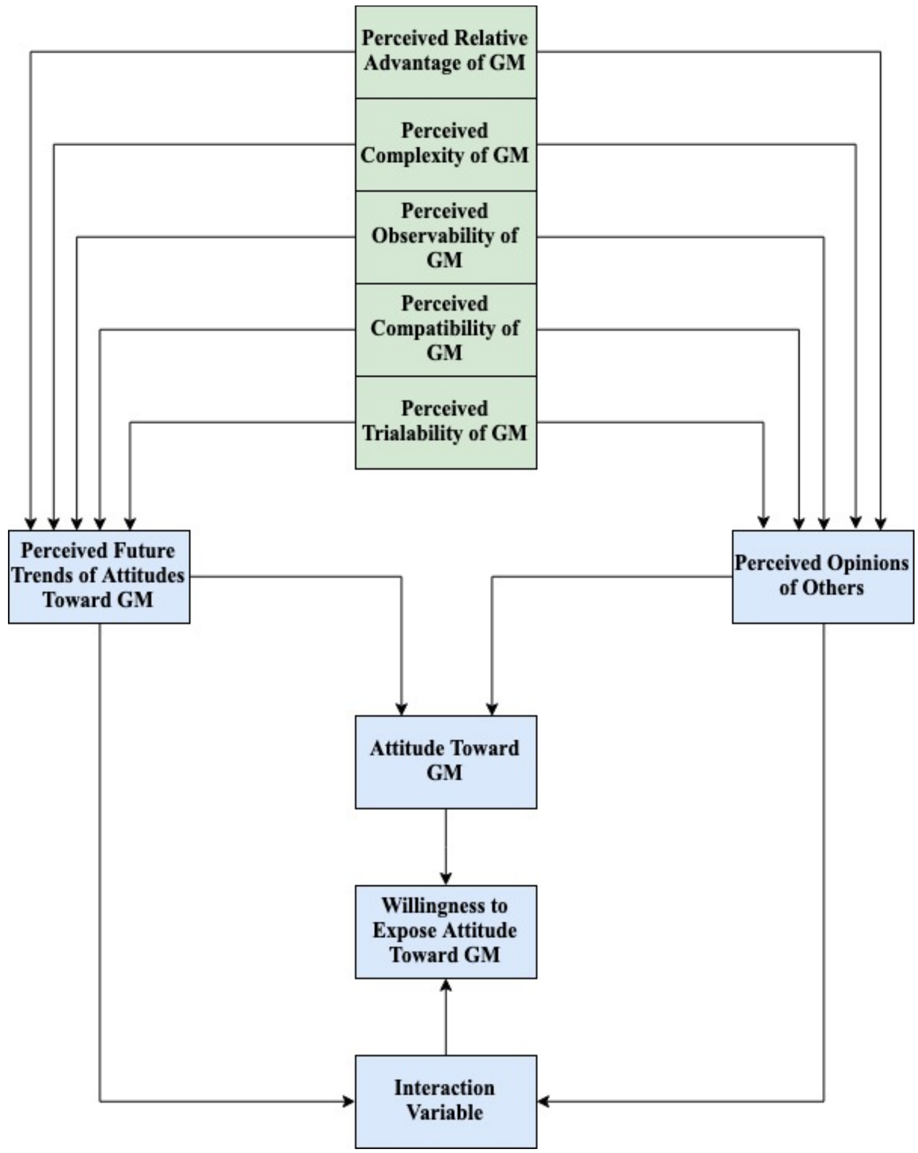

Figure 2. Adapted Decision-Making Model for ANR Science and Technology.

Purpose & Objectives

The purpose of this research was to test the first two components of the model (perceived Diffusion characteristics and Spiral of Science attributes) using GM as the ANR science of interest. It was guided by the following objectives:

1. Describe respondents' perceptions of the five Diffusion characteristics related to GM.
2. Describe respondents' perceptions of the Spiral of Silence attributes related to GM.
3. Identify the direct and indirect effects of the perceptions of the five Diffusion characteristics related to GM and perceptions of the Spiral of Silence attributes related to GM on Willingness to Expose Attitude toward GM.

Methods

The study was part of a larger research project undertaken to identify the most effective communication and education strategies that could assist in garnering public acceptance of GM as a potential solution to Huanglongbing (citrus greening disease).

Data Collection

The population of interest was members of the adult U.S. population. Using non-probability opt-in sampling, data from 1,046 respondents representative of the U.S. population were obtained using an online survey. Since this technique is most often used to make population estimates (Baker et al., 2013), it was deemed as the most ideal sampling method to meet the objectives of the study. Limitations associated with non-probability opt-in sampling include introducing bias from under coverage and nonresponse (Lamm & Lamm, 2019). In addition, selection bias also can occur based on the type of person that would opt-in to complete a survey online (Lamm & Lamm, 2019). However, research has shown "non-probability samples have yielded results that are as good as, or even better than, probability-based samples when appropriate techniques are employed to overcome its limitation" (Lamm & Lamm, 2019, p. 55). Quota sampling was applied (Moser & Stewart, 1953) prior to data collection. Weighting, based on the 2010 census data, was used after data collection was completed to ensure the sample was representative of the population of interest (Baker et al., 2013).

Instrument Development

Three parts of the survey were used to achieve the research objectives: perceptions of the five Diffusion characteristics (Rogers, 2003), perceptions of the Spiral of Silence attributes (Noelle-Neumann, 1974), and Attitude toward GM. Indices were created using the average response from multiple items for each of the five Diffusion characteristics, the three Spiral of Silence attributes and Attitude toward GM. Details on the number of items making up each indice and reliability statistics determined *post hoc* can be seen in Table 1.

Table 1

Reliability of Indices Used to Measure Perceptions of Diffusion Characteristics, Perceptions of Spiral of Silence Attributes and Attitude toward GM

	Number of items in the construct	α
Relative Advantage[a]	8	.92
Compatability[a]	6	.77
Trialability[a]	5	.76
Complexity[b]	6	.83
Observability[b]	6	.92
Perceptions of future trends[a]	7	.89
Perceived opinions of others[c]	8	.97
Willingness to expose attitude toward GM[a]	7	.80
Attitude toward GM[c]	8	.97

[a] Scale: 1 = *strongly disagree,* 2 = *disagree,* 3 = *neither agree nor disagree,* 4 = *agree* 5 = *strongly agree*
[b] Scale: 5-point semantic differential scale with 1 = *low,* 5 = *high*
[c] Scale: 5-point semantic differential scale with 1 = *negative,* 5 = *positive.*

Relative advantage was measured by requesting respondents indicate their level of agreement with eight items on a five-point Likert-type scale. Example items include:

GM science enhances the taste of food, GM science reduces the use of pesticides and GM science is part of a solution to end world hunger. Compatability was measured by requesting respondents indicate their level of agreement with six items on a five-point Likert-type scale. Example items include: Developments in GM science help make society better, GM science is essential for improving the quality of human lives, and GM science makes our way of life change too fast (reverse coded when the indice was created). Trialability was measured by requesting respondents indicate their level of agreement with five items on a five-point Likert-type scale. Example items include: I can easily try food products that result from plants made with GM science, Food products that result from plants made with GM science are easy to try, and Food products that result from plants made with GM science are readily available for me to try.

Complexity was measured by requesting respondents indicate the level to which an adjective best represented their thoughts about GM science. They were presented with six sets of opposing adjectives on a five-point semantic differential scale. Example sets include: Complex/Simple, Clear/Unclear, and Confusing/Straightforward. Observability also was measured by requesting respondents indicate the level to which an adjective best represented their thoughts about GM science. Six sets of opposing adjectives were presented on a five-point semantic differential scale. Example sets include: Easy to identify/Difficult to identify, Evident/Concealed, and Visible/Invisible.

Perceptions of future trends were measured by requesting respondents indicate their level of agreement with seven items on a five-point Likert-type scale. Example items include: In the future, people will not worry about GM science; In the future, people will be supportive of GM science; and In the future people will be appreciative of GM science. Perceived opinions of others were measured by requesting respondents indicate the level to which an adjective best represented their thoughts about how others in the U.S. feel about GM science. They were presented with eight sets of opposing adjectives on a five-point semantic differential scale. Example sets include: Good/Bad, Positive/Negative, and Beneficial/Not Beneficial. Willingness to Expose Attitudes toward GM was measured by requesting respondents indicate their level of agreement with seven items on a five-point Likert-type scale. Example items include: I would enjoy a good discussion about GM science, I would worry about being isolated if the people I am talking to disagree with me about GM science, and I would readily participate in a group discussion about GM science. Finally, Attitude toward GM was measured by requesting respondents indicate the level to which an adjective best represented their thoughts about how they feel about GM science. They were presented with the same eight sets of opposing adjectives on a five-point semantic differential scale that were used to determine perceived opinions of others. Example sets include: Necessary/Unnecessary, Important/Unimportant, and Crucial/Trivial.

The survey was expert panel reviewed by an agricultural communication professor specializing in science communication, a genetics professor currently testing GM science as a potential solution to citrus greening, and an extension evaluation specialist who is considered an expert in survey design. After expert panel review, the survey was pilot tested on 100 undergraduate college students at the University of Florida and Kansas State University. Cognitive interviews were then conducted with eight of the college students to determine face and content validity. Based on the reliability of the instrument during the pilot test and feedback obtained during the cognitive interviews, adjustments were made to one of the complexity items and two of the trialability items prior to full data collection.

Data Analysis

Descriptive statistics were used to achieve the first two research objectives using SPSS25. Structural equation modeling (SEM) was used to achieve the third objective. The Chi-square test of model fit was significant ($\chi^2 = 152.86$, $df = 16$, $p < .001$). Error terms associated with variables were allowed to correlate based on recommendations within the literature. Associated errors are allowed when items are conceptually associated or related to respondent relative answering based on item or stem preconditioning (McDonald & Ho, 2002; Saris & Aalberts, 2003).

Multiple model fit statistics were calculated in accordance with the recommendations in the literature (Hu & Bentler, 1998; Schreiber, Nora, Stage, Barlow, & King, 2006) to establish sufficiency of the model and data. Specifically, the comparative fit index (CFI), Tucker Lewis Index (TLI), and root mean square error of approximation (RMSEA) were computed. According to Hu and Bentler (1998), several benchmarks have been established to analyze model fit statistics and thus identify model misspecification. Specifically, the following thresholds have been proposed: RMSEA values less than 0.08 represent acceptable model fit; CFI and TLI values of 0.90 represent marginal fit, with values below 0.90 indicating poor fit and values 0.95 representing good fit. Model fit statistics were within acceptable ranges, indicating good fit for both CFI (.98) and TLI (.95). The other fit statistic, RMSEA (.09), was not within the established range for acceptable model fit. However, Schreiber et al. (2006) would find the model acceptable indicating that "if the vast majority of the indexes indicate a good fit, then there is probably a good fit" (p. 327).

Results

Perceptions of Diffusion Characteristics Related to GM

The respondents were neutral regarding the perceived observability of GM, complexity of GM, compatibility of GM, and trialability of GM. Respondents agreed GM had a perceived relative advantage. Details can be seen in Table 2.

Table 2

Perceptions of Diffusion characteristics related to GM

	M	*SD*
Relative Advantage[a]	3.59	.79
Compatability[a]	3.27	.71
Trialability[a]	3.27	.53
Complexity[b]	2.69	.78
Observability[b]	2.69	.98

[a] Scale: 1 = *strongly disagree,* 2 = *disagree,* 3 = *neither agree nor disagree,* 4 = *agree* 5 = *strongly agree*
[b] Scale: 1 = *low,* 5 = *high*

Perceptions of the Spiral of Silence Attributes Related to GM

Respondents were neutral regarding perceived future trends and opinions of others; however, respondents agreed to exposing their attitude toward GM as seen in Table 3.

Table 3

Perceptions of the Spiral of Silence Attributes Related to GM

	M	*SD*
Willingness to expose attitude toward GM[a]	3.51	.73
Perceptions of future trends[a]	3.30	.83
Perceived opinions of others[b]	2.98	1.08
Attitude toward GM[b]	2.69	1.02

[a] Scale: 1 = *strongly disagree,* 2 = *disagree,* 3 = *neither agree nor disagree,* 4 = *agree* 5 = *strongly agree*
[b] Scale: 1 = *negative*, 5 = *positive*

Direct and Indirect Effects of Diffusion Characteristics and Spiral of Silence Attributes Related to GM on Attitude toward GM

The direct effects indicated that Relative Advantage, Compatibility, and Trialability were all positively related to Perceived Future Trends of positive attitudes toward GM (Table 4). Of the three, Compatibility had the largest effect (standardized coefficient = .49).

Table 4

Unstandardized, Standardized, and Significance Levels for Direct Effects

Parameter Estimate	Unstandardized	Standardized	*p*
Perceived Future Trends of Attitudes Toward GM			
← Relative Advantage	.24	.21	.00**
← Complexity	.02	.02	.22
← Observability	.02	.02	.30
← Compatibility	.56	.49	.00**
← Trialability	.19	.12	.00**
Perceived Opinions of Others			
← Relative Advantage	.12	.09	.03*
← Complexity	.15	.11	.00**
← Observability	.30	.28	.00**
← Compatibility	-.01	-.01	.89
← Trialability	.19	.10	.01*
Attitude Toward GM			
← Perceived Future Trends of Attitudes Toward GM	-1.10	-.92	.00**
← Perceived Opinions of Others	-.38	-.39	.00**
Interaction Variable			
← Perceived Future Trends of Attitudes Toward GM	2.50	.46	.00**
← Perceived Opinions of Others	3.30	.74	.00**
Willingness to Expose Attitude Toward GM			
← Attitude Toward GM	-.02	-.03	.49

← Interaction Variable (Perceived Future Trends x Perceived Opinions of Others)	.00	-.00	.96

A total of 19.8% of the variance of perceived future trends of attitudes was predicted by the Diffusion characteristics (Table 5). The direct effects observed in the model indicated that four of the five Diffusion characteristics were positively related to to Perceived Opinions of Others; Compatibility was not found to be related. Of the four remaining characteristics, Observability had the largest effect (standardized coefficient = .28). A total of 53.8% of the variance in the Perceived Opinions of Others was predicted by the Diffusion characteristics (Table 5). The direct effects observed in the model also indicated that both Perceived Future Trends of attitudes toward GM and Perceived Opinions of Others were negatively related to Attitude toward GM. Of the two, Perceived Future Trends of attitudes toward GM had the largest effect (standardized coefficient = -.92). No statistically significant direct effects were observed with respect to Willingness to Expose Attitude toward GM.

Table 5

Squared Multiple Correlations of Spiral of Silence Attributes Related to GM on Attitude toward GM

	R^2
Perceived Future Trends of Attitudes Toward GM	.198
Perceived Opinions of Others	.538
Interaction Variable (Pereived Future Trends x Perceived Opinions of Others)	.954
Attitude Toward GM	.306
Willingness to Expose Attitude Toward GM	.001

A graphical representation of the model resulting from the SEM analysis is shown below in Figure 3. Non-significant direct effects were removed from the original version shown in Figure 2 to aid in clarity and interpretation. Of particular note is the absence of direct effects associated with the Willingness to Expose Attitude Toward GM variable. Error terms, although not indicated in the figure, were present in the analysis.

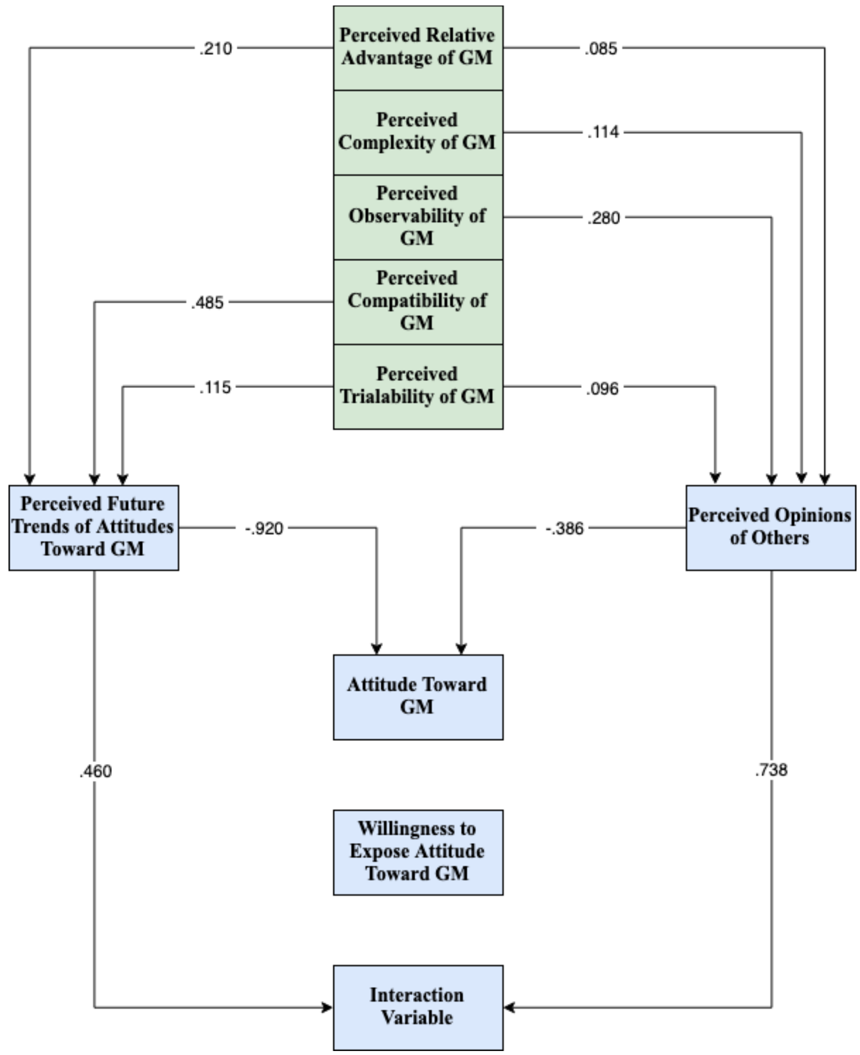

Figure 3. Statistically significant direct effect results for the decision-making model.
NOTE: CFI = .98; TLI = .95; RMSEA = .09; X^2 = 152.86; degrees of freedom = 16.

The standardized indirect effects observed in the model are presented in Table 6. Of the five Diffusion characteristics, Compatibility (standardized coefficient = .219) and Observability (standardized coefficient = .217) had the largest significant indirect effect on the interaction variable (Perceived Future Trends of attitudes toward GM X Perceived Opinions of Others). A total of 95.4% of the variance in the interaction variable was predicted by the model, including both direct and indirect effects (Table 6).

Significant negative effects were found for all five Diffusion characteristics on attitude towards GM. Of the five, compatibility (standardized coefficient = -.444) had the largest significant negative effect on attitude towards GM. A total of 30.6% of the variance in attitude toward GM was predicted by the model, including both direct and indirect effects (Table 6). Lastly, standardized indirect effects ranged from .002 to .012 between the five Diffusion characteristics and willingness to expose attitude toward GM. A total of 0.10% of the variance in the willingness to expose attitude toward GM variable was predicted by the model, including both direct and indirect effects (Table 6).

Table 6

Standardized Indirect Effects of Diffusion Characteristics and Spiral of Silence Attributes Related to GM on Attitude toward GM

	Relative Advantage	Complexity	Observability	Compatibility	Trialability
Interaction Variable (Perceived Future Trends x Perceived Opinions of Others)	.159	.094	.217	.219	.124
Attitude Toward GM	-.226	-.064	-.129	-.444	-.143
Willingness to Expose Attitude Toward GM	.006	.002	.003	.012	.004

Conclusions, Implications & Recommendations

The respondents expressed a neutral attitude toward GM overall and believed others had a more positive opinion of GM than they did, although still neutral. Several other studies have found negative attitudes toward GM, especially when it comes to food (Funk & Rainie, 2015; Maghoub, 2016). Therefore, this finding implies attitudes toward GM are not as negative as expected. The distribution of the respondents' attitudes should be further examined to determine if attitude is normally distributed or if individuals are polarized on the subject and when responses are combined they look neutral overall. The large standard deviation would indicate variability exists and would warrant more exploration.

In aggregate, the respondents agreed they were *Willing to Expose their Attitudes toward GM* but were neutral in regards to their perceptions related to *Future Trends of Attitudes toward GM*. Noelle-Neumann (1974) indicated individuals do not want to risk social isolation. One way to avoid social isolation is finding a social group and aligning with their viewpoints (Glynn & Park, 1997). However, if an individual is not sharing their opinions with the group on a regular basis, especially in a social media environment, the individual will not receive feedback (positive or negative) and their feeling of belonging will fade – socially isolating themselves. Therefore, once in a safe, social environment, group members are willing and eager to share their attitudes, thoughts and opinions. The findings from this study imply the respondents have found a social group, often referred to as echo chamber (Scheufele et al., 2006), where they feel *Willing to Express their Attitudes toward GM*, feel socially accepted for those attitudes, and want to engage. However, it does not imply that they are expressing these attitudes or opinions in a way that is exposing themselves to criticism. In future studies *Willingness to Expose Attitudes toward GM* should be analyzed within a specific context. Perhaps individuals feel willing to expose their attitudes in a safe environment but not in one where they are opening themselves up to criticism.

In terms of the Diffusion characteristics, the respondents neither agreed nor disagreed GM was complex, observable, something they could try, or compatible with their current beliefs. While strong public opinions regarding GM exist, the public has little actual knowledge of the science (Lusk et al., 2005), which may explain the neutral response to the Diffusion characteristics. However, respondents agreed GM had a greater Relative Advantage compared to current production practices. Given the regulatory and consumer acceptance challenges associated with GM (Maghoub, 2016), further exploration of perceived Relative Advantage may be warranted to assist in legislative decision-making.

As theorized, the Diffusion characteristics did have an impact on the Spiral of Silence Attributes. Three of the Diffusion characteristics had significant positive direct effects on perceived Future Trends of Attitudes toward GM and four of the five Diffusion characteristics had a significant positive direct effect on respondents' *Perceived Opinion of Others*. In addition, 95.4% of the variance in the interaction between *Perceived Future Trends of Attitudes toward GM* and *Perceived Opinions of Others* was predicted by the model, including the Diffusion characteristics. Compatibility and Observability had the largest indirect effect on the interaction.

In opposition to what you would expect based on Spiral of Silence theory (Noelle-Neumann, 1974), both *Perceived Future Trends* and *Perceived Opinions of Others* had a significant negative direct effect on Attitude toward GM. In addition, all five Diffusion characteristics had significant indirect negative effects on Attitude toward GM. Of the five Diffusion characteristics, Compatibility had the largest significant negative effect. Also, in opposition to Spiral of Silence theory (Noelle-Neumann, 1974), none of the variables in the model had a significant direct effect (positive or negative) on respondents' *Willingness to Expose his/her Attitude toward GM*. In total, the direct and indirect effects of all the variables only predicted .10% of the variance in a respondent's *Willingness to Expose his/her Attitude toward GM.*

The finding implies there is little to be done as educators and communicators that can alter *Willingness to Expose Attitudes toward GM*. However, this may be due to the echo chambers mentioned previously (Scheufele et al., 2006) and should be examined further to determine if the model works when *Willingness to Expose Attitudes toward GM* is set in an oppositional environment. The study could also be replicated in a developing country, as opposed to the U.S., where food is not readily available and GM is viewed as a solution or it could be replicated using a different ANR technology as the dependent variable. Perhaps examining a new water conservation technology or food safety protocol would elucidate further understanding of how the public makes decisions about agricultural systems.

Above all else, the findings revealed just how complex and multi-dimensional public decision-making about ANR issues can be (Trowler, 2012) and that when thoroughly vetted theoretical explanations are tested, they will not always have the expected result. The need to be innovative, collaborative, and discovery-driven in our approaches to research (Irani & Doerfert, 2013) is highlighted by the results that both support and oppose the theoretical model explored, further adding to our understanding of public decision-making around ANR issues. As the agricultural education and communication discipline strives to translate scientific solutions to real global challenges in a rapidly changing world (Lindner, 2018), it is more important than ever to recognize the role perceptions, social norms, emotions, ethics, morals, and politics play in the personal decision-making process; especially as it relates to exposing attitudes in an ever-changing social media environment.

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