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Effects of graphical cues during information processing in a social science context

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Effects of graphical cues during information processing in a social science context

by

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The student author and the program of study committee are solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

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DEDICATION

I dedicate my thesis work to my beloved wife, Xin Lu, who supports me throughout the time, and our soon-to-be-born son, Luke Sun.

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ABSTRACT

Social science is sometimes faced with legitimizing its own scientific value to certain audiences. The Elaboration Likelihood Model offers a way to understand how audiences process information and previous studies suggest that graphical cues within science messages may help to increase its perceived scientific value, especially among individuals with lower need for cognition. This study extends these predictions into a social science context by manipulating the presence of graphical cues within a popular article using an online experiment. Results suggest that graphical cues interacted with college major where students majoring in a non-science-related field perceived messages with graphical cues to have less scientific value, which is opposite of what was predicted. Within these non-science majors, need for cognition interacted with the treatment, such that participants with higher need for cognition perceived the messages with graphical cues and having less scientific value.

CHAPTER 1. INTRODUCTION

As an essential part of the scientific community, social science was first defined by Edwin Seligman in his book, *Encyclopedia of the Social Sciences*. Seligman stated that social sciences explain, classify and interpret social phenomena (Seligman, 1930). Thus, social sciences may include psychology, sociology, cultural anthropology, and any other discipline that means to discover the social functions and group activities of human beings. Social science is a distinctive product of modern culture and it has profound effects on Americans' social thoughts and practical issues (Ross, 1992). Ross suggested that social sciences invite people to look through history and understand the underlying social processes (1992).

However, even though social science plays an important role in understanding social phenomena, it is sometimes undervalued or viewed as less "real" of a science. Due to the complex nature of human responses, it is hard for social science to make causal predictions for behaviors (Winch, 2008). Flyvbjerg said in his book *Making Social Science Matter* that social science, by its very nature, has never and will probably never be able to develop constructed and systematic theories as in natural science (2001). As a consequence, social sciences have often faced substantial budget cuts because some decision makers perceive social science to lack significant impact (Wallerstein, 1995).

One aspect of this situation is in how individuals perceive science itself. By definition, science is "a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about nature and the universe. This knowledge is determined through the scientific method by experiments and observations, and may take the form of scientific facts, scientific models, or scientific theories" (Heilbron, 2003, p. vii).

However, an individual's perception of science does not always align with this definition, and is affected by social norms and knowledge structures. Social norms, which are defined as cultural products, including values, customs, and traditions, are part of a person's basic knowledge and automatic perception about the world (Sherif, 1936; Cialdini, 2003).

One possible area to approach this conflict in with science communication. As a bridge between the science and the public, science communication is the process by which science is presented to non-experts (Miller, 2002). There are many goals for which science communication can apply. From an informative perspective, science communication may be used to inform and inspire good decision making, including political and ethical thinking (Hilgartner, 1990). From a strategic perspective, science communication may be used to generate public support for scientific activities, or change attitudes or behaviors toward a certain preferred outcome (Dahlstrom, 2014). Because the area of interest for this study is understanding how to increase perceptions of the value of social science research, this study will focus on factors underlying the persuasive potential of science communication.Theoretically, the Elaboration Likelihood Model (ELM) offers a way to understand how audiences process information. The ELM is a dual process theory that describes how attitudes form and change by two different routes of thinking and processing (Petty & Cacioppo, 1984). In the central route, audiences systematically elaborate upon the content of a message to decide on their resultant beliefs. In the peripheral route, audiences instead only minimally process the content and instead rely on heuristic cues to provide shortcuts for evaluation. These heuristic cues can range from word and visual cues, to the length of the message or even to the attractiveness of the communicator (Petty & Cacioppo, 1984). ELM therefore offers a theoretical framework of how minor differences or trigger mechanisms in a message can impact the evaluation of the information (Tam & Ho, 2005).

Within the context of scientific information, previous research has identified some of these heuristic cues that influence audiences to view content as more or less scientific. McCabe and Castel (2008) found that the presence of brain images within articles summarizing cognitive neuroscience research caused higher ratings of scientific reasoning and perceived argument quality. Haard et al. (2004) found that the mere presence of the word "science" on medical labels increased perceived persuasiveness of readers. Tal and Wansink (2014) found that people who read claims about medication in the presence of a graph rated the medication as more effective than people who read the same information without the graph.

Within the specific context of social science, it is possible that some audiences don't view social science with as much value as natural science because they base some of their judgments on how messages are presented. It's easier for natural science to prove statistical significance and present greater amounts of data and numbers than social science (Winch, 2008 & Flyvbjerg, 2001). Presenting social science research with fewer of these scientific cues may lead audiences processing the content peripherally to see the research as not as empirical or accurate as hard science. This study will explore this possibility by testing how the presence or absence of a specific scientific cue in a popular article about social science will affect the perceived value of the research. Specifically, this study will explore if a graphical cues will heuristically increase the persuasive power of a scientific message in a social science context.

CHARPTER 2. LITERATURE REVIEW

Social Science

The definition of social science is the knowledge, explanation and classification of human behaviors and responses to natural stimuli (Seligman, 1930). Social science has profound effects on establishing social thoughts and practice. These significant impacts not only help humans understand themselves as creatures but also understand historical experiences and social structures (Ross, 1992). Social science has been called an "instrument of social problem solving" (Lindblom and Cohen, 1979, p. 2) and can not only be used in policy making, but also in any areas that want to solve social problems (Lindblom and Cohen, 1979). Social science is differentiated into various fields, such as psychology, sociology, communication or economics, and constantly shifts to address new problems facing groups, families and individuals (Lynd, 2015).

Yet, social science as a whole often faces criticism that it only represents a "soft" version of science or is not as important as the natural sciences. Social science is sometimes criticized for a lack of consistency in reliability, validity, effect size or for not being objective. Wallerstein argues that the separation between research and researchers are not possible in social science, as researchers themselves are not able to be totally excluded from their own social contexts (1995). Edward (2008) argues that some research methods in social science are biased since there is a lack of consistency across different measures. Podsakoff, MacKenzie and Podsakoff (2012) concur, claiming that biases in measurements can significantly influence validities and reliabilities as well as the co-variation within the constructs of social science findings. Bhattacherjee (2012) claims there are no reliable measurements for human emotions, noting that

different metrics may show the same person is "more happy" or "less happy" at the same instant.

One recent and public critique of social science research followed the publication of an article entitled, *Estimating the Reproducibility of Psychological Science* (Nosek et al., 2013). The article conducted replications of 100 psychological studies and found only 36% of their replications found significant results. Popular media outlets covered the results, often trumpeting the growing "crisis" of meaningful results in psychology (Gilbert & Strohminger, 2015;Yong, 2016).

While some social science research is undoubtedly less rigorous than it should be (as is the case with natural science too), this categorical denigration of social science research can lead to the underutilization of quality social science research by publics and policy makers in ways that could otherwise benefit society. Therefore, it becomes important to explore how individuals evaluate scientific information and come to an perception of its perceived value.

Elaboration Likelihood Model and Scientific Cues

The Elaboration Likelihood Model (ELM) provides a theoretical framework of how individuals process information using different level of elaboration (Petty & Cacioppo, 1984). In the central route, audiences systematically elaborate upon the content of a message to decide on their resultant beliefs. In the peripheral route, audiences instead only minimally process the content and instead rely on heuristic cues to provide shortcuts for evaluation. Two important factors that can help determine which pathway and individual uses to process a message are motivation and ability (Petty & Cacioppo, 1986). High motivation about a topic often encourages central route processing. Ability describes whether or not an individual has the appropriate background knowledge or cognitive resources at that time to devote to elaborating on the message. Even though central processes increase with greater elaboration and peripheral

processes decrease, attitude change is often determined by some combination of both central and peripheral processes working in tandem. (Eagly & Chaiken 1993; Petty & Wegener, 1998; Petty, 2013).

ELM has been applied widely in social science research, especially in contexts that explore persuasion and attitude changes, such as marketing and consumer research (Park, Lee, & Han, 2007), advertising (Johar, & Sirgy, 1991; Kahle, & Homer, 1985) and health communication (Withers, Twigg, Wertheim, & Paxton, 2002; Flynn, Worden, Bunn, Connolly, & Dorwaldt, 2011). For instance, Park el al. (2007) examined the impact on online reviews on product evaluations and found that consumers who use the central route to process product information are more likely to base their evaluations on reviews that discuss the quality of the product. In contrast, consumers who use the peripheral route are more likely base their evaluations on the mere number of reviews present. Similarly, Kahle and Homer (1985) found that consumers with higher motivations to process information centrally respond more favorably when advertisements provide positive information about the product. In contrast, consumers with low motivations to process responded more favorably to tangential cues, including products with likable celebrity pictures.

A relevant moderating factor used within ELM is Need for Cognition (NFC). NFC is defined as "a need to structure relevant situations in meaningful, integrated ways" and "a need to understand and make reasonable the experiential world"(Cacioppo & Petty, 1982, p. 117). Greater NFC is associated with a higher likelihood of debate, idea evaluation and problem solving (Cacioppo & Petty, 1984). Because of this desire to think deeply about issues, people with higher NFC often favor high elaboration using central processing. People with lower NFC may show an opposite likelihood, and may be more likely to process information peripherally

using heuristics. Several studies (Zhang, 1996; Zhang & Buda, 1999) show this moderation of persuasion based on NFC. For example, Sicilia et al. (2005) found that the increase in information processing between an interactive versus a non-interactive web site was smaller for high NFC than for low NFC individuals.

ELM has been employed within the processing of scientific communication. Bhattacherjee and Sanford (2006) examined how central and peripheral routes help improve information technology acceptance. Results found that highly-involved users were more likely to adopt the technology when the messages contained stronger arguments and low-involved users were more likely to adopt the technology when the message had stronger credibility (Bhattacherjee and Sanford, 2006).

Specific cues that can serve as scientific heuristics have also been a focus of research. McCabe and Castel (2006) found that including images of the brain in messages about cognitive neuroscience increased individuals' judgment of the scientific merit of the reported research when compared to identical articles with no image, a bar graph, or a topographical map. McCabe and Castel (2006) interpreted that brain images embedded in a message was more persuasive because it provided a tangible explanation that was easier to interpret. Even though the brain images were "superfluous" (McCabe & Castel, 2006, p. 350), part of the scientific credibility of the research technique was contained within the images themselves. Haard et al. (2004) found that use of use of scientific jargon, or as they called it "scientese," increased the persuasiveness of promotional messages of unproven medical remedies. These technical terms functioned as a heuristic cue suggesting sophistication and expertise of the message source. Brossard and Scheufele (2013) suggest that there are numerous cues embedded in online science articles to indicate popularity and credibility that could serve as heuristics, such as "likes" "retweets" and

comments. Anderson et al. found that readers' judgments about nanotechnology differed depending on civil or uncivil tones in the comments embedded in online articles (Anderson, Brossard, Scheufele, Xenos, & Ladwig, 2014).

Graphical data representations in particular have garnered attention. For instance, Tal and Wansink (2014) found that the mere presence of graphs embedded within medication efficacy claims increased persuasion. According to Tal and Wansink (2014), the graphs themselves embodied a scientific basis and granted the claim greater credibility. This influence persisted even when no additional information was provided for the graphs. Because this effect was not moderated by the understanding or knowledge about the scientific claims, Tal and Wansink (2014) believed that the persuasion increased solely due to the mere presents of these elements. This influence is not unknown to communicators, as Renn and Levine (1991) explained how graphical data as a message-related cue has been used in communication about environmental issues to increase message credibility (1991).

There are many other studies try to investigate the interrelationship between ELM, picture cues and message persuasiveness. For example, Miniard et al. (1991) has proposed that involvement, which directly leads to central and periphery processing, acts as a moderate effect on how readers' attitudes are changed by graphic cues. Their studies found that participants with a low involvement level with the product would be more persuaded by periphery pictures that are affect-laden, however, as involvement level increases, the effects would disappear. On the contrary, participants with a high involvement level are more likely to be persuaded by pictures that convey product-relevant information. Their study further examined that the underlining mechanism of graphic-based periphery processing is imagery evoked by the pictures and cognition about picture appropriateness. More specifically, participants rely their evaluations on

imagery evoked when the image content is attractive and on picture appropriateness when the image content is unattractive.

It has raised researchers' attention as of how computer-generated graphics will influence readers' information processing and attitude and behavior change. King et al. (1991) has conducted a study to investigate persuasive effectiveness of static and dynamic graphics, compared with written texts. Their studies found that participants are more persuaded by written texts with static images embedded than just written texts. They argued that possible reasons are: the pictures are better at maintaining readers' attentions and interest; graphics may serve as a persuasive evidence, which enhanced the persuasive effectiveness.

While graphical cues may serve as influential scientific heuristics in the natural sciences, their influence have yet to be tested in a social science context. Since social science is often faced with legitimizing its own value, the previous literature suggests that purposefully incorporating more of these scientific cues within relevant social science messages may help to increase its perceived value, especially among individuals with lower NFC that may be more likely to process information peripherally.

CHAPTER 3. STUDY OBJECTIVES

Social science faces critiques from various audiences that it is not as valuable or scientific as the natural sciences. These critiques can impact the funding dedicated for social scientific research or the application of its findings. Communicating social scientific research in ways that increase its perceived value could serve as one step to help overcome this perspective. The Elaboration Likelihood Model (ELM) provides theoretical guidance explaining how audiences evaluate messages and research has identified heuristic scientific cues that may serve to bolster the perceived value of scientific communication. This study will extend the literature examining how the presence of graphical cues may serve as heuristics to increase the perceive scientific value of a message to a social scientific context.

The existence of data and its graphical representation serve as important signals that indicates scientific reasoning and argument in people's general knowledge structure (Frankel & DePace, 2012). The type of graphical cue used in this study will be a histogram visualizing scientific data. The following hypothesis is therefore proposed to extend this into a social science context:

H1. Participants exposed to a message about social scientific research including graphical cues will perceive the research to be of greater scientific value than the same message without graphical cues.

The ELM suggests that heuristic cues are more impactful for audiences that process a message through the peripheral pathway as opposed to the central processing pathway (Petty & Cacioppo, 1986). Need for Cognition (NFC) can help identify individuals who are more or less likely to process information using a particular pathway. Specifically, individuals who are low

on NFC are less inclined to think carefully about information and are therefore more likely to process information peripherally. This group would therefore likely be more influenced by the presence of graphical cues. Therefore, the following hypothesis is proposed:

H2. NFC will interact with the presence of graphical cues such that participants low in NFC will exhibit greater influence due to graphical cues than participants high in NFC.

Because the ELM predicts that a person's ability and interest to process information can influence elaboration , an individual's affinity toward science may therefore influence these relationships. Participants who have a greater ability and interest to process scientific information are more likely to be able to process the information centrally and will be less likely to be influenced by the graphical cues. In contrast, participants with lesser ability and interest to process scientific information will more likely rely on the graphical cues to process the information through the peripheral route. Participant's choice of a college major, wither science-related or not, may serve as a measure of this affinity. Therefore, the following hypothesis is proposed:

H3. Participants in non-science-related majors will exhibit greater influence due to graphical cues such that cues relate to greater perceived value than participants in science-related majors.

Of course, there are other factors that could influence the evaluation of a scientific message. Two factors in particular include science literacy and deference to science authority. Science literacy measures participants' basic knowledge about scientific facts and represents a measure of knowledge and understanding of scientific concepts (Adam et al., 2006). An individual's science literacy level will influence their confidence about scientific facts (Gormally et al., 2009). In the current context, a participant higher in science literacy may have greater

ability to process the scientific message centrally and therefore rely less on heuristics to make evaluations about article's scientific merits. On the other hand, the measure of scientific literacy is based on facts about the natural sciences, and therefore a participant more knowledgeable about these facts may already be primed to question the legitimacy of social science and be less likely to process the scientific message centrally.

Deference to scientific authority represents how much authority participants think scientists should be granted regarding the value of their own research (Anderson et al., 2011; Brossard & Nisbet, 2007). Individuals high in deference to scientific authority generally think scientists know what is best and that scientists should be allowed conduct research and make decisions regardless of what the public thinks. Individuals low in deference to scientific authority believe the opposite, such that scientists should conduct research and make decisions based on what society thinks is acceptable and important. In this current context, individuals high in deference to scientific authority generally have a positive view of science and may be more motivated to process a scientific message centrally. On the other hand, because individuals high in deference to scientific authority already trust scientists to do what is right, they might not feel the need to scrutinize research and instead accept it heuristically.

Because there exists little literature to predict which way these two factors will interact with graphical cues, the following research question is proposed.

RQ1: How will science literacy and deference to scientific authority relate to perceived value of a social scientific message and/or interactions with the presence of graphical cues?

CHAPTER 4. METHODS

An experiment was used as the main research method for this study because it allows for the isolation of specific effects caused by the individual independent variables of interest. Random selection also helps balance out potential influences of other factors. An online dissemination of the study was used because it balanced the costs and sample size needed for this study.

Participants and Design

Participants were students in three undergraduate advertising, public relations and journalism courses at Iowa State and were given extra credit in their respective course as incentive for participation. The initial sample contained 373 subjects. Twenty-six participants were removed from the data for dropping out of the study, resulting in a final sample of 347 participants. Participants were predominantly female (72.9%), with a median age of 20 years and 84.7% were majoring in a non-scientific field.

Procedure

Data was collected over one week in June of 2017. Participants were invited by email to participate in a 25-minute online survey. After consenting to participate, participants completed a pre-test capturing their initial beliefs and attitudes about science and need for cognition. The survey then informed participants that they would read a story about science. Random assignment exposed participants to one of four versions of a stimulus article in a 2x2 between-subjects design that differed by the presence of graphical cues and social science article. Finally, participants completed a series of questions about their perceived value of the science and other items evaluating the article. All research was approved by IRB.

Stimuli

Background articles: To ensure that any results are based on the manipulation and not the specific topic or article chosen, two different social science articles were manipulated for this study. Both base stimuli articles were created from two published popular social science articles retrieved from phys.org social science section and New York Magazine Science of Us section, respectively. The first article reported results of a study finding that cooperation instead of competition is mutual-beneficial and can utilize social connections. The second article reported results of a study finding that marriage and relationship need more deep communication. These two articles were selected as they represent standard research reports targeting a non-expert audience and both represent social science themes that face the previously described criticisms. Information about specific authors, institutes or publishing outlets were removed to reduce potential recognition. Several paragraphs in both articles were edited or deleted to align and reduce word counts. The final version of the first article contained 656 words and the second article contained 620 words.

Manipulations: Both of the base stimuli articles were modified into two manipulations – either with a graphical cue or without. For the conditions with a graphical cue, a set of two histograms was created with Microsoft Excel and inserted into the base stimuli articles. Each set of histograms were identical in both design and values with only the labels altered to match the content of each article. Within each condition with a graphical cue, the first graph was inserted after the second paragraph of base stimulus article and the second graph was inserted before the last paragraph. Random assignment placed participants into one of these four cells: Article one with (n=87) and without (n=87) graphical cues and article two with (n=88) and without (n=85) graphical cues.

Variables

Independent Variable.

Graphical cues represent the presence or absence of a graphical display of numerical data, which is the main manipulation of this study.

Dependent Variable.

Perceived scientific value represents participants' judgments of the scientific value of the research presented in the stimulus article. Perceived scientific value was measured with three questions: "I personally value the research presented in the article," "I believe the research presented in the article is valuable for society," and "I believe the presented results are scientifically true." Although this last question asks about truth rather than value, this concept scaled closely with the value factors and so likely was interpreted as true aligning with "valued" and false with "meaningless." Participants were asked their agreement on each question using a 7-point scale and the three values were summed into a single measure with greater values representing a greater perceived scientific value ($M=13.75$, $SD=3.07$, $\alpha=.76$).

Moderators.

Need for cognition represents individuals' tendencies to pursue and enjoy the process of thinking and was measured with the standard 18-item scale (Cacioppo et al., 1996). Participants were asked their agreement on statements such as, *"I would prefer complex to simple problems,"* each on a seven-point scale. Items were reverse coded as needed and averaged into a single need for cognition measure with grater values representing a greater need for cognition ($M=4.71$, $SD=12.6$, $\alpha=.81$).

Science literacy represents the knowledge and understanding of scientific concepts and processes required for personal decision making (Adams et al., 2006) and was measured with

eight items (Miller, 1983). Participants were given a series of scientific facts such as, *"All radioactivity is man-made,"* and asked to rate each as either true, false, or don't know. All correct answers were summed into a single science literacy measure such that grater values representing greater science literacy (*M*=6.2, *SD*=1.82).

Deference to science authority represents a judgment of how much authority scientists should be allowed regarding deciding the value of their own research and was measured with the standard 4-item scale (Brossard & Nisbet, 2007). Participants were asked their agreement on statements such as, *"Scientists know best what is good for the public"* on a four-point scale. Items were averaged into a single deference to science authority measure with grater values representing a greater deference to science authority (*M*=2.9, *SD*=3.12, *α*=.64).

College major represents a proxy for affinity toward science and was measured by asking participants to report their current major in an open-ended question. Natural science and technology related majors were coded as "science-related" while others were coded as "non-science-related." The exception was the field of psychology which was coded as "science-related" because the stimuli were based on psychology research, which this group would likely identify as science. This resulted in 84.7% of participants coded as coming from non-science-related majors. The full questionnaire is presented in Appendix A, the stimuli articles with graphical cues are presented in Appendix B and a frequency table of the participant majors and their codes are presented in Appendix C.

The strategy used to analyze this data was hierarchical OLS regression as it permits the simultaneous testing of relationships within a block of factors while controlling for all of the factors that were already entered in the model. This provides a measure of the unique variance accounted for by the specific variables of interest.

CHAPTER 5. RESULTS

Before addressing the hypotheses and research questions, the main effect of stimulus article was tested with a one-way ANOVA. Two different stimulus texts were used to avoid confounds based on the specific social science article used. Perceived scientific value of the cooperation/competition article ($M = 13.56$, $SD = 2.79$) was not significantly different than that of the marriage/relationship article ($M = 13.94$, $SD = 3.32$; $F (1, 345) = 1.282$, $p = .258$). Therefore, the data from these articles will be collapsed leaving a single comparison for the rest of the analysis: graphical cues versus no graphical cues.

Hierarchical OLS regression was used to explore the hypotheses and research question. Perceived scientific value was entered as a dependent variable in a regression model. The first block consisted of age, gender, and a dummy variable of college major with 0 representing a non-science major and 1 representing a science major. The second block consisted of science literacy and deference to scientific authority. The third block consisted of NFC by itself. The fourth block contained a dummy variable representing the presence of graphical cues, with 0 representing no graphical cues and 1 representing graphical cues. Finally, a fifth block was used to test the interaction of graphical cues with NFC, science literacy and deference to scientific authority, with each continuous variable mean-centered before constructing the interaction term. This regression was run three times, each time with one of the three interaction variables present by itself in the fifth block. The regression results are presented in Table 1.

Table 1. Hierarchical Regression Predicting Perceived Scientific Value

Predictors	Perceived Scientific Value		
	B	SE	β
Intercept	12.99	1.96	
Block 1			
Age	.01	.08	.01
Gender	.50	.38	.07
Major	-1.90	.52	-.20***
ΔR^2			.03*
Block 2			
Science Literacy (SL)	-.05	.10	>-.01
Deference to Scientific Authority (DSA)	.15	.05	.15*
ΔR^2			.03*
Block 3			
Need for Cognition (NFC)	.03	.04	.12
ΔR^2			.01
Block 4			
Graphical Cues	-.40	.33	-.07
ΔR^2			<.01
Block 5			
Graphical Cues * NFC	-.01	.03	.03
Graphical Cues * SL	.07	.18	.07
Graphical Cues * DSA	-.06	.10	-.09
ΔR^2			<.01
Total R^2			.07

Note. *p<.05. **p<.01. ***p<.001.

ΔR2 values represent each block when added.

All other values come from the final model.

H1 predicted that participants exposed to a message about social scientific research including graphical cues would perceive the research to be of greater scientific value than the same message without graphical cues.

Graphical cues were not a significant predictor of perceived scientific value (β = -.065, p =.231). H1 was not supported.

H2 predicted that NFC would interact with the presence of graphical cues such that participants low in NFC would exhibit greater influence of graphical cues than participants high in NFC.

The interaction between NFC and graphical cues was not a significant predictor of perceived scientific value (β = -.033, p =.846). H2 was not supported.

H3 predicted that non-science-major participants would exhibit greater influence due to graphical cues such that cues relate to greater perceived value. Because the number of non-science majors to science majors was heavily skewed, this relationship was initially explored using an ANOVA. As shown in Figure 1, a significant interaction was found between graphical cues and college major such that non-science majors rated articles with graphical cues as having less perceived value than articles without graphical cues (F (2, 344) = 6.015, p = .003). While the non-science majors did exhibit greater influence due to the graphical cues, the direction was in the opposite direction as expected.
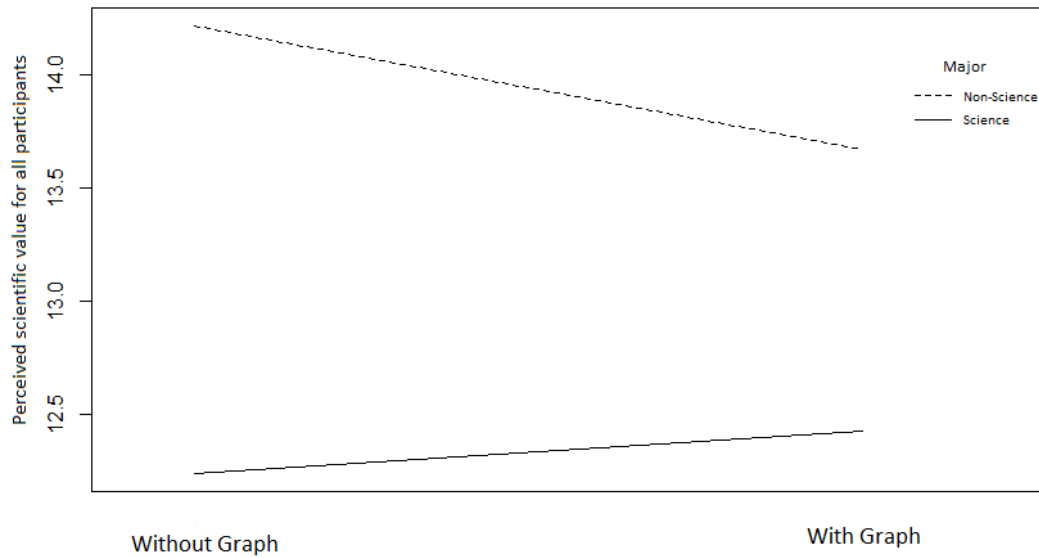
Figure 1 **Interaction between Graphical Cues and Major on Perceived Scientific Value**

To better understand this relationship, science majors were removed from the dataset and the remaining non-science majors were used to test the interaction between graphical cues and NFC. As shown in Figure 2, the interaction was significant (F (2, 305) = 4.444, p = .013) such that non-science majors with high NFC rated articles with graphical cues as having less perceived value than articles without graphical cues.
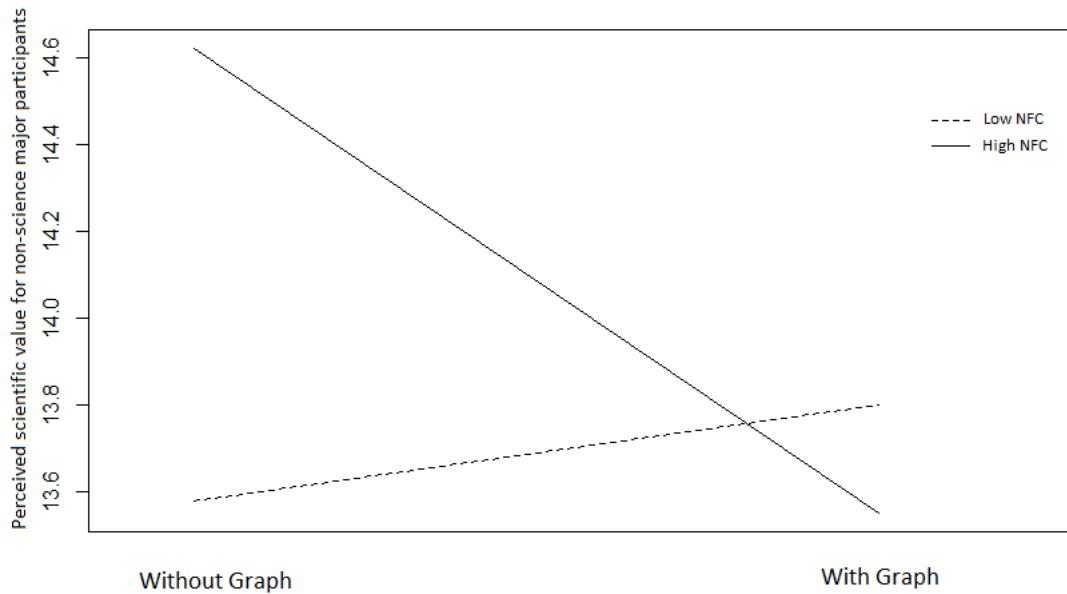
Figure 2 Interaction between Graphical Cues and NFC on Perceived Scientific Value for Participants in Non-Science Majors

RQ1 asked if science literacy and/or deference to scientific authority would relate to perceived value of a social scientific message or their interactions with graphical cues. Science literacy was not a significant predictor of perceived scientific value (β = -.003, p =.958) nor was its interaction with graphical cues (β = .065, p =.229). However, deference to scientific authority was a significant predictor of perceived scientific value (β = .152, p =.005) even though its interaction with graphical cues was not (β = -.525, p =.600). In response to RQ1, only deference to scientific authority was related to perceived scientific value such that individuals with greater deference to scientific authority also viewed the articles as having greater perceived scientific value. This relationship remained when also rerunning the regression with only the non-science majors (β = .174, p =.002).

CHAPTER 6. DISCUSSION

This study sought to explore how the presentation of messages about social science research could impact the perceived scientific value of the science. Previous studies suggest that the presence of graphical cues in a scientific message can serve as a heuristic to persuade audiences the science is more effective or important (McCabe & Castel, 2006; Haard et al., 2004). This study extended these findings into a social science context.

The first hypothesis predicted that social scientific messages presented with graphical cues would lead to a greater perception of scientific value than the same message without graphical cues. This prediction was not supported as the graphical cues had no significant relationship to perceived scientific value. The second hypothesis predicted that participants low in NFC would exhibit greater influence of graphical cues than participants high in NFC. This prediction was also not supported. There are several possible explanations for this lack of support.

One explanation is that there may have been an unmeasured interaction with complexity, both regarding the science itself and the graphical cues. Regarding the science, social science interprets social phenomena and human responses to the phenomena as opposed to the technical analysis of the natural world within natural sciences (Frankel and DePace, 2012). The prior literature exploring graphical cues on perceived value of science has focused almost completely on natural science contexts. It may be that the natural sciences in general are complex enough that audiences rely on graphical cues to a greater extent for comprehension aids, resulting in the published effects. In contrast, social science may be familiar enough, and therefore less complex, that audiences don't rely on graphical cues as much for comprehension, especially if they have

encountered the phenomena themselves in real life scenarios. Under these circumstances, the presence of the graphs might not serve as much of a pivotal role for the readers to understand the materials and not fulfill their role as a heuristic.

Regarding complexity of the graphical cues used, the histograms used in this study represent only one level of complexity within many possible types of graphical cues. It is possible that testing graphical cues with more or less complexity, and therefore requiring more or less cognitive resources to process, would lead to more nuanced results. For instance, a chart that is overly complex and difficult to comprehend may serve as a stronger heuristic cue because fewer individuals will take the necessary elaboration to comprehend it. Likewise, a simple pie graph may require so little cognitive energy to understand that little is gained for processing it heuristically. Future studies should either collect pilot data on various types of graphical cues to determine which are seen by the target audience as the most relevant or manipulate the complexity of various types of graphical cues to test for heuristic effects. If this potential interaction with either form of complexity is supported, this could introduce a relevant construct to this area and represent a meaningful theoretical contribution.

Of course, another explanation is that participants may not have engaged in a heuristic processing pathway at all when reading the stimuli articles. This would render the graphical cues less relevant than the content of the articles themselves, leading to non-significant effects. The second hypotheses predicted that any effect of graphical cues would interact with NFC and this was an attempt to parse out this processing difference – participants lower in NFC would likely be processing peripherally more often than those higher in NFC. However, since this hypothesis was not supported, the data cannot identify which participants were primarily using which

pathway to process the stimuli. This is a limitation and future studies should include measures of processing elaboration to better understand the underlying mechanisms.

Regardless of why the first two hypotheses were not supported, the analysis also found college major to be a significant predictor of perceived scientific value. There was a significant interaction between college major and graphical cues such that non-science majors found the stimulus articles with graphical cues as offering less scientific value than those without. One explanation to this pattern is that science majors are more likely to use histograms, such as those used in this study, as information since their field of study is more embedded with numerical processing. According to the ELM, an individuals' familiarity and habituation are important indicators of preferred processing routes (Petty & Cacioppo, 1986). Graphical cues may therefore serve as more of a familiarity heuristic for science majors than non-science major participants, since they are more likely to be exposed to a data-rich environment on daily basis. Therefore, graphical cues might not embody the scientific credibility for non-science majors, leading them to react differently.

Looking only at these non-science majors, the second finding is the predicted interaction between graphical cues and NFC was supported but to an unexpected degree. Participants with low NFC show the expected increase in perceived scientific value with the graphical cues present. Similar to the previous explanation, since non-science major participants may be less likely to use graphical cues as familiarity heuristic, NFC becomes a stronger determinant for influencing processing. The unexpected degree was that individuals with higher NFC perceived the stimuli with graphical cues with much less scientific value. This is harder to explain, but may be related to the graphical cues themselves if individuals were elaborating on the graphs and found them to be somehow informationally deficient relative to the article itself.

The research question asked if two additional factors would relate and/or interact with perceived scientific value. While science literacy was not a significant predictor, deference to scientific authority was significantly related. Specifically, participants with higher deference to scientific authority viewed all treatment articles, regardless of graphical cues, with more scientific value than participants with lower deference to scientific authority. This finding is reasonable because individuals with higher deference to scientific authority are more likely to trust scientists to make good decisions and therefore are more likely to value scientific results regardless of content or cues. The processing pathway these participants are using remain unknown, however. High deference to scientific authority could provide individuals with the motivation to elaborate upon and process science information centrally. This would account for why the graphical cues did not moderate this relationship. In contrast, high deference to scientific authority may serve as a heuristic cue itself to let these individuals value science peripherally without elaborating on the message. This would also account for why graphical cues did not moderate this relationship because a different cue already served its heuristic role. Future research should explore the mechanisms underlying this relationship.

Limitations and Future Directions

There are significant limitations in this study. Theoretically, while the literature has shown that graphical cues can have positive effects on scientific persuasion, not all graphical cues are created equal. There are many different types of graphs, and even within a certain type, the design elements, such as color, scale, size or specific labels may impact its influence as a heuristic cue. These factors remain practically untested, so it remains unknown what kind of graphical cues would best serve as powerful heuristics for social science. Likewise, the use of histograms as the operationalization of graphical cues in this study was chosen for ease of

manipulation and high familiarity. In hindsight, these decisions touch on deeper theoretical questions and it remains unclear how or why the graphs used in this study compare to other options. This area seems to represent a potentially fruitful area of future research, not just within graphical cues, but in identifying and comparing the effects of different types of scientific cues. Methodologically, there was no measure to capture which processing pathway participants were using when reading the stimuli articles. NFC was intended to capture this difference, and seems to have been successful in the non-science majors. Nonetheless, better determining which processing route participants were using would likely account for more variance and better uncover the mechanisms behind these relationships. This was a significant omission and as such limits the testing of the possible explanations for a lack of the predicted effect. Future research should explore many of these same relationships with this added measurement.

Additionally, this study used college students as participants and this group is likely more skewed toward science literacy and deference to science compared to the general population, which may have led to less variance to identify effects. Meanwhile, almost ninety percent of the participants in this study represented non-science major, so the large difference in sample size between science and non-science majors requires caution when interpreting the post hoc analysis comparing the two.

Future research should also explore the relationships of graphical cues and perceptions in a more generalizable population and expand upon the differences in how these groups attend to and evaluate scientific messages, possibly dividing participants into more nuanced groups related to their background and training.

In conclusion, this study examined how the presentation of social science research could influence the perceived value of the science itself. The findings support the theoretical

framework of ELM as it illustrated how different group of participants, likely varying on motivation and ability, processed information differently. Likewise, this study also supported the theoretical linkage between ELM and NFC for a subset of the sample. And as discussed earlier, a possible moderation of complexity, of either the science context of the graphical cues used, could represent a future theoretical contribution for better understanding these relationships.

From a practical standpoint, this study can offer little guidance at this stage. Graphical cues did lead to increased perceived value of science for some participants, but not for others. The current limitations prevent a full understanding of the mechanisms underlying the findings and it would be premature to suggest practitioners alter their practice based on these findings. Nonetheless, these results suggest that further research in this area could addressing some of the present limitations might help social scientists present their work in ways that earn them more of the perceived scientific value they deserve.

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APPENDIX A

FULL QUESTIONNAIRE

You are invited to participate in a study about how science is communicated. This study is being conducted by Jingru Sun in the Greenlee School of Journalism and Communication. If you have any questions, please contact jsun@iastate.edu.

In this study you will be asked to read an article about science and answer a series of questions, most of which require checking boxes. Completing the study will take approximately 25 minutes and you will be compensated with extra credit in one of your courses that disseminated this study.

The risks of participating are considered minimal, as you are asked only to read a brief article and share some of your thoughts.

Your participation in this survey is voluntary and all responses will be kept confidential. You may decline to answer any question and you have the right to withdraw from participation at any time.

This study has been reviewed and approved by the Iowa State University Institutional Review Board. If you have any questions about your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact the Institutional Review Board by phone at 294-1516 or email at orrweb@iastate.edu.
IRB Approval Number: 16-051

I consent to participating in the study described above.

I acknowledge that I have read and fully understand the consent form. By completing this study, I am participating freely and voluntarily.
○ I agree to participate
○ I do not agree to participate

This study will ask you to evaluate a story about science. In a moment, we will show you a randomly selected article about science and ask for your thoughts, but first we want to know a bit about you.

Please select the answer to each of the following questions that best represents you.
(7-point scale; strong disagreement, moderate disagreement, slight disagreement, neither agreement nor disagreement, slight agreement, moderate agreement, strong agreement)
1. I would prefer complex to simple problems.
2. I like to have the responsibility of handling a situation that requires a lot of thinking.
3. Thinking is not my idea of fun.
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities?

5. I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.
6. I find satisfaction in deliberating hard and for long hours.
7. I only think as hard as I have to.
8. I prefer to think about small, daily projects to long-term ones.
9. I like tasks that require little thought once I've learned them.
10. The idea of relying on thought to make my way to the top appeals to me.
11. I really enjoy a task that involves coming up with new solutions to problems.
12. Learning new ways to think doesn't excite me very much.
13. I prefer my life to be filled with puzzles that I must solve.
14. The notion of thinking abstractly is appealing to me.
15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.
17. It's enough for me that something gets the job done; I don't care how or why it works.
18. I usually end up deliberating about issues even when they do not affect me personally.

Next, we want to ask a few questions about science.

Please answer the following questions to the best of your ability.
(True, False, Don't Know)
1. The center of the Earth is very hot.
2. All radioactivity is man-made.
3. It is the father's gene that decides whether the baby is a boy or a girl.
4. Lasers work by focusing sound waves.
5. Electrons are smaller than atoms.
6. Antibiotics kill viruses as well as bacteria.
7. The continents on which we live have been moving their locations for millions of years and will continue to move in the future.
8. Does the Earth go around the Sun, or does the Sun go around the Earth?
(Earth around Sun, Sun around Earth, Don't Know)
*9. How long does it take for the Earth to go around the Sun?
(One Week, One Month, Six Months, One Year, Six Years)

Next, we want to ask a few questions about what you think about scientists.
(Disagree, Somehow Disagree, Somehow Agree, Agree)
1. Scientists know best what is good for the public.
2. It is important for scientists to get research done even if they displease people by doing it.
3. Scientists should do what they think is best, even if they have to persuade people that it is right.
4. Scientists should make the decisions about the type of scientific research.

Would you say your knowledge of what scientists/engineers do day-to-day on their jobs is excellent, good, fair, poor, or very poor?
(Excellent, Good, Fair, Poor, Very poor, Don't Know)

Thank you. On the next page you will see a randomly selected story about science. Just the main content is presented – we are not including any identifying information so you don't base your evaluation on the author or where the article is published.

Please complete the following questions to tell us what you thought about the science story you just read.

**Pseudoscience consists of claims, beliefs, or practices presented as being plausible scientifically, but which are not justifiable by the scientific method. Do you believe the methods and theories in this article are closer to pseudoscience or real science? Use point 1 to 7 to indicate your answer
(1= strongly disagree, 2, 3, 4, 5, 6, 7 = strongly agree)

Please mark how much you agree or disagree with the following statements:

I believe the presented results are scientifically true.
(1= strongly disagree, 2, 3, 4, 5, 6, 7 = strongly agree)

I personally value the research presented in the article.
(1= strongly disagree, 2, 3, 4, 5, 6, 7 = strongly agree)

I believe the research presented in the article is valuable for society.
(1= strongly disagree, 2, 3, 4, 5, 6, 7 = strongly agree)

**With limited money to fund scientific research, how important is it to continue funding research like what was presented in the previous article?
(Very Important, Important, Somehow important, Somehow not important, Not important, Not important at all)

**What type of media outlet would you most expect to see the previous article published?
☐ A national/regional general type of newspaper e.g. USA Today, New York Times, etc.
☐ An entertainment and life style magazine e.g. Young Life, College Magazine, etc.
☐ A popular scientific interest magazine e.g. Science Daily, Popular Science, etc.
☐ An academic scientific journal e.g. Science, Applied Psychology, Journal of Linguistics, etc.
☐ Others

You select "Others" in last question for appropriate media types to publish, please specify
_____

Please select your sex:
(Male, Female)

What is your age?
_____

What is your year in college?
(Freshman, Sophomore, Junior, Senior, Graduated or graduate level)

What is your primary college major?
_____

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* This question only appeared when participants correctly answered the previous question.
Answers to this question were not used when creating the science literacy measure.
** Answer of these questions are collected but not used due to low reliability toward perceived
scientific value

APPENDIX B

STIMULI ARTICLES

Article 1 with Graphical Cues:

Study finds social networks promote cooperation, discourage selfishness

It turns out nice guys can finish first.

A new paper found that dynamic, complex social networks encourage their members to be friendlier and more cooperative, with the possible payoff coming in an expanded social sphere, while selfish behavior can lead to an individual being shunned from the group and left – literally – on their own.

This research is among the first such studies to examine social interaction as a fluid, ever-changing process. Previous studies of complex social networks largely used static snapshots of the groups to examine how members were or were not connected. This new approach is the closest researchers have yet come to describing the way the planet's 6 billion inhabitants interact on a daily basis.
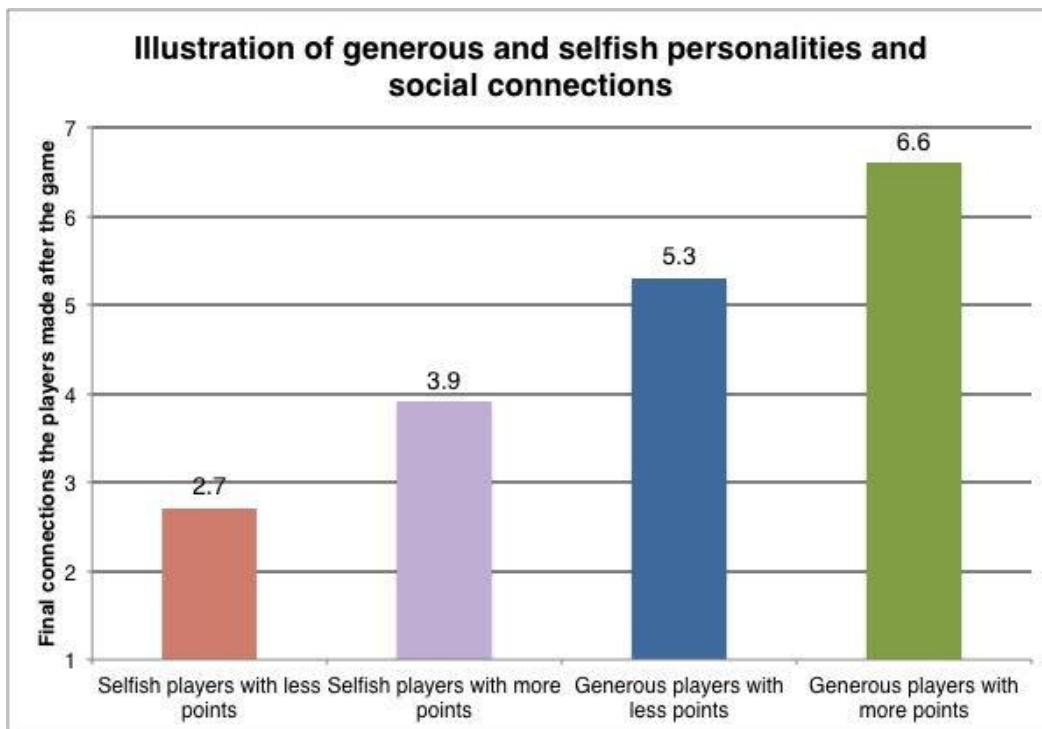

Figure B1 Article 1 Stimuli Graph 1

"What we are showing is the importance of the dynamic, flexible nature of real-world social networks," researcher said. "Social networks are always shifting, and they're not shifting in random ways.

"Although people sometimes do nasty things to each other, for the most part we are fantastically cooperative," Researcher said. "We do an amazing job of having thousands or even millions of people living in very close quarters in cities all over the world. In a functioning society, things like trade, friendship, even democracy itself require high levels of cooperation, and when everyone does it, you get good collective outcomes."

"Cooperation is a fascinating topic," Sociology and Medicine Professor and Pforzheimer House master Nicholas Christakis said. "We see cooperation everywhere in the biological and social worlds, but it's actually very hard to explain. Why do creatures, including ourselves, cooperate?

"What our paper shows is that there is a deep relationship between cooperation and social networks. In particular, we found that if you allow people to re-wire their social networks, cooperation is sustained in the population. I believe this paper is the first to show, empirically, how that relationship works. As humans, we do two very special things: we re-shape the social world around us, and in so doing, we create a better place for ourselves by being nice to each other."

To demonstrate how groups reach those good collective outcomes, the researchers recruited nearly 800 volunteers, who, in groups of between 20 and 30 people, took part in the study by playing a simple game.

At the outset, each player begins with an equal number of points, and is randomly connected with one or more players. As the game progresses, players have the opportunity to be either generous, and pay to give points to each player they are connected with, or be selfish, and do nothing. Following each round, some players are randomly given the opportunity to update their connections, based on whether other players have been generous or selfish.

The findings showed that players re-wired their social networks in intriguing ways that helped both themselves and the group they were in. They were more willing to make new connections or maintain existing connections with those who acted generously, and break connections with those who behaved selfishly.

"Because people have control over who they are interacting with, people are more likely to form connections with people who are cooperative, and much more likely to break those links with people who are not," researcher said. "Basically, what it boils down to is that you'd better be a nice guy, or else you're going to get cut off."

Intriguingly, the study also uncovered a correction mechanism inherent to social groups. Those who were initially non-cooperative, Researcher said, were found to be twice as likely to become cooperative after being shunned, suggesting that being cut off from the group acts as a sort of internal discipline, ensuring that cooperation remains high within a social network.
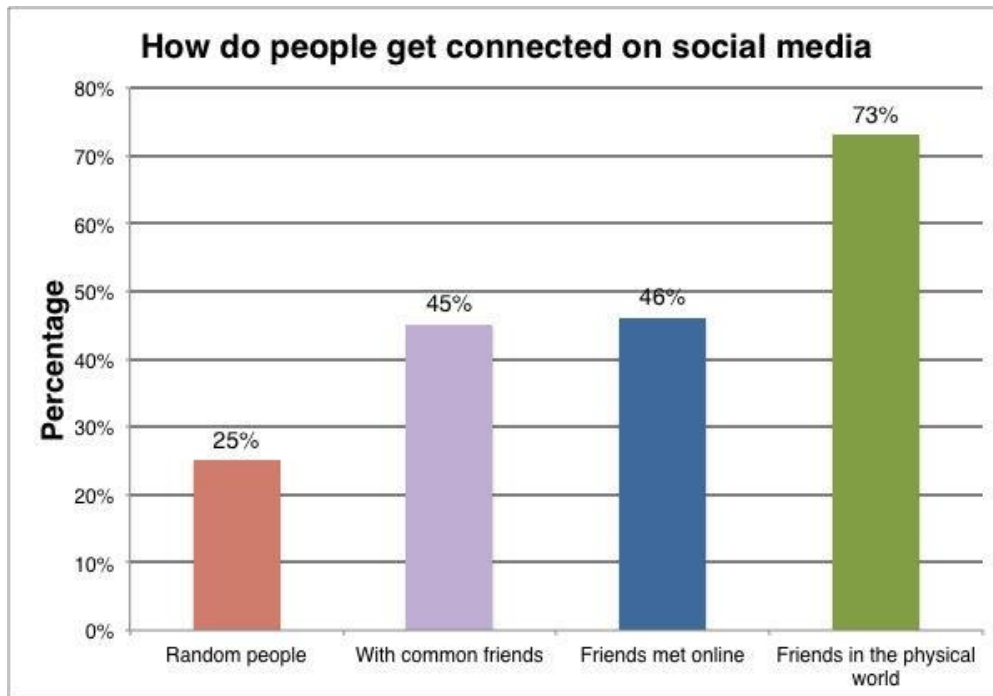

Figure B2 Article 1 Stimuli Graph 2

"As a result, when you have a network that's dynamic, you see stable, high levels of cooperation, whereas in networks where people have no choice about who to interact with, you see a steady breakdown of cooperation," Researcher said.

Article 2 with Graphical Cues:

American Marriages Are Much Better — and Much Worse — Than Ever

When your partner is your best friend — someone who really gets you, you know? — it's a wonderful thing. And yet thinking of marriage as the ultimate BFF-ship potentially comes with its own set of problems, setting some lofty expectations for the relationship. It often means that this is the one person to whom you look to meet your deepest psychological and personal growth requirements.

 When it works, it's bliss. But according to the conductors of a new research about marriage — it's also incredibly difficult to meet these huge and time-consuming demands, meaning the modern American marriage has the potential to be both much better and much worse than ever before. Because here's the twist: At the same time Americans are asking more out of their marriages than ever, they're also spending less time with their spouses.
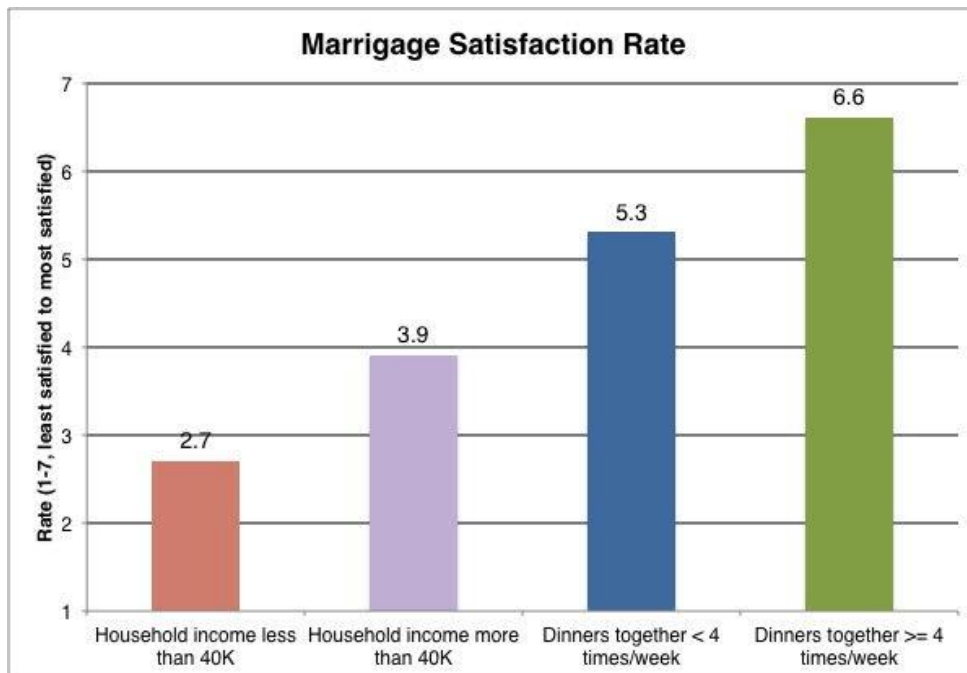

Figure B3 Article 2 Stimuli Graph 1

Modern American marriages are more strongly linked to psychological well-being — happiness, basically — than they were in decades past, according to a review of 93 studies from 1980 to 2005, and the authors on this current paper, believe they know why. Basically, they think Americans have begun understanding their marriages in a different, historically unusual way than they used to.

Today, in the opinion of the authors', it's a "self-expressive era" of marriage, in which Americans look to the institution "to fulfill needs like self-esteem, self-expression and personal growth."

As we have increasingly come to look to our marriages to help us achieve our deepest psychological needs—rather than helping us harvest crops or even just loving us, for example—we need much stronger communication and responsiveness than ever before. More and more marriages are struggling to achieve those lofty standards, especially on top of all of the other stresses in our lives.

However, those of us who succeed in building a marriage that can meet our deepest psychological needs—a marriage that helps us become closer to our ideal self—are immensely satisfying. That is, achieving a successful marriage today is tougher than in the past, while at the same time the payoff for such achievement is larger than in the past.

This problem is likely exacerbated for lower-income couples, who likely have less time or money to devote to the kind of quality time needed to meet today's marriage expectations than their wealthier counterparts. But the research shows that lower-income couples still very much want the same things out of marriage as higher-income spouses.

It's not hopeless, however. There are a few ways of improving marriage quality, none of which take huge amounts of time:

If you want to get nerdy about it, you guys can take on some writing exercises. The researchers cite a study that found couples who spent just 21 minutes a year writing about their conflicts through the eyes of an impartial third party saw improvements in their relationships over the following two years. It's not going to magically turn a dissatisfying relationship into a blissfully happy one, but it's a pretty simple way to give it a nudge.

Seek at least some of that self-actualization stuff elsewhere. Find a hobby, join a group, call your friends — shift at least some of that personal-growth burden off of your relationship. "Doing so can bring the demands on the marriage into closer alignment with the available resources," the authors write, "thereby reducing dissatisfaction from unmet expectations."
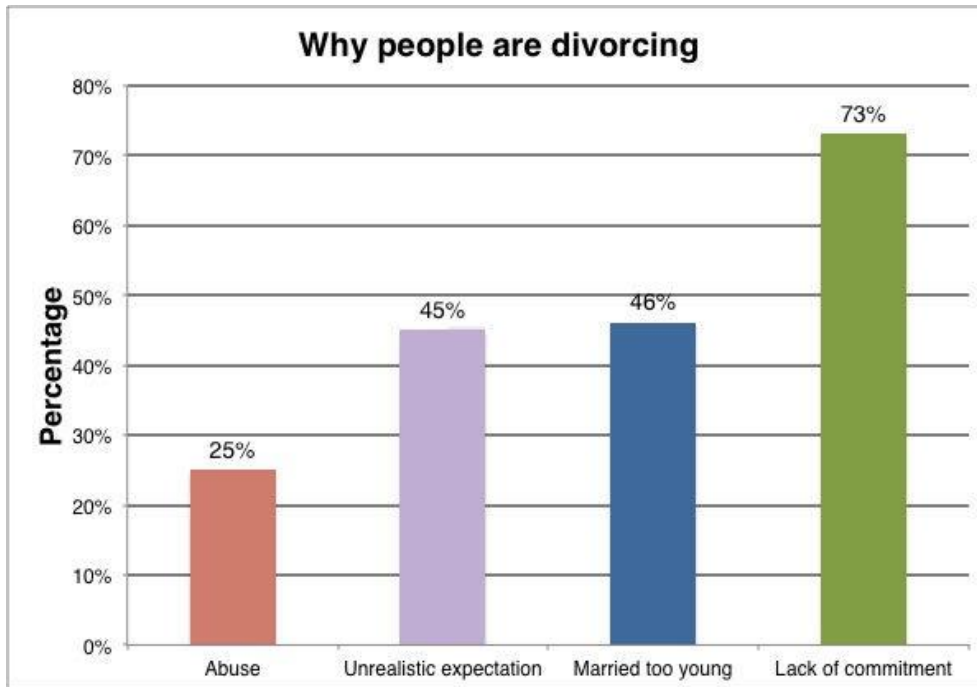
Figure B4 Article 2 Stimuli Graph 2

It's not impossible to have a successful marriage in this "self-expressive" era, but we're only just starting to learn how to do it. (Incidentally, he's currently writing a book on that very subject.) Finding a balance between sky-high expectations and the time people can realistically invest in their relationships seems like one way to start.

APPENDIX C

PARTICIPANTS' COLLEGE MAJOR FREQUENCY TABLE

Major	Frequency	Category
Business, Finance, Marketing and Management	70	Non-Science
Apparel Merchandising and Design	52	Non-Science
Public Relations	37	Non-Science
Event Management	35	Non-Science
Advertising	28	Non-Science
Journalism and Mass Communication; Communication Studies	28	Non-Science
Agriculture Related Major	14	Science
Undecided	11	Non-Science
Political Science	10	Non-Science
Psychology	7	Science
Engineering	7	Science
English and Education	5	Non-Science
Kinesiology	5	Science
Animal Science	4	Science
Biology	4	Science
Computer Science	4	Science
Family and Consumer Sciences Education and Studies	4	Non-Science
Criminal Justice	3	Non-Science
Economics	3	Non-Science
Architecture	2	Non-Science
History	2	Non-Science
Human sciences	2	Non-Science
General B.S.	1	Science
Liberal Studies	1	Non-Science
Chemistry	1	Science
Genetics	1	Science
Meteorology	1	Science
Nutritional Science	1	Science
Performing Arts	1	Non-Science
Pre-Dietetics	1	Science
Statistics	1	Science
Technical Communication	1	Science
Total	347	

APPENDIX D

IRB APPROVAL LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 3/31/2016

To: Jingru Sun   **CC:** Dr. Michael Dahlstrom
101 Hamilton Hall   215 Hamilton Hall

From: Office for Responsible Research

Title: Word and Visual Cues Effectiveness in Science Communication

IRB ID: 16-051

Study Review Date: 3/31/2016

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:
- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please be aware that **approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.**

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.