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Stoeklen, Phillip M. ***Irrational Beliefs and Support for Pseudoscience: The Role of Need for Cognition***

Abstract

Science denial, support for pseudoscience, and overall irrationality about the world are prominent social issues. This research examines whether the prevalence of these social issues is affected by the need for cognition personality trait. It was hypothesized that need for cognition is negatively correlated with irrational beliefs and support for pseudoscience and science denial, and that irrational beliefs and support for pseudoscience and science denial are positively correlated. Results indicated that individuals high in need for cognition were less likely to hold irrational beliefs, and less likely to support pseudoscience and science denial positions. However, no relationship was found to exist between irrational beliefs and support for pseudoscience and science denial. These findings suggest that additional personality traits other than need for cognition may be influencing whether individuals adopt irrational, pseudoscientific, or science denial positions.

Acknowledgments

Thank you, Dr. Sarah Wood, for your steadfast support and guidance throughout this research and my undergraduate and graduate studies. You have been an amazing research advisor and overall mentor, and I count myself lucky for having had the opportunity to both know and study under you.

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Chapter I: Literature Review

Irrational beliefs are not an uncommon thing to encounter in people, and they can consist of anything from simple unrealistic ideas about self-expectations, to a wholesale denial of complex and scientifically verified theory. The latter form of irrational beliefs is particularly problematic because there are real consequences to having an anti-science minded public, such as in the case of growing anti-vaccination sentiment. According to the Center for Disease Control and Prevention, Measles is one of the leading causes of death in children around the world, even though there has been an effective vaccine in existence since the mid-1960's (CDC, 2016). Although some of the reason for Measles ongoing global presence is because of lack of access to immunizations in developing countries, the anti-vaccination movement in the western world has caused a return of this dangerous disease to countries that it had been all-but-eradicated from. The current research examines the relationship that need for cognition has with irrational and pseudoscientific beliefs. The research is grounded in the literature on need for cognition and dual process theory of persuasion.

Dual-Process Theory of Persuasion

Dual-process theories of persuasion such as the Elaboration Likelihood Model (Petty & Cacioppo, 1986) and Heuristic Systematic Model (Chaiken, 1980; 1987) have been extensively researched since their introduction in the mid 1980's. Both models argue that persuasion can happen using one of two distinct processes. Petty and Cacioppo's (1986) elaboration likelihood model suggests that individuals process persuasive messages using what they call the central route or the peripheral route. The central route is employed when individuals engage in deep, effortful processing of message content. The central route has been demonstrated to be more common when the target of a persuasive message is either knowledgeable on, or has interest in

the topic being conveyed in the message (Katsuya, 2002; Petty & Cacioppo, 1983; Petty, Cacioppo, & Schumann, 1983). In other words, people who already know something about a topic or who are interested in the content of a message will be more likely to think carefully about it. This isn't simply because they are motivated to process messages that they are familiar with, but it also has to do with an individuals' ability to process the information (Carpenter & Boster, 2013). Ability is a non-trivial determinant of route selection, because people are more willing to engage in complex message processing when they are in fact familiar with the topic. Without the ability and motivation to process messages, it is more likely that the peripheral route will be utilized (Carpenter & Boster, 2013).

When individuals are not knowledgeable or interested they will rely on the peripheral route. The peripheral route is characterized by very shallow thinking and the use of so-called peripheral cues. Peripheral cues are signals to the target of a persuasive message that lead to message acceptance without much thinking. There are a variety of peripheral cues that have been shown to be effective under the right circumstances such as presence of a credible or trustworthy source (Zhou, 2012), presence of an attractive or likable source (Lee & Koo, 2016; Ziegler & Diehl, 2001), or merely providing a longer message (Petty & Cacioppo, 1986).

Peripheral cues. Research suggests source attractiveness (e.g., a source that is good looking) can influence attitudes, regardless of what the person being influenced might feel about the message being conveyed (Lee & Koo, 2016; Puckett, Petty, Cacioppo, & Fischer, 1983). Message elaboration is dependent on more factors than simple motivation or understanding of the topic. When motivation or understanding are not present, then it is often less likely that central route processing will take place. However, some peripheral cues that would otherwise be used in peripheral route processing can actually cause individuals to engage in central route

processing instead. This can be demonstrated when talking about peripheral cues such as source likeability, as Ziegler and Diehl (2001) found that cases of message scrutiny increased both when the message source was unlikeable, and when the source was likeable but not perceived as being an expert source.

Winter and Kramer (2012) examined factors associated with message processing as well, and found that when individuals are faced with controversial messages, they are much more likely to engage in careful message scrutiny when they believe they have arguments for and against the topic at their disposal. This indicates that individuals will evaluate controversial claims more carefully when they believe there is equal representation of positive and negative information. This might materialize in the real-world when people are presented with an argument for human-caused climate change. As this is a controversial topic, it would be most effective to engage the target people by presenting arguments for and against the topic and let them explore both sets of purported evidences. If individuals feel as though they are being presented arguments in a fair manner, they will be more likely to engage in effortful message processing.

Another factor regarding message processing has to do with source trustworthiness. In research that was conducted by Zhou (2012) to examine what factors contribute to individuals engaging in online banking technology. One of the main items raised as being a concern had to do with how much participants trusted the bank and its established system. It was found that trust develops through both the central and peripheral route of message processing, largely influenced by the individual's level of self-efficacy. Specifically, individuals that were high in self-efficacy relied on the central route to form trust perceptions, whereas individuals low in self-efficacy were more reliant on peripheral cues to form trust perceptions. The importance of trust

in persuasion is amplified when dealing with people that are not readily familiar with or interested in the topic being presented, and this phenomenon has been illustrated not only in the context of online banking (Zhou, 2012), but also in the context of attitudes toward nuclear power (Katsuya, 2002). Katsuya demonstrated that trust is a major consideration when individuals weigh whether to support something, especially when it is controversial (2002). The studies on online banking and nuclear attitudes have outlined important considerations in the task of persuasion, namely the level of motivation, interest, and knowledge that a target audience has on the topic being presented. These factors have been shown to have predictive power over whether individuals utilize a central route or peripheral route of information processing, and have also identified what specific factors are weighted as being important in decision making, such as whether quality arguments or trust in source credibility are valued more (Katsuya, 2002; Zhou, 2012).

Content knowledge has also been shown to have an entrenching capability, whereby individuals become more extreme in their positions when they are faced with controversial counter-arguments (Kardash & Scholes, 1996). For example, if an individual has been raised for years to think that climate change is nothing more than a liberal conspiracy, then they are much more likely to dig in their heels when confronted with a scientifically accepted argument and explanation of what climate change is and how it has been demonstrated extensively. The simple fact that the individual holds strong preexisting beliefs about something makes it much more difficult to change their mind.

This research suggests that there are both situational and individual difference effects that influence the method by which someone will be persuaded. On topics such as vaccination the public may have limited existing knowledge or interest, and therefore there may be an increased

reliance on peripheral processing. This is problematic because when important science and health related denial such as anti-vaccination messages are propagated, it is dangerous for the public to base decisions on simple peripheral cues like how attractive or famous the source of said message is.

Need for Cognition

Haugtvedt and Petty (1992) found that attitude change may be affected by personality factors. Specifically, need for cognition. Need for cognition refers to the extent to which individuals enjoy thinking, and it has been found that there is a positive relationship between need for cognition and an individuals' likelihood to engage in cognitively demanding tasks (Cacioppo, Petty, & Morris, 1983; Curseu, 2011; Petty & Cacioppo, 1986; See, Petty, & Evans, 2009). Cacioppo, Petty, Feinstein, and Jarvis (1996) referred to individuals that are high in need for cognition as being "chronic cognizers", and those low in need for cognition as being "chronic cognitive misers". Need for cognition is important because it suggests that some people may be naturally more inclined to use the central route. The implication of this is that an increased reliance on effortful message processing would, in theory, increase the likelihood that individuals arrive at accurate message conclusions. This means an increase in acceptance of quality messages, and a decrease in acceptance of low-quality messages. Additionally, it was found that high need for cognition individuals are more likely to maintain their attitudes when exposed to counter attitudinal messages. Curseu (2011) found that need for cognition is positively related to whether individuals are willing to seek out information or conduct searches for additional information. Individuals scoring high in need for cognition have also shown to be better at not only assessing the amount of cognitive effort that a given task requires, but are also better at

working through difficult tasks with others than their low need for cognition counterparts (Curseu, 2011; Reinhard & Dickhauser, 2009).

Need for cognition has been studied in many contexts, and findings suggest that not only are individuals that are high in need for cognition more accepting of scientific topics (Kudrna, Shore, & Wassenberg, 2015), but they are also more likely to utilize the central route of information processing (Mokhtari, Davarpanah, Dayyani, & Ahanchian, 2013), and are better at making adaptive decisions (Levin, Huneke, & Jasper, 2000) than their low need for cognition counterparts. Importantly, Mahoney and Kaufman (1997) found that individuals who scored high on need for cognition held fewer irrational beliefs, such as the belief that "one must be perfectly competent, adequate and achieving to consider oneself worthwhile". This finding suggested that need for cognition may be playing a vital role in one's ability to identify message and source quality, and therefore need for cognition demonstrated a predictive capacity for irrational beliefs. This research also demonstrated a connection between an individuals' need for cognition and their ability to recognize when their beliefs are in fact irrational. This again points to the effect that an individual's capacity to process information may be connected to attitudes and beliefs held.

The existing literature on need for cognition and dual-process theory of persuasion supports the idea that individuals who are low in need for cognition, are more reliant on the peripheral cues associated with persuasive messages. In some of the situations, the peripheral cues (e.g., source expertise) can lead to a positive outcome regarding accurate messages being taken as fact. For example, if a student takes an advanced mathematics course they may not initially understand the reason behind complex processes used to calculate an answer, but they nonetheless follow the instructors lead because they are perceived as an expert. In this case, a

positive outcome occurs due to peripheral cues, as the student follows along based on the expectation that the instructor is an expert, and so the complex processes may become easier to understand. However, it is often the case that a reliance on these cues causes individuals to adopt messages that are inaccurate or harmful. The U.S. political stage of the 2016 primary election provided Dr. Ben Carson, a retired neurosurgeon, the opportunity to campaign for the presidency. Being that Carson was a relatively unknown individual, people had to rely on what they did know about him: he was highly educated, and he was to all outward appearances a respected member of his field. It was however immediately made apparent that although Carson had made a career in the medical field, he was advocating for a series of strange beliefs that were not commonly accepted in the scientific community. Perhaps the most stunning of which was that he was a staunch opponent of evolutionary theory, the cornerstone of his field. The problem with this scenario is that public opinion surrounding topics like evolution was likely harmed because a scientist presented explicitly anti-scientific views.

The connections between need for cognition and personality traits, such as openness to experience, have been demonstrated to exist (Fleischauer et al., 2010; Sadowski & Cogburn 1997) For example, Feist (2012) using the Scientific Attitude Inventory-II (SAI-II) and the Big Five Inventory (BFI), found that both need for cognition and personality affected scientific interest and attitudes. Specifically, people high in need for cognition and openness to experience, were more interested in science. Other research has shown that need for cognition is strongly positively correlated with intelligence, and serves as a mediator between openness to experience and intelligence (Furnham & Thorne, 2013; Hill et al., 2013). In other words, the researchers also attempted to explain this relationship by pointing out that it may be the motivation to learn that bridges the gap between need for cognition and intelligence. This research not only reinforces

the presence of a positive relationship between need for cognition and interest in or favorable attitudes toward science, but also suggests the possibility of a relationship between need for cognition and interest in things that are not scientific.

Irrational beliefs. Prominent psychologist Albert Ellis described beliefs that are false and rationally unsupported as being irrational (Ellis, 1962). For this research, irrational beliefs will be defined as strongly held attitudes, beliefs, and values of individuals, even though objective contradictory evidence exists and is generally well known and understood. Irrational beliefs about the world vary widely. For example, it would be irrational for an individual to think that they are never going to make a mistake, or to think that they are a worthless person if everyone doesn't like them.

Research that was conducted by Lewandowsky, Oberauer, and Gignac (2013) provided insights into a specific form of irrational beliefs - science denial. The researchers concluded that scientific topics that are viewed as controversial (e.g., climate change) are at an increased risk of being denied by individuals that hold irrational beliefs such as conspiracy theories. This indicates that a positive relationship exists between irrational beliefs and denial of controversial scientific topics. Research conducted by Samar, Walton, and McDermut (2013) found that personality traits may account for not only the likelihood of an individual holding irrational beliefs, but also that some personality factors can be linked to specific types of beliefs. For example, the researchers found positive correlations between neuroticism and irrational beliefs about self-worth. Irrational beliefs in this sense are important to consider because they demonstrate that a great many types of irrational beliefs exist, and that they aren't simply limited to beliefs about the world or beliefs about science.

Lobato, Mendoza, Sims, and Chin (2014) aptly described unsubstantiated claims regarding pseudoscience, the paranormal, and conspiracy theories as being 'epistemically unwarranted beliefs' (p. 2). Essentially, they are beliefs that are not supported by existing evidence. This brief definition for pseudoscience and science-denial beliefs will be used in the current research, as it captures what is meant when referring to these belief types. It may be that these beliefs are spread because of the qualities of their source (i.e. peripheral cues), and one such quality could simply be perception of expertise. For example, a British physician by the name of Andrew Wakefield published an article (see Wakefield et al., 1998) claiming that there was a causal link between the MMR vaccine, and developmental disorders such as autism in children. This claim was subjected to almost a decade of empirical research. Not only was no causal link between vaccines and autism found, it was also discovered that Wakefield et al. had fabricated evidence, breached ethical boundaries by failing to fully disclose the full nature of the research that was conducted on children, and had also failed to disclose his connection to anti-vaccination funding sources (Sathyanarayana Rao & Andrade, 2011). The publication was eventually fully retracted, and Wakefield was permanently banned from practicing medicine in the United Kingdom. However, because the anti-vaccination message had the better part of 10 years to spread after the initial claim, it remains a problem for global vaccination efforts. In addition to harm done by this claim in terms of anti-vaccination sentiment, it also spread an ignorant idea about what causes disorders like autism.

Impey, Buxner, and Antonellis (2012) examined non-scientific beliefs in an undergraduate student population across 20 years and found that these beliefs are quite common in a seemingly well-educated population. For example, more than 30% of students indicated a belief in the idea that planetary positions influence everyday life on earth (i.e. astrology). The

researchers suggested that at least some of these numbers might be inflated due to confusion of terms, as astrology and astronomy were widely reported as being confused with one another. This confusion causes pseudoscience to gain a foothold as being considered scientific without actually engaging in the scientific process.

Knowledge, interest, and support. The research findings of Katsuya (2002) regarding how individuals form attitudes toward or against nuclear power, illustrated an important consideration in attitude formation. The researchers demonstrated that an individuals' preexisting knowledge and interest in a controversial topic (i.e., nuclear power), affects how willing they are to be open-minded when weighing the options. Results of data analysis revealed that when a person has knowledge and interest in the topic of nuclear power, they are more likely to be swayed by compelling arguments. In other words, knowledge and interest in the controversial topic led to central route processing of the arguments.

Analysis found that individuals who were not interested or knowledgeable, were much less likely to be swayed by a complex analysis of efficiency and risk/benefits. Broadly speaking, these findings suggest something about how the motivation level of individuals affects how much they are willing to engage in complex analysis. The researchers identified that the unmotivated individuals were not concerned with or swayed by how persuasive the argument was presented, rather they focused on simple peripheral cues such as perceived competence of the energy companies and the government to effectively manage nuclear power. Both hypotheses were supported by the findings, and they serve to inform the research described herein.

Purpose of the Study

Altogether the literature on persuasion and need for cognition suggests that people will tend to avoid effortful processing of information that they don't already understand or have an

interest in, unless they enjoy deep thinking due to their disposition (Cacioppo, Petty, & Morris, 1983; Curseu, 2011; Petty & Cacioppo, 1986; See, Petty, & Evans, 2009). These tendencies could help explain how people develop and maintain irrational and pseudoscientific beliefs. The current research is built upon the existing literature that suggests that need for cognition is connected to irrational beliefs in some way. It was hypothesized that need for cognition is an important variable that affects whether individuals hold general irrational beliefs, and that the presence of these general irrational beliefs affects whether individuals are willing to support pseudoscientific beliefs. The existing literature suggests that need for cognition plays a significant role in message scrutiny and evaluation, and that individuals that are low in need for cognition are at risk of accepting messages that are not accurate or valid. The current literature on dual-processes of persuasion has gone into great depth regarding how individuals process messages, and what cues are most salient and effective during persuasive tactics. However, little is known regarding the mixed processes that predispose individuals to believing low-veracity or irrational things. The current study will explore the relationship between need for cognition, irrational beliefs, and pseudoscientific beliefs.

This research examined the factors that influence whether an individual supports pseudoscientific ideas. To address participant motivation levels, the need for cognition scale was utilized to determine how much individuals enjoy engaging in complex thought. The need for cognition scale results helped in determining whether a critical evaluation of the message or argument occurs, and whether individuals develop pro or anti positions as a result. Much of the existing literature examined these processes from the perspective of climate science and evolution deniers (Kudrna, et al., 2015; Lewandowsky, et al., 2013; & Lewandowsky et al., 2015). These research examples built upon the idea that there is a connection between irrational

beliefs, whether it be beliefs about conspiracies or pseudoscience, and the denial of science. Thus, the following is hypothesized:

Hypothesis 1a: Need for cognition will be negatively correlated with irrational beliefs.

Hypothesis 1b: Need for cognition will be negatively correlated with pseudoscientific beliefs.

Hypothesis 2: Irrational beliefs will be positively correlated with pseudoscientific beliefs.

Chapter II: Methodology

The design used for this research made it possible to conduct comparisons between participants belonging to separate groups. Specifically, participants belonging to different academic programs. Further, correlational analyses were used to determine whether the constructs of need for cognition, irrational beliefs, and knowledge, interest, and support for pseudoscience were related.

Participants

Participants were recruited via email, which was made possible with the aid of the University's Planning Office through their student distribution lists. No specific populations were targeted in this distribution list, and the only parameter that was asked of the Planning Office is that they generate a list with 1,100 individuals. The only thing that participants needed to participate in this research was a computer with internet connection.

Measures

The survey tool utilized in this research incorporated three distinct measures. Validated measures of both need for cognition and irrational belief, as well as a novel measure of knowledge, interest and support for scientific topics. General demographics were collected as well, to establish comparison groups based on respondent academic programs of study.

Need for cognition. Participant need for cognition was measured using the 18-item Need for Cognition Scale (Cacioppo, Petty, & Kao, 1984), which was adapted from the original 34-item Need for Cognition Scale (Cacioppo & Petty, 1982). The scale consists of items that are designed to measure how much respondents enjoy engaging in thought. An example item from the measure is "I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought." Rather than using the measures

original 9-point Likert scale (-4 = *very strong disagreement* to 4 = *very strong agreement*), a modified scale (1 = *strongly disagree* to 4 = *strongly agree*) was used to create response anchor consistency across the entire survey. Recent research conducted by Furnham and Thorne (2013) into Need for Cognition and personality traits, found a Cronbach's alpha of .91. To see a full listing of the items utilized, refer to Appendix A.

General irrational beliefs. Non-specific irrational beliefs will be assessed with the 50-item Irrational Beliefs Inventory (IBI) (Koopmans, Sanderman, Timmerman, & Emmelkamp, 1994). This measure will be used to help understand how respondents might hold irrational beliefs across more general domains of life, and not just areas that are considered controversial. An example item from the measure is "One should blame oneself severely for all mistakes and wrongdoings." The items are rated on a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). Psychometric research conducted by Woodward, Carless, and Findlay (2001) found that the IBI was reasonably reliable, with a Cronbach's Alpha =.81. In addition to the 50-item IBI, six items from the Beliefs Scale (Lobato, et al., 2014) will be added to measure irrational beliefs. To see a full listing of the items utilized, see Appendix B.

Knowledge, interest, and support. The topics utilized in the knowledge, interest, and support (KIS) measure were selected to accommodate a wide-variety of potential pseudoscientific beliefs in the student sample. Items regarding existing attitudes and beliefs will be asked to determine respondents' level of knowledge, interest, and support for a series of controversial, pseudoscientific and anti-scientific topics. The topics that respondents are rating knowledge, interest level, and support for include: astrology, vaccines, evolution, and anthropogenic climate change. An example item from the measure is "All life on Earth has come about by evolutionary processes over millions of years." The items are rated on a 4-point

Likert scale (1 = *strongly disagree* to 4 = *strongly agree*). The topics targeted with this measure were chosen after an extensive literature search to determine which supposed anti-scientific and pseudoscientific beliefs have been recognized by the scientific community as invalid and unsupported by evidence. It was only after empirical research demonstrated extensively that the respective topic was designated as being anti-scientific and pseudoscientific. The concepts that will be used for this research, include: anti-genetically modified organisms, anti-vaccination, anti-evolution, and anti-anthropogenic climate change. See Appendix C for a full list of the items utilized to measure knowledge, interest, and support for science. For further justification of pseudoscientific and anti-science topic designation, refer to Appendix D.

Procedure

With the aid of the University Planning Office, individuals were contacted through their university email to participate in this research. The participants were asked to complete a survey via Qualtrics, and all the participants viewed the survey measures in the same order. The 18-item Need for Cognition Scale was the first measure that respondents completed. Upon completion of the Need for Cognition Scale, participants were asked to complete the 56-item modified Irrational Beliefs Inventory measure to ascertain potential irrationality that the respondent possesses across general domains. Finally, respondents were prompted to complete the 24-items regarding their knowledge, interest, and support for the different scientific and pseudoscientific topics (e.g. vaccines, astrology, etc.). Once the participant completed the Need for Cognition Scale, IBI, and the knowledge, interest, and support questions, they were thanked for their participation and released. Researchers engaged participants with follow-up and reminder emails throughout the process, to bolster response rate.

Chapter III: Results

A total of 150 individuals began the survey, but only 109 of the respondents completed the measure. Respondent ages were collected (M = 25) as a part of the demographics portion of the survey. Additionally, respondent class standing was as follows: freshman (n = 24); sophomore (n = 27); junior (n = 22); and senior (n = 32). Four individuals declined to indicate their class standing. Respondents also indicated their academic program, which was coded into one of the following three categories: natural science and mathematics (n = 26); social science (n = 26); and non-science (n = 51). Six individuals declined to indicate their academic program.

Reliability Analysis

A reliability analysis was conducted on each of the three developed measures used (i.e., support for science, interest in science, and knowledge about science) to determine whether the items utilized in each scale were effectively measuring their respective constructs. The reliability analysis found that the support for science measure had an initial alpha level (α = .61), however, after removing the item "I think parents should have the right to choose whether to vaccinate their children" the alpha level increased (α = .78). The reliability analysis of knowledge about science items found an alpha level (α = .71), however, after removing the item "Vaccines cause autism to develop in children" the alpha level increased (α = .82). The interest in science items were found to have an acceptable alpha level (α = .88), so no items were removed from that measure.

ANOVA Analysis

Composite scores of each of the measures were created. The majors were coded into three categories: natural science and mathematics (e.g., applied science, applied mathematics and computer science), social science (e.g., psychology, applied social science), and non-science

(e.g., studio art, interior design). One-way ANOVA's were conducted to determine whether there were any differences between the major classifications, in terms of composite scores.

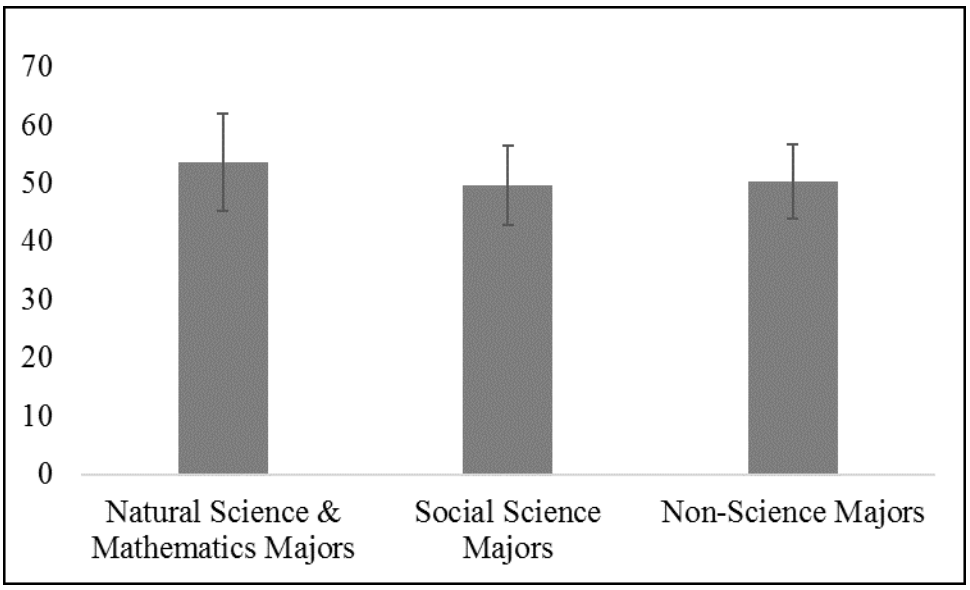

Figure 1. ANOVA: Differences in NFC by coded major. Scores ranged from 18 to 72.

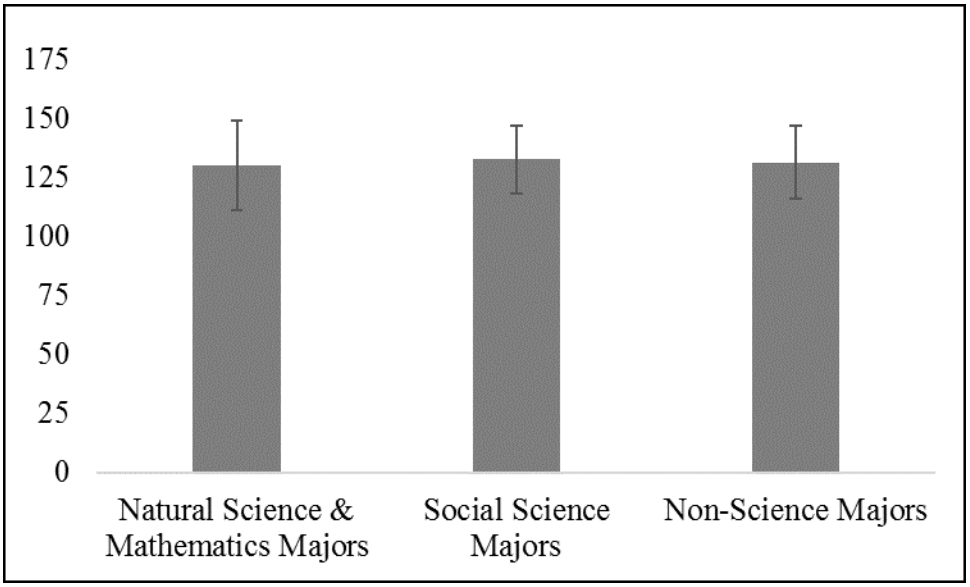

Figure 2. ANOVA: Differences in irrational beliefs by coded major. Scores ranged from 56 to 185.

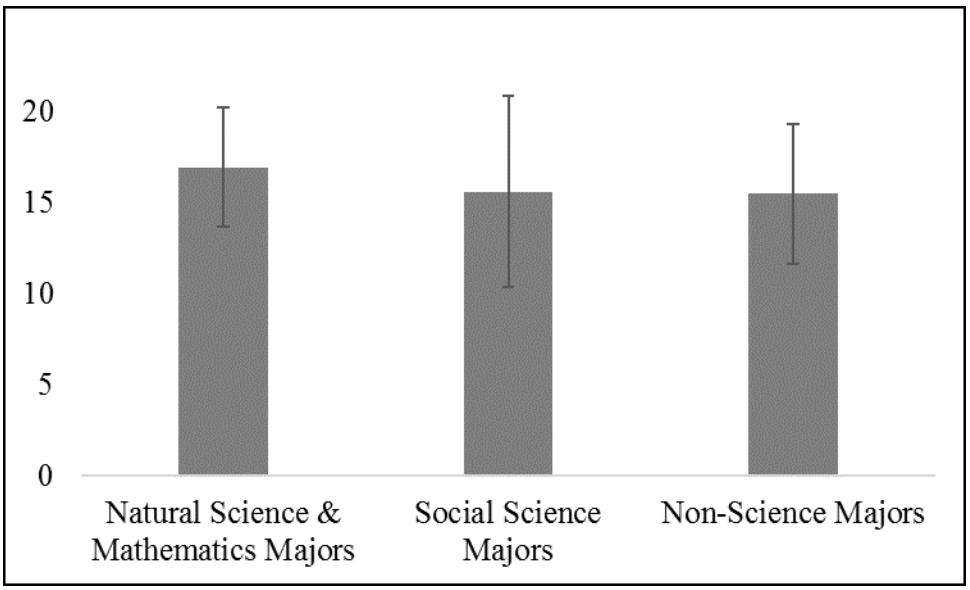

Figure 3. ANOVA: Differences in interest in science by coded major. Scores ranged from 6 to 24.

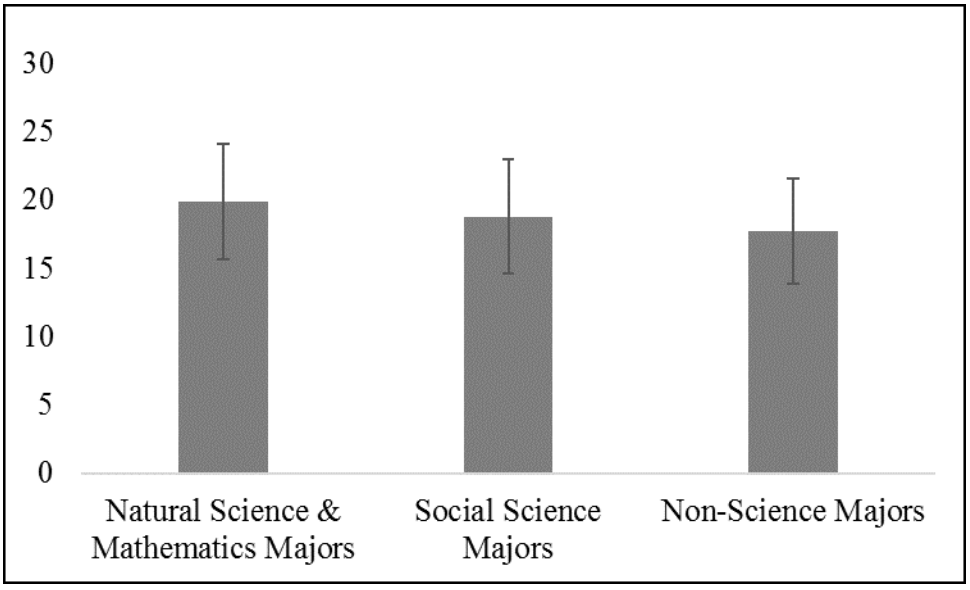

Figure 4. ANOVA: Differences in support for science by coded major. Scores ranged from 8 to 32.

The One-Way ANOVA did however reveal a slight difference between major program of study and knowledge about science, F (2, 100) = 3.67, p = .029. Respondents in the Natural Science and Mathematics majors (M = 28.19, SD = 5.56) knew only slightly more about science

than the Social Science majors (M = 26.08, SD = 4.77) and Non-Science Majors (M = 25.04, SD = 4.45). Post-hoc Bonferroni tests suggest only the difference between Natural Science and Mathematics and Non-Science Majors is significant, p = .024.

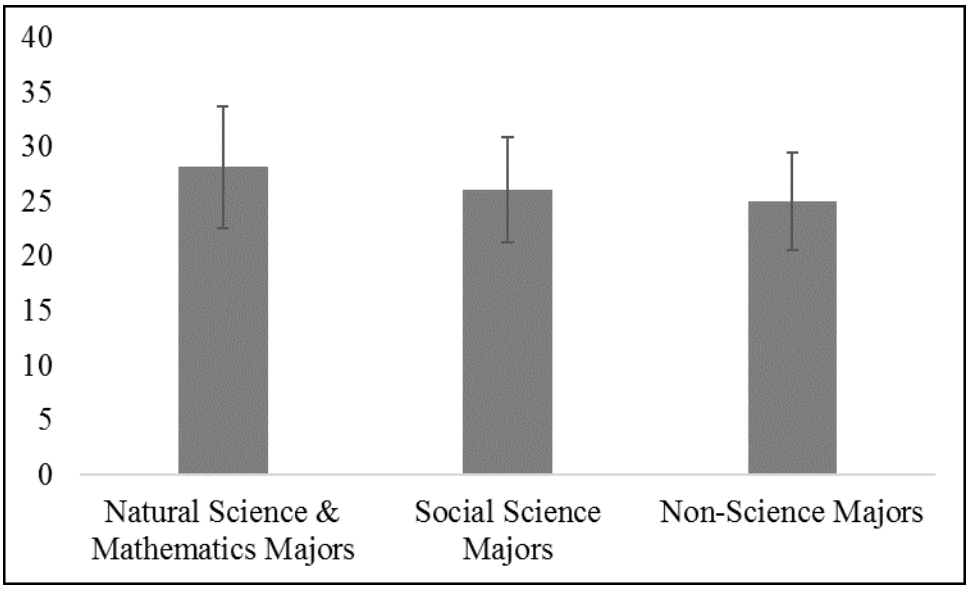

Figure 5. ANOVA: Differences in knowledge about science by coded major. Scores ranged from 10 to 40.

Correlational analyses were used to test Hypotheses 1A, 1B, and 2. Need for cognition and irrational beliefs were found to be negatively correlated, r = -.29, p < .01, affirming Hypotheses 1A. Need for cognition and interest in science are positively correlated, r = .39, p < .01; Need for cognition and support for science are positively correlated, r = .39, p < .01; and need for cognition and knowledge about science are positively correlated, r = .25, p < .05. As a positive score in interest, support and knowledge about science is indicative of low support for pseudoscientific items in the measure, hypothesis 1B is affirmed. Hypothesis 2 was not supported, as nonsignificant correlations (p < .05) were found between irrational beliefs and knowledge, interest, and support for science. Refer to table 1 for a visual of the correlational results.

Table 1

Correlations, Means, and Standard Deviations of Measure Composite Scores

Measure	Mean	SD	1	2	3	4
1. Need for Cognition	50.86	7.15				
2. Irrational Beliefs	131.56	16.11	-2.93**			
3. Interest in Science	15.78	4.19	.394**	-.148		
4. Support for Science	18.48	4.06	.385**	-.069	.508**	
5. Knowledge About Science	26.02	4.94	.248*	-.071	.486**	.824**

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Chapter IV: Discussion, Conclusion and Recommendation

This research seems to indicate that there is a connection between an individuals' willingness to engage in deep message processing, and the prevalence of irrational and science denial beliefs. An enjoyment of thinking may lead to more critical assessments of messages, and an increased subscription to outputs of the scientific process. Additionally, it appears that individuals who are drawn to the natural sciences may have an increased knowledge regarding accepted scientific concepts, however, educational background does not appear to significantly affect whether an individual will be interested or supportive of science.

Conclusions and Implications

The findings of this research provide evidence that there is a connection between personality traits, such as need for cognition, and the rationality of beliefs held by individuals. It was determined that individuals with high need for cognition were significantly less likely than their low need for cognition counterparts to hold irrational beliefs about the world, or to believe in pseudoscientific/science denial ideas. Although the negative relationship between need for cognition and irrational beliefs and support for pseudoscience/science denial is significant, there doesn't appear to be a significant relationship between whether a person has irrational beliefs about the world, and whether they are interested, supportive, and knowledgeable about science. This finding is relevant because it implies that people can be knowledgeable, supportive, and interested in science, while still being able to possess irrational beliefs. This indicates that there are potentially cognitive biases supplementing personality factors like need for cognition.

The results of this research also provide an opportunity to contemplate the consequences of certain beliefs and dispositions toward scientific inquiry. One such consequence may be that individuals are not aware of the faulty beliefs they hold, and because of factors such as need for

cognition, they may not be interested or open to thinking about their beliefs on a deeper level. When one thinks about low-stakes faulty beliefs (e.g., that astrology is useful) the social consequences are relatively trivial. For example, there may be an uptick in the number of zodiac charts completed. While this behavior is not sensible, it is also not directly harmful to anyone other than the individual taking the horoscope, who may only experience an increase in superstitious beliefs. However, the scenario changes when thinking about the consequences of high-stakes faulty beliefs (e.g., vaccines are harmful), as the social consequences become more palpable, and are anything but trivial. A belief in the idea that vaccines are harmful is an example of dangerous science denial beliefs, and the social cost isn't limited to increases in superstition, but an increase in unnecessary loss of life.

In examining how these ideas are propagated, it is important to consider the fact that the field of psychology has identified ways in which not only the audience of messages is susceptible to adopting harmful information, but also the ways in which the messenger is susceptible to believing their message is infallible. The Dunning-Kruger effect was first described by Kruger and Dunning (1999) as being a cognitive bias that occurs when incompetent people are unaware of how incompetent they are when it comes to carrying out a task, and are confident nonetheless. This bias also has a carryover effect in that incompetent individuals are not only unaware of their own competence level, but are also unaware of the competence level of others (Dunning, Johnson, Ehrlinger, & Kruger, 2003). These findings suggest that when individuals have faulty information they may be oblivious to the value of the truth when confronted with it. This indicates that although content knowledge often has the side-effect of increasing central processing of messages, it also can be a barrier to attitude change for individuals with strong preexisting beliefs about something. The Dunning-Kruger Effect is but

one example of potential message processing defects, but it helps illustrate the fact that the persistence of irrational beliefs and thinking is due to factors not fully understood yet.

Limitations

The primary limitation of this study has to do with the measures used. Specifically, the measures of knowledge, interest, and support for science. These items were all developed for this research, but validation research was not conducted prior to their use. Although the reliability analysis indicated that there is a satisfactory level of consistency for each of the items measuring their respective construct, it still would have been beneficial to either utilize an already validated measure, or to have conducted validation research on the measure used.

Future Directions

There next direction to take regarding this research would be to examine the interaction between an individuals' need for cognition and other personality factors, such as need for closure. Kudrna, et al. (2015) noted that a need for closure may play a significant role in whether individuals adopt either scientific or pseudoscientific views. It is suspected that resistance to some scientific research may be linked to the idea that science is not necessarily concerned with providing closure for people, and so individuals may either deny science or adopt faulty alternative explanations to achieve cognitive closure. Other personality traits that may be useful to examine further in this regard include tolerance for ambiguity and openness to experience. These two factors, along with need for closure, all are similar based on the idea that people want definitive answers, rather than the often hedged or nuanced answers provided by science.

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Appendix A: Need for Cognition Scale

Participants will be instructed to respond to the following items with agreement ratings. The responses are anchored on a 9-point Likert scale (-4 = *very strong disagreement* to 4 = *very 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 likely a 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.

(*) indicates that the item is reverse scored.

Appendix B: Modified Irrational Beliefs Inventory

Participants will be instructed to respond to the following items with agreement ratings. The responses are anchored on a 5-point Likert scale (1 = *strongly disagree* to 4 = *strongly agree*).

1. If I can't keep something from happening, I don't worry about it.
2. I worry a lot about certain things in the future.
3. Certain people are bad or wicked and should be severely punished for their sins.
4. People should observe moral laws more strictly than they do.
5. I want everyone to like me.
6. I often can't get my mind off some concern.
7. I tend to become terribly upset when things are not the way I would like them to be.
8. I am fairly easygoing about life.
9. Punishing oneself for all errors will prevent future mistakes.
10. I hardly ever think of such things as death or atomic war.
11. I avoid facing my problems.
12. A person won't stay angry or blue long, unless he keeps himself that way.
13. I usually try to avoid chores which I dislike doing.
14. Those who do wrong deserve to be blamed.
15. If a person wants to, he can be happy under almost any circumstances.
16. I tend to worry about possible accidents and disasters.
17. Nothing is upsetting in itself - only in the way you interpret it.
18. A large number of people are guilty of bad sexual conduct.
19. I often get exited or upset when things go wrong.
20. It is sinful to doubt the Bible.
21. I often worry about how people approve of and accept me.
22. Sometimes I can't get a fear off my mind.
23. I hate to fail at anything.
24. The fear of punishment helps people to be good.
25. I shrink from facing a crisis or difficulty.
26. I feel little anxiety over unexpected danger or future events.
27. If something is necessary, I do it even if it is unpleasant.
28. Frustrations upset me.
29. One should blame oneself severely for all mistakes and wrongdoings.
30. People are disturbed not by situations but by the view they take of them.
31. I usually put off important decisions.
32. I get terribly upset and miserable when things are not the way I like them to be.
33. More people should face up to the unpleasantness of life.
34. Helping others is the very basis of life.
35. There is a right way to do everything.
36. It is difficult for me to do unpleasant chores.
37. It is important to me that others approve of me.
38. Too many evil persons escape the punishment they deserve.
39. It is realistic to expect that there should be no incompatibility in marriage.

40. I often spend more time trying to think of ways of getting out of things than it would take me to do them.
41. Immorality should be strongly punished.
42. There is never any reason to remain sorrowful for very long.
43. What others think of you is most important.
44. One should rebel against doing unpleasant things, however necessary, if doing them is unpleasant.
45. I can't stand to take chances.
46. Man makes his own hell within himself.
47. I dislike responsibility.
48. Although I like approval, it's not a real need for me.
49. People who are miserable have usually made themselves that way.
50. I have considerable concern with what people are feeling about me.
51. Geological objects, such as certain crystals, precious metals, or magnets, have intrinsic mystical properties.
52. Condoms used properly during sexual intercourse are very effective at preventing the spread of sexually transmitted diseases and pregnancy.
53. Astrology is a valid explanation for the behaviors and personality of people.
54. Most human beings only use approximately 10% of their brain.
55. Homeopathic treatments are just as valid as traditional medical treatments for serious illnesses.
56. Certain objects, such as rabbits' feet and four-leafed clovers, genuinely bring good luck.

Appendix C: Knowledge, Interest, and Support Items

Knowledge

1. Genetically Modified Organisms (GMO's) are safe for human consumption.
2. GMO's are safe for the environment.
3. GMO's are a necessary component of the planet's available food.
4. The scientific community supports the safety of GMO's.
5. Vaccines are safe.
6. Vaccines cause autism to develop in children.
7. The scientific community supports the use of vaccines.
8. All life on earth has come about by evolutionary processes over millions of years.
9. The scientific community believes that human activity has caused climate change.
10. Climate change is a global threat.

Interest Items

1. I have read a lot about GMO's.
2. I have done a lot of research on vaccines.
3. I have read a lot about evolution.
4. Evolutionary science is a fascinating subject.
5. I am willing to talk about climate change with others.
6. I have done a lot of reading on climate change and its causes.

Support Items

1. I am in support of GMO production.
2. I am willing to recommend that others eat GMO's.
3. The general public is supportive of GMO's.
4. I think parents should have the right to choose whether or not to vaccinate their children.
5. Evolution is supported by evidence.
6. I am willing to tell people that evolution is a fact.
7. The public is supportive of evolution as a theory.
8. Evolution should be taught as fact in schools.

Appendix D: Pseudoscientific and Anti-Science Topics

Pseudoscientific Belief	Definition	Literature
Anti-Vaccination	**The belief that vaccinations are unnecessary and harmful, especially regarding children. Specific links between vaccines and developmental disorders such as autism are cited by this movement.**	• **Leask, J., Chapman, S., & Spring, C. C. R. (2010). "All manner of ills": The features of serious diseases attributed to vaccination. *Vaccine*, *28*, 3066-3070.** • **Taylor, L., Swerdfeger, A., & Eslick, G. (2014). Vaccines are not associated with autism: An evidence-based meta-analysis of case-control and cohort studies. *Vaccine*, *32*, 3623-3629.** • **Taylor, B., Miller, E., Paddy Farrington, C., Petropoulos, M. C., Favot-Mayaud, I., Li, J., & Waight, P. A. (1999). Autism and measles, mumps, and rubella vaccine: No epidemiological evidence for a causal association. *The Lancet*, *353*, 2026-2029.** • **Uno, Y., Uchiyama, T., Kurosawa, M., Aleksic, B., & Ozaki, N. (2015). Early exposure to the combined measles-mumps-rubella vaccine and thimerosal-containing vaccines and risk of autism spectrum disorder. *Vaccine*, *33*, 2511-2516.**
Anti-Evolution	**The belief that life has not come about by gradual changes.**	• **Killian, J. K., Buckley, T. R., Stewart, N., Munday, B. L., Jirtle, R. L. (2001). Marsupials and eutherians reunited: Genetic evidence for the theria hypothesis of mammalian evolution. *Mammalian Genome*, *12*, 513-517.** • **Gonder, M. K., Disotell, T. R., & Oates, J. F. (2006). New genetic evidence on the evolution of chimpancee populations and implications for technology. *International Journal of Primatology*, *27*(4), 1103-1127.**

		• **Milot, E., Mayer, F. M., Nussey, D. H. Boisvert, M., Pelletier, F., & Reale, D. (2011). Evidence for evolution in response to natural selection in a contemporary human population. *PNAS*, *108*(41), 17040-17045.**
Climate Change Denial	**The belief that anthropogenic climate change is a conspiracy invented by the liberal scientific community.**	• **Akhmat, G., Zaman, K., Shukui, T., & Sajjad, F. (2014). Does energy consumption contribute to climate change? Evidence from major regions of the world. Renewable and Sustainable Energy Reviews, 36, 123-134.** • **Dyurgerov, M. B., & Meier, M. F. (1999). Twentieth century climate change: Evidence from small glaciers. *PNAS*, *97*(4), 1406-1411.** • **Baum, S. D., Haqq-Misra, J. D., & Karmosky, C. (2012). Climate change: Evidence of human causes and arguments for emissions reduction. *Sci Eng Ethics*, *18*, 393-410.** • **Nott, J. & Price, D. (1999). Waterfalls, floods and climate change: Evidence from tropical Australia. *Earth and Planetary Science Letters*, *171*, 267-276.**
Anti- Genetically Modified Organisms	**The belief that genetically modified organisms pose a health risk.**	• ***Evidence for the anti-GMO movement as a form of pseudoscience appears to be based on the idea that non-evidence is used to support the movement (i.e., a lack of evidence that GMO's are completely safe is viewed as a testament to the danger they pose) *.**
Astrology	**The belief that the zodiac calendar and general position of the stars affect human traits and activities.**	• **Allum, N. (2011). What makes some people think astrology is scientific? *Science Communication*, *33*(3), 341-366.** • **Carlson, S. (1985). A double-blind test of astrology. *Nature*, *318*(5), 419-425.**

		• **Wyman, A. J. & Vyse, S. (2008). Science versus the stars: A double-blind test of the validity of the neo five-factor inventory and computer-generated astrological natal charts. *The Journal of General Psychology*, *135*(3), 287-300.**