TRUST ME, I HAVE A PHD: THE EFFECTS OF RELIGION, POLITICAL CONSERVATISM, AND EXPOSURE TO SCIENCE FEATURE STORIES ON TRUST IN SCIENCE

by

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Abstract

Widespread debates about scientific issues, from global warming to vaccinations, have raised questions about public trust in science and scientists. Many studies have attempted to determine the cause of observed declines in public trust. This project employs framing theory, suggesting that the way science frames research might improve public trust. Research questions explore whether political conservatism, public religiosity, and exposure to a feature story about a scientist affects trust in science and scientists. A between-subjects quasi-experiment exposed participants to feature articles about scientists in either controversial or non-controversial fields, and asked a series of questions in order to measure the participant's trust in science and scientists. Results indicated that participants who were male or participants who had some college education and who read the non-controversial feature story were statistically more likely to have a higher level of trust in science and scientists than any other group. Suggestions for future studies are discussed.

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Chapter 1 - Introduction

Widespread debates about scientific issues, from global warming to vaccinations, have challenged public trust in science and scientists (Kahn, 2009; Stemwedel, 2006; Haerlin & Parr, 1999; Nisbet, "In science we trust," 2001; Millstone & Van Zwanenberg, 2000; Rensberger, 2009; Briggs, 2004). Fiske and Dupree (2014) confirmed the decline in trust among Americans. Many studies have endeavored to determine the reasons for this deterioration (Gray, Shwom & Jordan, 2012; Whyte & Crease, 2009; Kempner, 2008; Granado, 2011; Gauchat, 2012; McIntosh White, 2012; Palmer, 2013). Researchers have explored politics (Gauchat, 2012; Kempner, 2008), journalism (Ramsey, 1999; Tsfati, 2004; Wilkie, 1996; Regules, 2014; Illman & Clark, 2008; McIntosh White, 2012; Fursich & Lester, 1996; Granado, 2011; Lasorsa & Lewis, 2010; Palmer, 2013), and religion (Campbell, 2005; Leshner, et al., 2009; Nadelson, et al., 2014) as themes that correlate with public lack of trust in science. Research finds that people who are religious or politically conservative are more likely to distrust science (Leshner, et al., 2009; Nadelson, et al., 2014; Gauchat, 2012; Kempner, 2008). Additionally, a variety of editorials and rhetorical studies have suggested negative portrayals of science in the media have impacted public trust in science (Perloff, 1998; Dornan, 1990; Rensberger, 2009; Fagin, 2005; Briggs, 2004). Other studies have examined journalism as a source of distrust. For example, the way journalism approaches explanations about the nature of science and scientific discovery in science coverage in the news (Kulkarni, 2013), journalists' perceptions of science audiences (Tsfati, 2004), the visibility of team science in the media (Illman & Clark, 2008), and the sources to which journalists refer (Granado, 2011; Wilkie, 1996; Ramsey, 1999).

Many researchers have begun to examine the ways to resolve this dearth of trust in science (Labov & Pope, 2008; Isabelle, 2000; Sharkawy, 2006; Fara, 2003). Science-education researchers have explored the use of storytelling about scientists and how those scientists made discoveries (Isabelle, 2000; Sharkawy, 2006). Rhetorical historians have suggested the use of images of the scientists historically increased the spread of those scientists' work (Fara, 2003). Researchers in communication have focused on the ways framing and storytelling can impact trust, through manipulation of the context of presentations of science, audience levels of elaboration, and the audience's involvement or transportation into a story (Nisbet, "Communicating climate change," 2009; Nisbet, "Framing science," 2009; Nisbet, Brossard & Kroepsch, 2003; Labov & Pope, 2008; Entman, 2007). New studies have attempted to create and validate a standardized method with which to measure an audience's level of trust in science and scientists outside of public polling (Nadelson, et al., 2014; Brossard & Shanahan, 2006).

Framing theory, often considered the second step in agenda-setting theory, explains the idea of *frames*, or the way the media presents an issue, which can influence that issue's definition, the symbols associated with the subject, and even the ultimate resolution of the issue (Entman, 2007). Framing has often been used in the past-tense, to demonstrate the way media has influenced policy decisions or public opinion (Entman, 2007). However, framing can also be used to demonstrate how different types of communication and message strategies can influence audience opinions (Entman, 2007).

The field of science communication has used framing to analyze the media's approach to nuclear power, stem-cell research, and climate change, among other topics. Nisbet (2009) discussed the way the intelligent design versus evolution debate was framed into a political controversy and determined that coverage deemphasized the technical and scientific aspects while focusing on things like funding and lending credence to the belief there was controversy within the scientific community when there was none. Similarly, global warming was reframed into climate change and covered using the conflict and strategy frame used by political reporters, which emphasizes who is winning, personalities that had become involved, and the strategies of the messages used (Nisbet, 2009). Labov and Pope (2008) reviewed the National Academy of Sciences' studies examining how audiences responded to different frames about teaching evolution in schools. The researchers presented prospective audience members with communications about evolution framed in different ways and found that framing evolution as a necessary point from which scientists could develop important medical advances was the most effective (Labov & Pope, 2008).

Current research has used framing to attempt to identify ways to impact an audience's level of trust (McIntosh White, 2012; Labov & Pope, 2008). In addition, many theorists have posited in editorials and speeches that scientists must be more willing to discuss their research and to interact with journalists and the media in order to improve audience perceptions of science (Rand, 1998; Fagin, 2005; Rensberger, 2009; Stemwedel, 2006; Haerlin & Parr, 1999). However, while research has examined the use of narrative in journalism and its impact on perceptions of science (Ramsey, 1999; Regules, 2014; Ebbers, 2002), this author found no research measuring the impact of feature stories about scientists on audience perceptions of science.

The purpose of this study was to determine whether feature stories about scientists impact audience trust in science, especially when that audience has high religiosity or political conservatism. In order to answer this question, this paper explores the literature on the decline in public trust in science and discusses framing theory as a possible lens through which to view the issue. Literature regarding variables such as scientific literacy, public religiosity, political conservatism, and public trust in science and scientists are examined. A between-subjects exploratory experiment was performed. Participants in this quasi-experiment were presented with one of three articles to read (Experiment group 1 read a feature story about a scientist studying an issue considered controversial in the United States; Experiment group 2 read a feature story about a scientist studying a non-controversial issue; and the Control group read a generic news feature story). Subjects were then asked a series of questions to determine their level of trust in science and scientists along with demographic information, levels of political conservatism, and public religiosity. Results indicated that participants who were male or participants who had some college education and who read the non-controversial feature story were statistically more likely to have a higher level of trust in science and scientists than any other group. The table below provides a preview of the next chapters:

Table 1.1 Preview of chapter contents

CHAPTER	CONTENTS
CHAPTER 2	Recent studies suggest the American public's trust in science is declining. Research has explored reasons for the decline, such as scientists' reluctance to speak to the media, and ways to mitigate the decline, such as the use of framing.
CHAPTER 3	During this quasi-experiment, ninety-four participants were contacted via email. Procedure is explained in-depth and justification for decisions are made.
CHAPTER 4	Results of the quasi-experiment show no significant difference among treatment groups and no interaction effects with religiosity or conservatism. However, gender and level of education showed some interaction effects with treatment groups on trust in science and scientists.
CHAPTER 5	Results of this exploratory study suggest that the trust level of certain groups may be impacted by exposure feature stories about a scientist studying an un-politicized topic. Implications for practitioners and academics are discussed.

Chapter 2 - Literature Review

Decline in Public Trust in Science

Recent debates about a variety of scientific topics, from global warming to vaccines, have paved the way for studies questioning whether the increase in public debates indicates the public's distrust of science in general (Fiske & Dupree, 2014; Leshner, et al., 2009). In 2009, one study suggested that trust in science had not declined, but the public perceived that scientific topics were less represented in the media than a decade before (Leshner, et al., 2009). Leshner, et al.'s (2009) study found that the American public was skeptical of the U.S. science's global standing; 17 percent of the public thought that U.S. science rates as the best in the world, while 49 percent of American scientists believed that scientific achievements ranked best in the world.

In 2014, Fiske and Dupree determined that the American public's distrust of science is on the rise. Fiske and Dupree (2014) examined online survey data that asked adults to rate the warmth/trustworthiness and competence/capability of several different American jobs; scientists were rated as well-respected, but untrustworthy.

Reasons for the Decline

Many studies have attempted to explore the reasons for a decline in trust in science. Politics (Gauchat, 2012; Kempner, 2008), religion (Campbell, 2005; Leshner, et al., 2009; Nadelson, et al., 2014), and science literacy (Miller, 1998; Deming, O'Donnell & Malone, 2012; Laugksch, 1999; Laugksch & Spargo, 1996) have all been correlated with an audience's distrust of science. Audience members who consider themselves more religious or politically conservative are less likely to trust science (Leshner, et al., 2009; Nadelson, et al., 2014; Gauchat, 2012; Kempner, 2008). Conway and Oreskes (2012) suggest that the historical relationship between conservatives and scientists, starting from the cold war and the development of policy restricting the use of natural resources, has created the tempestuous relationship that exists today. Kempner's (2008) research into the politicization of scientific issues suggested that an increase in political debates about a scientific issue leads to "the chilling effect," making it less likely for scientists to choose to study those issues. Research has also suggested that increased debates about an issue can influence the media's presentation of the issue. Debates about evolution taught in schools and global warming's existence are good examples of the influence politicization has on media presentation of issues (Nisbet, 2003; Nisbet, 2009).

Scientists' Reluctance to Interact with Media

Several scientists have spoken at conferences or written editorials suggesting that scientists need to interact more with the media in order to increase public trust in science and to provide adequate information to journalists about research (Rand, 1998; Fagin, 2005; Rensberger, 2009; Stemwedel, 2006; Haerlin & Parr, 1999). Palmer's (2013) research demonstrated that people who have been misquoted by journalists will mistrust journalists if the error is egregious. Scientists would find such an error especially difficult to handle because of professional stigma that could be associated with making the error. Granado (2011) examined science journalists' sources, discovering that about 95 percent of reporters surveyed utilized scientific journals and the Internet as primary sources for their articles. If the reporter does not fully understand the concept explained in the journal or refers to a flawed Internet source, his or her article could contain errors that could have been avoided by speaking directly with a scientist. Studies have also suggested that media portrayals of scientific issues have led to public distrust of science (Illman & Clark, 2008; Lasorsa & Lewis, 2010). McIntosh White's (2012) study suggested that scientific principles were inadequately represented in articles about the

MMR vaccine controversy. Lesher, et al. (2009) found that scientific achievements have become less prominent in the media. Illman and Clark's (2008) content analysis of news coverage regarding the National Science Foundation's Science and Technology Centers revealed that team science has decreased in visibility in the media and articles are unlikely to discuss science centers and research models.

Mitigating the Decline in Trust

Some studies have attempted to find methods to reverse the decline of public trust in science by examining potential reasons and suggesting solutions. Gray, Shwom, and Jordan's (2012) study suggested that natural resource science stakeholders' trust in scientific methods was not influenced by the health status of natural resources. Kulkarni (2013) suggested that, since science is no longer a universal term and different disciplines often do not overlap, science communication may need to be broken into smaller segments. Sharkowy (2006) examined the value of storytelling in teaching elementary students about science, emphasizing the use of stories about scientists and how they came to make discoveries in order to increase students' understanding and trust of science. The use of story to frame the science that was presented to students had both positive and negative impacts on children's trust of science: some children became more enthusiastic about science, and others decided they never wanted to become scientists (Sharkowy, 2006). Other studies have approached public distrust in science using the theory of framing (Labov & Pope, 2008; Nisbet, "Framing science," 2009; Entman & Rojecki, 1993; Nisbet, Brossard & Kroepsh, 2003; Entman, 2007; Nisbet, "Communicating climate change," 2009).

Framing Theory

Framing theory is often described as the second part of agenda-setting theory (Nisbet, “Framing science,” 2009). However, Scheufele (2009) argues that agenda-setting theory and framing theory are distinctly different. Scheufele (2009) suggests that agenda-setting emphasizes the salience of an issue to the audience while framing emphasizes the attribution of societal and environmental factors on an issue. Framing assumes that the public receives its information about issues from the media (Entman, 2007). Therefore, when the media chooses to convey information regarding a subject, the topic is brought to the attention of decision-makers, interest groups, and the public (Nisbet, “Framing science,” 2009). The way the media conveys the subject, called a *frame*, can influence that issue’s definition, the symbols associated with the subject, and even the ultimate resolution of the issue (Entman, 2007). Framing theory does not just pertain to the use of positive and negative frames; the theory describes the way a communicator approaches an issue overall (Entman, 2007). Political reporters typically use what is commonly referred to as a *conflict and strategy* frame, which pits two sides against each other and highlights the personalities, strategies, and win/loss ratios of a debate (Nisbet, “Communicating climate change,” 2009). When the issues of global warming and stem cell research became a topic of political concern, political news desks reframed the scientific topic into a more familiar (to them) *conflict and strategy* frame and shifted public focus to winning and losing sides and the personalities involved in the ensuing political debates (Nisbet, “Communicating climate change,” 2009; Nisbet, Brossard & Kroepsh, 2003). The use of narrative to communicate information is another frame which has received both positive (Sharkowy, 2006) and negative feedback (Nisbet, Brossard & Kroepsh, 2003).

Framing is often used to examine past media coverage of an issue (Entman & Rojecki, 1993; Nisbet, Brossard & Kroepsh, 2003; Entman, 2007; Nisbet, “Communicating climate change," 2009). While these studies are useful to help understand how frames have been used in the past and can inform research about the framing methods used for today's issues, they do not predict how an audience will react to any given frame. Science-communication researchers have begun to examine how an audience will react to a particular frame used for a specific scientific issue (Labov & Pope, 2008). In their study, Labov and Pope (2008) examined the National Academy of Sciences' use of focus groups to examine how the public reacts to certain frames. Using this information, the National Academy of Sciences created a pamphlet about evolution in schools, which has become the most widely used pamphlet on the subject (Labov & Pope, 2008).

Science Communication Framing

Framing theory has been used by science communicators to examine the methods of framing that have been used in science (Entman & Rojecki, 1993; Nisbet, Brossard & Kroepsh, 2003; Entman, 2007; Nisbet, "Communicating climate change," 2009). Nisbet (2009) suggested that increased debates about an issue can influence the media's presentation of the issue, as with evolution in schools and global warming. These issues were turned over to political reporters who reframed the issues to focus on the different personalities on either side of an issue, debate winners and losers, and message strategies (Nisbet, "Framing science," 2009). Nisbet, Brossard and Kroepsh (2003) found the same framing trends in media coverage of the stem cell controversy.

Framing has also been used to determine communication methods that would be most effective in conveying information about a controversial issue to the public (Labov & Pope, 2008). During Labov and Pope's (2008) study, researchers provided participants with evolution articles representing several different frames. They found audience members preferred messages about evolution theory's importance in developing new medical technologies and messages that conveyed teaching evolution did not conflict with many religions (Labov & Pope, 2008). While many scientists have formed the belief that the public's unwillingness to believe science has to do with a knowledge deficit, Nisbet (2009) suggests that lack of knowledge is not the primary reason for resistance ("Communicating climate change"). Instead, Nisbet (2009) suggests that science communication requires more persuasive framing and should be more of a "negotiation of meaning" about the topics at hand ("Framing science").

Variables of Interest

Several variables have been explored with regards to the public's declining trust in science and scientists: scientific literacy, religion, political conservatism, and public trust in science. The following sections explore the variables more deeply.

Scientific Literacy

Scientific literacy, as Laugksch (1998) stated in his conceptual overview, is a broad and difficult-to-define topic utilized by many fields of study including sociology, public-opinion research, and science education. It is a term that generally describes what the public should know about science (Laugksch, 1998). Measures are created depending on the purpose and scope of the research (Laugksch, 1998), as well as the perspective from which the measure has been created. Scientific literacy and education was, at one time, thought to be the major reason for public distrust in science (Nisbet, "Framing Science," 2009). This belief, called the deficit model (Nisbet, "Framing Science," 2009), has since been called into question as there is little research to support that level of education or scientific literacy is correlated to trust in science (Labov & Pope, 2008; Gauchat, 2012). As such, despite considerable attention in the literature, scientific literacy is not a variable in the current study.

Religiosity

Another variable that has been associated with distrust in science and scientists is religion (Nadelson, et al., 2014). According to a Pew study done in 2014, America is a highly religious nation; 83 percent of Americans profess a belief in God (Leshner, et al., 2009). Campbell (2005) reported that students at Canadian universities considered religion and science to be entities independent from one another. However, Gauchat (2012) reported that levels of trust in science amongst religious conservatives in the United States had declined over the past decade.

Gorsuch (1984) suggested that use of questionnaires to measure religiousness has been relatively successful, especially among studies in psychology, as long as the scales utilized recognize the dimensions of religiosity. Vernon (1962) created and verified two types of functional measures of religiosity – public and private. The instrument measuring private religiosity (also referred to as spirituality) asks participants to write 20 statements answering the question “Who am I?” (Nudelman, 1976). The responses are then coded to determine religiosity (Vernon, 1962). The public measure asks participants to rate the importance of religion in their day-to-day lives, as well as their feelings toward religion on semantic differential scales (Nudelman, 1976). For the purposes of this study, religiosity does not have to do with religious denomination, but rather with whether or not the participant considers him- or herself religious (Gauchat, 2012), so participants will respond to Vernon’s (1962) public measure of religiosity.

Political Conservatism

Politicization of science issues is another variable to consider when discussing trust in science. Gauchat’s (2012) article evaluated polling data from 1974 to 2010 and determined that participants who identified as conservative were the only group to become more and more distrustful of science over the period (Gauchat, 2012). Conway and Oreskes (2012) suggest that conservative political views, based in laissez-faire enterprise, often perceive environmentally-minded restrictions on businesses as threatening to a thriving economic environment. The researchers outline the history of the global warming debate and emphasize the conservative tendency to shy away from the development of policy limiting free enterprise and democracy (Conway & Oreskes, 2012). In developing their trust in science and scientists measure, Nadelson, et al. (2014) found that conservative participants and participants with higher religiosity had lower trust in science and scientists.

Measurement of political conservatism has frequently been accomplished using tools created as-needed for studies (Castles, 1984). The creation of an instrument often has to do with the specific aspects of political affiliations a researcher is hoping to emphasize. Castles (1984) developed a left-right political scale from a survey of political scientists in a variety of countries. This scale does not, however, measure conservatism in the United States so much as the differences between left-right party lines in different countries. Givoli, Hayn, and Natarajan (2007) examined a 1997 measure of conservatism in reporting that gauged the political conservatism of articles via a content analysis. The instrument most relevant to this study, however, is Ray's (1983) 22-item scale that measures individuals on a continuum of liberal to conservative and has been used in research to determine how personal political views affect a person's belief in policies (Pratto, Stallworth, & Conway-Lanz, 1998), to examine whether personal political views correlate with personality, temperament, and psychological maladjustment (Mehrabian, 1996), and to control for political conservatism in an experiment on the third-person effect on beliefs about censorship (Rojas, Shah, & Faber, 1996).

Public Trust in Science

As established in previous sections of this paper, public trust in science is on the decline. A study by Fiske and Dupree (2014) determined the American public respects scientists, but their distrust of scientists is on the rise. Many researchers have attempted to postulate ways to improve public trust in science. Wynne's (2006) rhetorical essay discusses how public engagement in science has the potential to increase the public's trust of science, while Fara's (2003) essay indicated that research done by scientists who distributed pictures of themselves to the public was more likely to spread to a wider public. Ebbers's (2002) essay explored a multidimensional view of science and outlined the educational uses of different genres of science trade literature to promote science literacy and inquiry among students. Rolin's (2002) essay explored the impact of gender on trust in science, suggesting that subtle forms of gender bias can create obstacles to inclusive and responsive scientific dialogue and undermine a community's trust in scientific testimony.

Polling the public has traditionally been the method used to collect data regarding the public's opinions of, and feelings toward, science (Nadelson, et al., 2014). In 2014, Nadelson, et al. created and validated an instrument to measure trust in science and scientists. To begin, the researchers examined the literature surrounding trust which defines the trust concept as a multi-faceted construct, based on both emotion and rational thought, which includes such components as credibility, epistemology, and trustworthiness (Nadelson, et al., 2014). The researchers then created and validated a tool to measure college students' trust in science and scientists: The Trust in Science and Scientist Inventory is a 21-item instrument which focuses on science as a whole, as opposed to certain domains of science, and is meant only to measure general trust in science and scientists (Nadelson, et al., 2014).

Summary

Considerable research addresses the decline of the U.S. public's trust in science and seeks to mitigate the decline. Research has explored the use of frames to determine whether the media's approach to stories can impact audience perspectives on an issue. Additional research has examined the audience and the variables which can impact its trust in science and scientists, such as scientific literacy. Two variables have emerged as relevant to the current study, which seeks to determine if reading feature stories affects an individual's trust in science: public religiosity and political conservatism. Therefore, this study asks the following research questions:

Research Questions

RQ_1: Will exposure to feature stories about scientists improve audience trust in science and scientists?

RQ_2: Does audience level of religiosity impact the effects of exposure to feature stories about scientists on audience trust in science and scientists?

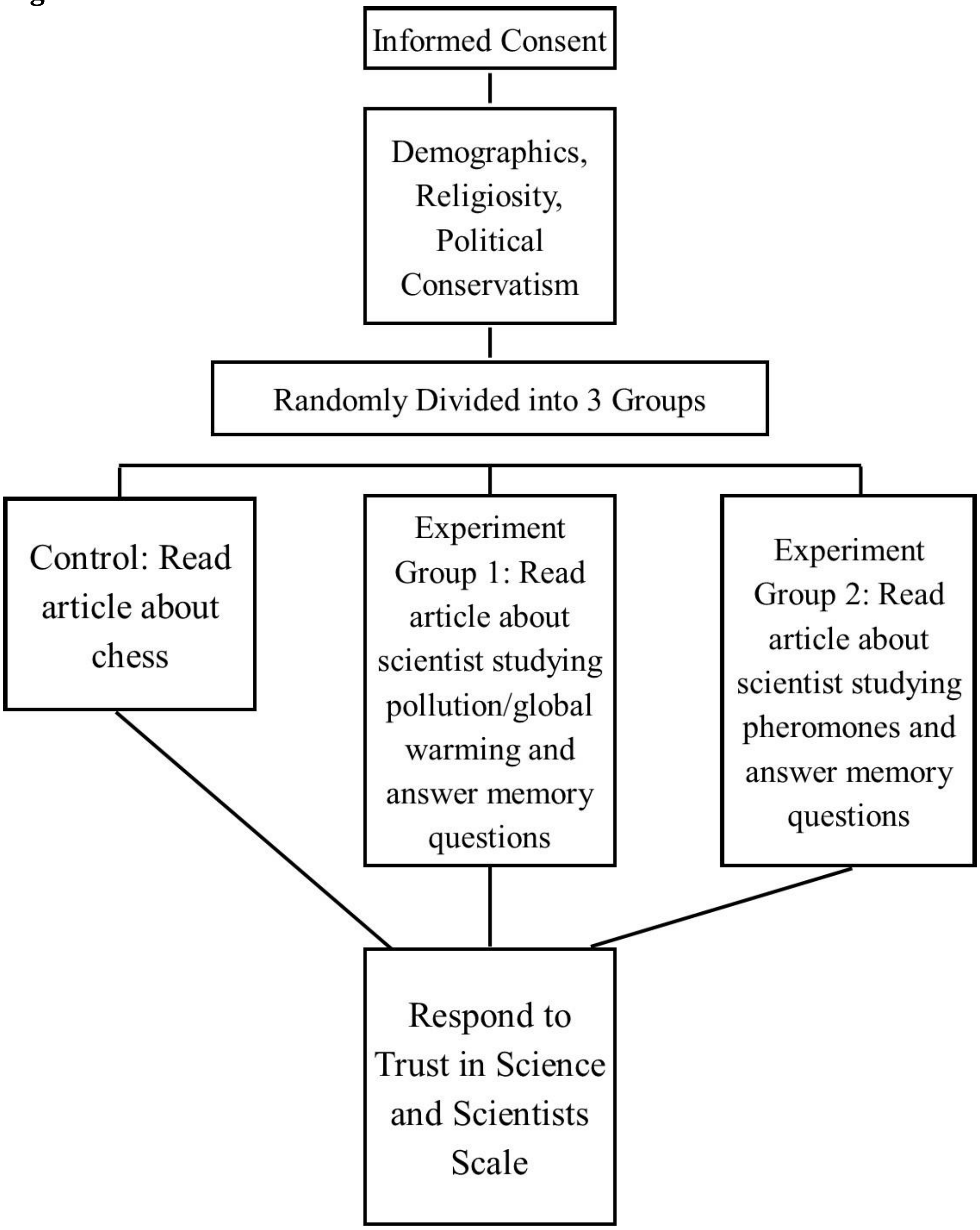
RQ_3: Does audience level of political conservatism impact the effects of exposure to feature stories about scientists on audience trust in science and scientists?

RQ_4: Does the level of controversy of the scientific topic of a feature story impact the effects of exposure to feature stories about scientists on audience trust in science and scientists?

Chapter 3 - Materials and Methods

The purpose of this study was to explore whether reading a feature story about a scientist could impact the audience's level of trust in science and scientists. The study was approved by Kansas State University's IRB (IRB #7595). Ninety-four participants between the ages of 18 and 65 (59% female, 49% male) were contacted via email through a third party service (Qualtrics's Panel Service, which compensates participants for their time aiding survey-based research). The method of contact was chosen to reach a wider variety of individuals to represent the greater American-born public and to prevent confounding variables that could arise from choosing participants from a single university. A quasi-experimental design was deemed appropriate in order to examine an affect. After agreeing to participate (Appendix A), subjects answered demographic questions including scales measuring public religiosity (Appendix B) and political conservatism (Appendix C). Participants were then randomly divided into one of three groups: subjects in the control group read a generic news feature story (Appendix D); subjects in experiment group 1 read a feature story about a scientist studying a subject considered highly politicized or controversial in the United States (Appendix E); and subjects in experiment group 2 read a feature story about a scientist studying a subject that is not considered controversial (Appendix F). Participants were asked five questions drawn from the facts of the articles in order to check that they read the story. Finally, subjects filled out a trust in science and scientists questionnaire (Appendix G). The figure below explains the procedure.

Figure 3.1 Procedure



Participants

The type of articles examined within this study (feature stories about scientists) are written in American English by native speakers and published with the intent of reaching a mass audience. In order to explore a larger population of U.S. public, a random sample of U.S. citizens, ages 18-65, born in the United States and for whom American English was their first language were contacted via email and asked to participate in this study. This population was chosen to prevent confounding variables such as language and cultural barriers.

Instrument

Demographics

Participants responded to several multiple-choice questions asking about ethnicity, age, highest level of education achieved, gender, and whether the subject works in a science field (to explore whether association with a science field increases affinity for science-related topics). Religiosity was measured using Vernon's (1962) 2-item public religiosity scale (Appendix B). The scale asks participants the importance of religion in their day-to-day lives and their feelings about religion using semantic differential scales. Political conservatism was measured using Ray's (1983) 22-item scale (Appendix C). The instrument asks participants to rate their agreement with statements on a 7-point Likert scale ranging from Strongly Disagree to Strongly Agree. Each statement corresponds with a polarized issue and half are reverse-scored to help prevent participant perceptions of bias.

Feature Stories

The feature stories in this experiment were selected from anthologies of the best science and nature writing (as chosen by industry professionals) published during or after 2011 as these articles would be the most articulate and widely-published and therefore a general population would be most likely to read. The articles were selected because they follow the story and research of one scientist in the third person. Feature stories for experiment group 1 follow a scientist researching a topic considered politicized or controversial in the United States – Global Warming/Pollution (Appendix E). Feature stories for experiment group 2 follow a scientist researching a topic that has not been politicized or would not be considered controversial in the

United States – Pheromones (Appendix F). Subjects in the control group read a feature story about Chess (Appendix D). Author and publisher information was removed to prevent gender and opinion bias in the experiment.

Public Trust in Science

Participants were asked to respond to a 21-item Trust in Science and Scientists Inventory created and validated by Nadelson, et al. (2014) (Appendix G). The measure was created and tested on college students, and should be able to measure variance in levels of trust among people of varying backgrounds and education levels. The purpose of the creation of the Trust in Science and Scientists Inventory was to develop an instrument to measure broad public trust in science and scientists, including aspects of trust such as credibility, epistemology, and trustworthiness (Nadelson et al. 2014).

Limitations

As this study served as an exploratory study for future research, the articles used for the stimuli were not pre-tested and, since they were pulled from different news sources in the real world, have a degree of variance in voice, length, and tone, and the scientists discussed were of different genders and ages with different educational backgrounds, which could have impacted study results. Participants were only exposed to one feature story, which limits the potential demonstrable effects on trust. However, this limited exposure and variation was more relevant to a real-world setting. The method of distribution used in this study was not necessarily realistic to a real-world setting and could lend itself to error: participants may have been distracted or gotten bored with the material and their low involvement could have skewed the results. There may also have been a bias involving subjects interested in participating in a study of this nature;

participants who actively search for scientific information may be more likely to trust what they read.

Chapter 4 - Results

Results were analyzed using SPSS. Simple descriptive statistics were run to describe the demographics of the participants. Participants were 59 percent female and 49 percent male. Forty-nine percent of participants were ages 50-65; 33 percent were ages 35-49; 15 percent were ages 25-34; and 3 percent were ages 18-24. Eighty-five percent of respondents described their racial heritage as White/Caucasian; 7 percent identified as African American; 4 percent identified themselves as Hispanic/Latino; 1 percent described their racial heritage as Native American; and 2 percent preferred not to say. Participants were also asked their level of education: 4 percent had doctorates; 10 percent had a graduate degree; 4 percent had completed some graduate school; 30 percent were college graduates; 33 percent had completed some college; 15 percent were high school graduates; and 4 percent did not graduate high school. When asked whether they were working in a science field, 11 percent said “Yes” and 89 percent said “No.”

RQ_1: Will exposure to feature stories about scientists improve audience trust in science and scientists?

A scale check was run to determine the reliability of the 21-item trust in science and scientists inventory; Cronbach’s Alpha was .911, which is within the acceptable range (Nadelson et al. 2014). Each participant’s responses to the 21-item Trust in Science and Scientists Inventory was averaged to provide a single score on a scale of 1 to 7. An independent-samples t-test was conducted to compare Trust in Science and Scientists in Control (feature story about chess) and Experimental (feature stories about scientists) conditions. There was not a significant difference in the scores for Control (M=3.36, SD=.55) and Experimental (M=3.51, SD=.58) conditions;

t(92)=-1.18, p = .239. These results suggest that exposure to feature stories about scientists had no impact on audience trust in science and scientists.

RQ_2: Does audience level of religiosity impact the effects of exposure to feature stories about scientists on audience trust in science and scientists?

Each participant's responses to the 2-item public religiosity scale were added together to provide a number between 1 and 12. A one-way between subjects ANOVA was conducted to compare the effect of Public Religiosity on Trust in Science and Scientists in Control, Experiment Group 1 (controversial feature story), and Experimental Group 2 (non-controversial feature story) conditions. There was not a significant effect of Public Religiosity on Trust in Science and Scientists at the $p<.05$ level for the three conditions [$F(10, 83) = 1.712$, $p = .091$]. This suggests that Public Religiosity does not have a statistically significant effect on Trust in Science and Scientists.

RQ_3: Does audience level of political conservatism impact the effects of exposure to feature stories about scientists on audience trust in science and scientists?

A scale check was run to determine the reliability of the 22-item political conservatism scale; Cronbach's Alpha for the scale was .804, which was within the acceptable range (Ray 1983). Each participant's responses to the 22-item political conservatism scale were averaged. A one-way between subjects ANOVA was conducted to compare the effect of Political Conservatism on Trust in Science and Scientists in Control, Experiment Group 1 (controversial feature story), and Experimental Group 2 (non-controversial feature story) conditions. There was not a significant effect of Political Conservatism on Trust in Science and Scientists at the $p<.05$ level for the three conditions [$F(53, 40) = 1.077$, $p = .407$]. This suggests that Political Conservatism did not have a statistically significant effect on Trust in Science and Scientists.

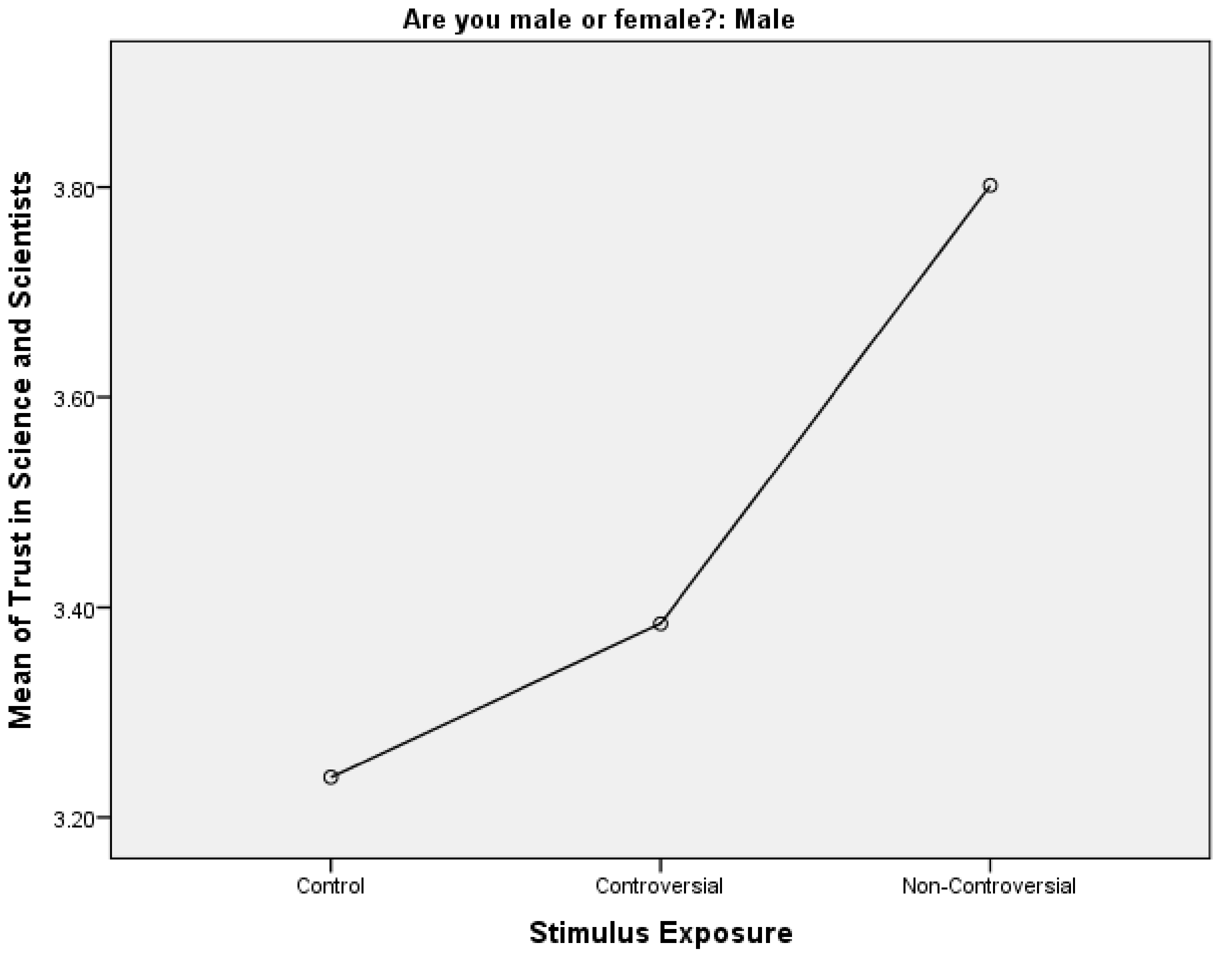
RQ_4: Does the level of controversy of the scientific topic of a feature story impact the effects of exposure to feature stories about scientists on audience trust in science and scientists?

An independent-samples t-test was conducted to compare Trust in Science and Scientists in Experimental Group 1 (feature story about Global Warming/Pollution) and Experimental Group 2 (feature stories about Pheromones) conditions. There was not a significant difference in the scores for Experimental Group 1 (M=3.36, SD=.69) and Experimental Group 2 (M=3.65, SD=.42) conditions; $t(49.84)=-1.96$, $p = .055$. These results suggest that the level of controversy of the feature story's scientific topic did not significantly impact audience trust in science and scientists.

Interaction Effects

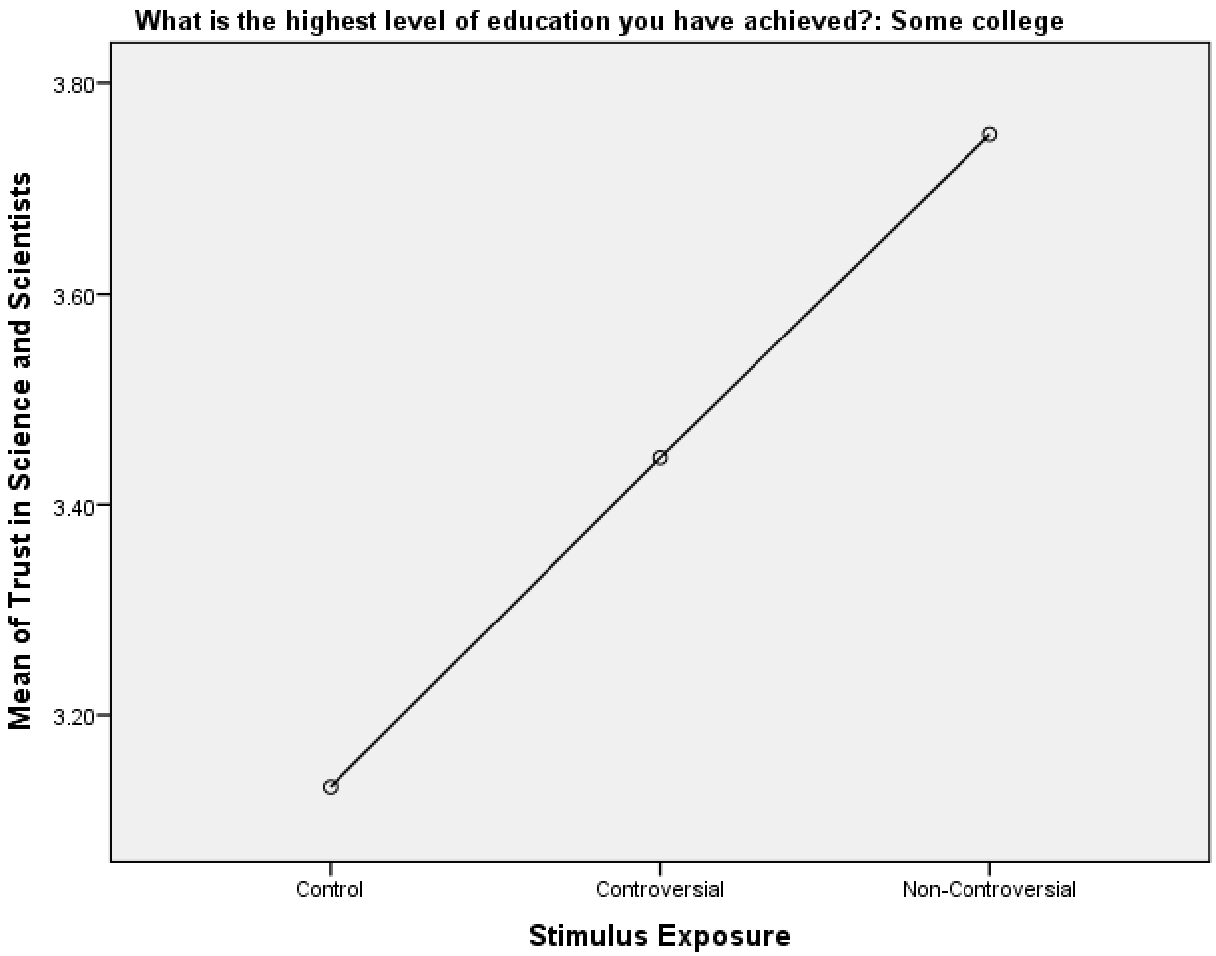
Additional one-way between subjects ANOVAs were conducted to compare the interaction effects of gender, age, ethnicity, level of education, and whether the participant works in a science field on Trust in Science and Scientists in Control, Experiment Group 1 (controversial feature story), and Experimental Group 2 (non-controversial feature story) conditions. Participants who were male demonstrated a statistically significant change in Trust in Science and Scientists at the $p<.05$ level [$F(1, 1) = 6.82$, $p = .013$]. Post hoc comparisons using the Tukey HSD test indicated that the mean score for the Control condition (M = 3.24, SD = .54) was significantly different than the Experimental Group 2 (non-controversial feature story) condition (M = 3.80, SD = 0.35). However, the Experimental Group 1 (controversial feature story) condition (M = 3.38, SD = 0.66) did not significantly differ from the Control and Experimental Group 2 conditions.

Figure 4.1 Level of trust in science and scientists of men who read control, controversial, or non-controversial stimulus



Similarly, participants who had some amount of college (but not a college degree) demonstrated a statistically significant change in Trust in Science and Scientists at the $p<.05$ level [$F(1, 1) = 4.785$, $p = .016$]. Post hoc comparisons using the Tukey HSD test indicated that the mean score for the Control condition ($M = 3.13$, $SD = .38$) was significantly different than the Experimental Group 2 (non-controversial feature story) condition ($M = 3.75$, $SD = 0.36$). However, the Experimental Group 1 (controversial feature story) condition ($M = 3.44$, $SD = 0.65$) did not significantly differ from the Control and Experimental Group 2 conditions. These results suggest that men and people with some college education but not a college degree who read a non-controversial feature story were statistically more likely to trust science and scientists.

Figure 4.2 Level of trust in science and scientists of participants who completed some college and who read control, controversial, or non-controversial stimulus



Further one-way ANOVAs were run to determine the interaction effects of the demographic data on trust in science and scientists. No significant results were found, as shown in Table 4.1 below.

Table 4.1 ANOVA results of demographic data interaction effects

		Age	Gender	Ethnicity	Level of Education	Occupation in a Science Field	Stimulus Exposure	Conservatism	Religiosity
	Religiosity	X	NO[F(3,35)=2.505, p=.075]	NO[F(1,12)=1.144, p=.306]	NO[F(4,9)=.678, p=.624]	NO[F(1,1)=.333, p=.667]	X	NO[F(8,5)=.595, p=.756]	X
Age	Conservatism	X	NO[F(3.35)=.781, p=.512]	NO[F(2,28)=.237, p=.790]	NO[F(4,9)=1.069, p=.426]	NO[F(1,1)=.333, p=.667]	X	X	NO[F(8,5)=.595, p=.756]
	Trust	X	NO[F(3,35)=.755, p=.527]	NO[F(1,1)=.750, p=.564]	NO[F(4,9)=1.117, p=.406]	NO[F(1,1)=27.0, p=.121]	NO[F(1,1)=27.0, p=.121]	NO[F(32,6)=.855, p=.653]	NO[F(1,1)=.750, p=.546]
	Religiosity	NO[F(3,35)=2.505, p=.075]	X	NO[F(4,34)=1.877, p=.137]	NO[F(6,32)=.452, p=.838]	NO[F(1,37)=.034, p=.855]	X	NO[F(9,29)=.879, p=.555]	X
Gender	Conservatism	NO[F(3.35)=.781, p=.512]	X	NO[F(4,34)=2.070, p=.106]	NO[F(6,32)=.368, p=.894]	NO[F(1,53)=3.519, p=.066]	X	X	NO[F(9,29)=.879, p=.555]
	Trust	NO[F(3,35)=.755, p=.527]	X	NO[F(4,34)=1.188, p=.334]	NO[F(6,32)=1.041, p=.417]	NO [F(1,37)=1.846, p=.183]	YES[F(2,1)=3.653, p=.036]	NO[F(32,6)=.855, p=.653]	NO[F(9,29)=1.849, p=.102]
	Religiosity	NO[F(4,9)=.678, p=.624]	NO[F(4,34)=1.877, p=.137]	X	NO[F(6,73)=1.049, p=.401]	NO[F(1,78)=.394, p=.532]	X	NO[F(10,69)=.849, p=.584]	X
Ethnicity	Conservatism	NO[F(4,9)=1.069, p=.426]	NO[F(4,34)=2.070, p=.106]	X	NO[F(6,73)=.309, p=.931]	NO[F(1,78)=1.668, p=.106]	X	X	NO[F(10,69)=.849, p=.584]
	Trust	NO[F(4,9)=1.117, p=.406]	NO[F(4,34)=1.188, p=.334]	X	NO[F(6,73)=.973, p=.450]	NO[F(1,78)=2.060, p=.155]	NO[F(2,1)=1.384, p=.257]	NO[F(48,31)=1.001, p=.508]	NO[F(10,69)=1.668, p=.106]
Level of Education	Religiosity	NO[F(4,9)=.678, p=.624]	NO[F(6,32)=.452, p=.838]	NO[F(6,73)=1.049, p=.401]	X	NO[F(1,29)=1.345, p=.256]	X	NO[F(6,7)=.592, p=.730]	X

	Conservatism	NO[F(4,9)=1.069, p=.426]	NO[F(6,32)=.368, p=.894]	NO[F(6,73)=.309, p=.931]	X	NO[F(1,29)=3.453, p=.073]	X	X	NO[F(6,7)=.592, p=.730]
	Trust	NO[F(4,9)=1.117, p=.406]	NO[F(6,32)=1.041, p=.417]	NO[F(6,73)=.973, p=.450]	X	NO[F(1,29)=.037, p=.850]	YES[F(1,1)=4.785, p=.016]	NO[F(21,9)=1.255, p=.377]	NO[F(6,7)=1.070, p=.459]
Occupation in a Science Field	Religiosity	NO[F(1,1)=.333, p=.667]	NO[F(1,37)=.034, p=.855]	NO[F(1,78)=.394, p=.532]	NO[F(1,29)=1.345, p=.256]	X	X	NO[F(4,5)=.326, p=.580]	X
	Conservatism	NO[F(1,1)=.333, p=.667]	NO[F(1,53)=3.519, p=.066]	NO[F(1,78)=1.668, p=.106]	NO[F(1,29)=3.453,j p=.073]	X	X	X	NO[F(4,5)=.326, p=.580]
	Trust	NO[F(1,1)=27.0, p=.121]	NO [F(1,37)=1.846, p=.183]	NO[F(1,78)=2.060, p=.155]	NO[F(1,29)=.037, p=.850]	X	NO[F(2,1)=.077, p=.927]	NO [F(49,34)=1.023, p=.479]	NO[F(10,73)=1.572, p=.132]

Ninety-four subjects took part in this exploratory study to determine whether exposure to feature stories can impact an audience's level of trust in science and scientists. There were no statistically significant differences in level of trust between treatment groups and public religiosity and political conservatism did not impact subjects' level of trust in science and scientists. However, men and participants who had some college (but had not graduated) and who read the feature article about a scientist studying a non-controversial topic showed statistically higher levels of trust in science and scientists than those who read the control. No other interaction effects were found.

Chapter 5 - Discussion

Research has demonstrated a decline in the American public's level of trust in science and scientists (Fiske & Dupree, 2014). Many studies have explored the reasons for this decline and ways to mitigate or even reverse this decline. This exploratory study was designed to assess the use of feature stories about scientists to impact a mass audience's level of trust in science and scientists. The results demonstrated that there was no statistically significant main effect of reading a feature story about a scientist on trust in science and scientists. However, there were interaction effects suggesting that certain groups (men and participants who had some college education but had not graduated) who read an article about a scientist studying a non-controversial science topic had statistically significantly higher levels of trust in science and scientists than those who read the control article.

Gender and Non-Controversial Feature Article Interaction Effects

The results of this study demonstrated statistically significantly higher levels of trust in science and scientists in men who read the non-controversial feature article (Appendix F) than men who read the control article (Appendix D). This could suggest that men are more likely to trust what they read than women. However, it is also possible that the gender of the scientists who were the topic of focus in the feature articles played a confounding role in this study. The non-controversial feature article was about a female scientist studying pheromones, while the controversial feature article was about a male scientist studying pollution and global warming and the control article was about a male chess player. This could indicate that men are more trusting of female scientists or that they tend to counter-argue other men.

Interestingly, no effect was found in women who read the non-controversial feature article. This could certainly be explained by the fact that the non-controversial article was, in part, about female menstrual cycles and the female participants were counter-arguing the facts of the article based on experience. Rolin's (2002) essay suggests that women are less likely to trust scientific topics because their gender is often marginalized in the field. Unfortunately, with only 94 participants, this study was not able to determine the cause of this effect. Further research into the effects of gender on trust in science and scientists is required.

Level of Education and Non-Controversial Feature Article Interaction Effects

This study also found that participants with some college (but not a college degree) who read the non-controversial article had a statistically significantly higher level of trust in science and scientists than those who read the control article. The demographic information may shed some light on this discovery: college students are trained in their classes to read articles for information, think critically, and develop opinions. For this reason, those participants who may currently be in college could have been more affected by the feature articles. The non-controversial article discussed a topic with little debate or controversy in recent years, which may have reduced counter-argument and heightened the effect further. Further studies should be done to explore whether level of education – regardless of scientific literacy – could affect trust in science and scientists. It would also be interesting to see if a person's current level of education could make them more susceptible to certain messages in the media.

Academic implications

The Trust in Science and Scientists Inventory and Political Conservatism Scale both demonstrated reliability, suggesting these scales can be used in future studies in the United States with confidence. Further use of the Trust in Science and Scientists Inventory could provide valuable information about the tenor of attitudes toward science in the United States. However, participants in this study seemed to gravitate toward the middle of the scale. More polarizing statements could help to spread responses across the spectrum. It would be interesting to see if this scale works equally well in other parts of the world, as well.

This quasi-experiment exploratory study suggests there is value in further exploring the impact of news feature stories on trust in science and scientists. Future studies could include questions regarding participants' level of involvement in the stories they read. People who enjoy reading or actively search out information about science might be more impacted by feature stories about scientists than those who prefer to watch television or do not enjoy learning about science. While this study did not find an interaction between political conservatism or public religiosity and trust in science and scientists, the small number of participants may have impacted the results. Further research regarding the interaction of politics and religion on public attitudes toward science is still necessary.

One of the limitations of this study was that participants were exposed only to one stimulus. Future studies should consider exposing participants to more than one feature story in order to increase potential effects. In a real-world setting, feature stories would not be presented to an audience in quantities of more than two. A longitudinal study could explore the effects of a more real-world presentation of science feature stories while also increasing the potential for effects and lessening the chances of confounding variables such as gender bias.

Practical Implications

While further research is certainly necessary in this area, this study has provided a good starting point for scientists and motivated communicators hoping to improve public trust in science and scientists. This quasi-experiment did not find conclusive evidence to suggest that feature articles about scientists will help improve audience trust in science and scientists.

However, the interaction effects demonstrated in this study could suggest that certain audiences may be impacted by feature articles about scientists studying a non-controversial (or heretofore un-politicized) scientific issue. Educational institutions and private research facilities should take this study into consideration when releasing information about ongoing research to the public. Highlighting non-controversial science topics or presenting un-politicized research alongside politicized research could help to prevent negative impacts on audience trust in science. While Granado (2011) found that journalists use the internet more than any other source, scientists studying non-controversial (or un-politicized) scientific topics should consider releasing more information about their work to the press, as it could improve public opinion overall.

Interestingly, participants who worked in a science field did not demonstrate significantly different levels of trust in science and scientists, suggesting that those who know about science are not more likely to trust it and casting further doubt on the validity of the deficit model. Those hoping to improve trust in science by educating the public about scientific topics may find that audience trust does not improve. Instead of focusing on the audience's lack of knowledge on the issue, communicators should consider other ways to build audience trust.

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Appendix A - Informed Consent and Debrief

KANSAS STATE UNIVERSITY

INFORMED CONSENT

PROJECT TITLE:Trust me, I have a PhD: Feature stories about scientists

PRINCIPAL INVESTIGATOR: CO-INVESTIGATOR(S):Joye Gordon, PhD; Bethany Quesnell

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SPONSOR OF PROJECT:AQ Miller School of Journalism and Mass Communications

LENGTH OF STUDY:30 minutes

RISKS ANTICIPATED:No known risks

BENEFITS ANTICIPATED:	No monetary benefits should be anticipated. However, if in the case the study produces any beneficial information, the study will be published in the K-State research website for their readership. They will have access to the researcher’s contact information if they wish to find out results of the study.
EXTENT OF CONFIDENTIALITY:	We will keep the data in private (in a locked file-cabinet to which no one except the researchers associated with this study will have access). We will remove the identities of participants from the data and we will not allow anyone else to see the data. Upon completion of the study, all data will be destroyed.

TERMS OF PARTICIPATION: I understand this project is research, and that my participation is completely voluntary. I also understand that if I decide to participate in this study, I may withdraw my consent at any time, and stop participating at any time without explanation, penalty, or loss of benefits, or academic standing to which I may otherwise be entitled.

I verify by clicking “I Accept” below, I indicate that I have read and understand this consent form, and willingly agree to participate in this study under the terms described, and that this acknowledges that I have received a copy of this consent form.

END OF SURVEY MESSAGE

Thank you for your participation!

This study was designed to explore whether exposure to a feature article about a scientist has an impact on an audience's level of trust in science and scientists. If you have any questions about the study, contact Bethany Quesnell, A.Q. Miller School of Journalism and Mass Communications, 105 Kedzie Hall, Kansas State University, Manhattan, KS 66506-1501, bquesnell@ksu.edu. If you have any questions about the method or the research procedure, contact the University Research Compliance Office, 203 Fairchild Hall, KSU, Manhattan, KS 66502, (785) 532-3224.

Appendix B - Public Religiosity

1. How important is religion in your day-to-day living?

    - Of great importance
    - Of moderate importance
    - Of slight importance
    - Of very slight importance
    - Of no importance

2. How would you rate your feelings toward religion?

    - Strongly favorable
    - Moderately favorable
    - Slightly favorable
    - Not religious but not opposed
    - Slightly opposed
    - Moderately opposed
    - Strongly opposed

Appendix C - Political Conservatism

Directions: Rank your level of agreement to each of the statements on a 7-point Likert Scale from Strongly Agree to Strongly Disagree. *Indicates reverse-coded item.

1. A free dental service should be provided by the Federal government*
2. Schoolchildren should have plenty of discipline
3. The government should not attempt to limit business profits
4. Erotic and obscene literature should be prohibited from public sale
5. The Federal government should introduce a health insurance scheme which would cover every American no matter what he does*
6. Labor unions should make more efforts to grab corporate profits for the workers*
7. People should be allowed to hold demonstrations in the streets without police interference*
8. The police deserve more praise for the difficult job they do
9. Law and order is more important than letting every kook have his say
10. People who are always protesting to have something banned or stopped would probably howl the loudest if they themselves were banned
11. Government attempts to prevent people using marijuana are just about as stupid as prohibition of alcohol was*
12. The rebellious ideas of young people are often a constructive source of change for the better*
13. Laws against homosexuality are old-fashioned and wrong*
14. People should be free to get on with their own lives without being pestered by governments and do-gooders
15. Busing of children to school outside their own neighborhoods is an unforgiveable infringement of individual liberties
16. People who show disrespect for their country's flag should be punished for it
17. The government should make sure that our armed forces are stronger than those of Russia at all times

18. The right of strikers to picket a firm they are striking against should not be interfered with*

19. The police are generally corrupt and brutal*

20. The government should do everything it can to eradicate poverty in this country*

21. Military training is unnatural and has a tendency to warp people*

22. People who want more money should work harder for it instead of trying to get it off the government in one way or another

Appendix D - General News Feature Story

Chasing World Chess Title, U.S. Recruits From Abroad

Dylan Loeb McClain

From: The New York Times

The United States team that will compete in the World Team Chess Championship next month in Armenia stands no real chance of winning. It is not sending its three best players, and even if it were, it does not have enough talent to compete with the stacked teams from Russia and China.

But one does not have to be born in a country to represent it in international competition, and so an official program and a clandestine effort are underway to recruit top players from other countries to switch their allegiance to the United States. Such transfers have happened in the past, but never in an organized manner. If the new efforts are successful, the American team could be radically altered by the time the Chess Olympiad, the most prestigious team competition in chess, is held next year in Azerbaijan. By then, the United States could even be the favorite to win the gold medal, something it has not done in decades.

The most important contribution to remaking the team may be an endeavor that has the whiff of a Cold War-era plot: a private overture to a top foreign grandmaster, tens of thousands of dollars in payments to secure his eligibility, and a rich American benefactor intent on overtaking the Russians and the Chinese in the game he loves. Similar campaigns to obtain the national allegiance of top prospects are not uncommon in the Olympic movement and international soccer, but they are virtually unprecedented in the more cerebral world of top-level chess.

The secret effort currently underway involves trying to persuade Fabiano Caruana, the No. 2 player in the world, to switch to playing for the United States from Italy. Last September, while playing in an elite tournament in St. Louis, Mr. Caruana said he was approached and offered a large sum to switch federations. Mr. Caruana, who was born in Miami and has dual American and Italian citizenship, said he had turned down the offer, for now.

Mr. Caruana would not say who approached him, but the offer came after he won the Sinquefield Cup, obliterating an impressive field that included the world champion, Magnus Carlsen of Norway. The tournament is named for Rex Sinquefield, a retired financier active in Missouri politics who has become the primary benefactor of chess in the United States. Mr.

Sinquefield provided the $315,000 prize fund for the event, as he also does for the United States Championship, which for seven consecutive years has been held at the Chess Club and Scholastic Center of St. Louis, which he financed and built.

In an interview, Mr. Sinquefield said, “I can’t add anything,” to Mr. Caruana’s statement that he had been recruited.

Mr. Sinquefield is uncomfortable talking about the role he has played supporting chess financially, though he acknowledged that his investments have benefited the chess community in St. Louis and across the country. But, he said, it was not part of some grand scheme.

“I am the admiring beneficiary of what is happening,” he said.

If it would help the United States team, Mr. Sinquefield said, he would not be opposed to recruiting foreign players, mentioning as an example that if he overheard Mr. Carlsen say that he wanted to switch federations he would not hesitate to try to persuade him to pick the United States.

“It’s funny how these things happen,” he said.

Switching federations, particularly for an elite player, is not simple. A grandmaster, for example, and the federation he would like to play for must apply to the World Chess Federation, the game’s governing body, for permission, then pay a fee of up to 5,000 euros (about $5,400) if the player is to be allowed to represent his new country immediately. If the player has not been a resident of his new country for two years, an additional compensation fee to the player’s old federation is required — as much as 50,000 euros for a player of Mr. Caruana’s caliber.

Consequently, transfers of elite players are rare. In the last 15 years, there have been only two involving players ranked in the world’s top 20: Sergey Karjakin, a Ukrainian-born player ranked No. 12 who now plays for Russia, and Wesley So, the world’s No. 8, who switched last year to the United States from the Philippines.

Mr. So’s decision was an unexpected boon for the United States team. In an interview, he said that he had not been recruited but had made the decision for personal and professional reasons. He also said he was not unmindful of how his decision might be received.

“In my opinion, Rex Sinquefield would prefer if I play for the United States,” Mr. So said. He added that it was his dream to play in the Sinquefield Cup.

Mr. So moved to the United States in 2012 as a student at Webster University in St. Louis, which has assembled one of the premier college chess teams in the country.

He said he decided last June, after his sophomore year, that he wanted to switch federations, but the rules governing transfers prevented him from playing for the United States during the August 2014 Chess Olympiad in Tromso, Norway. After he won the $100,000 first prize in the Millionaire Chess Challenge in Las Vegas in September, Mr. So said that he paid the transfer fee out of his own pocket and immediately became eligible to represent the United States.

He will not be playing in the World Team Championships, however, because he is competing in an elite tournament in Azerbaijan that is scheduled at the same time. But he said he was eager about the possibility of representing the United States in next year's Chess Olympiad.

Mr. So and Hikaru Nakamura, America's top player, would give the United States a formidable 1-2 punch. Mr. Nakamura has won two elite tournaments this year — the Gibraltar Chess Festival and the Zurich Chess Challenge — and his world ranking is a career-best No. 3.

But teams in the biggest international competitions need five players (four regulars and one reserve), and after Mr. Nakamura and Mr. So, there is a drop-off among United States talent, at least when compared with the Russian and Chinese teams, which can field entire rosters of players ranked in the top 40 in the world. The current No. 3 in the United States is Gata Kamsky, who is No. 61 in the world.

It is partly with that mind that the United States Chess Federation recently created a player opportunity committee and a charitable fund to help recruit and pay the fees of foreign players interested in moving to the United States, and why adding Mr. Caruana to the American stable would be a coup. Reached by email, Gianpietro Pagnoncelli, the president of the Italian Chess Federation, wrote, "If Fabiano is really interested in switching federations, I can only feel sorry about that." But he also cleared the path, saying that the Italian federation would not oppose such a decision.

Randy Bauer, a member of the executive board of the United States federation, said the committee and the fund were part of an effort to promote the game by raising its profile in the United States. "Certainly, if we have a team that wins a gold medal against Russia and China, that will help," Mr. Bauer said. "The United States loves winners."

The federation may not have far to look to find recruits. Like Mr. So, many of them already live in the United States and play for one of the elite college chess programs, which have expanded and become more competitive in recent years.

Jim Stallings, the longtime director of the chess program at the University of Texas, Dallas, said that while the United States is producing more homegrown grandmasters than it once did, there are still not enough of them. “By virtue of the fact that there are not that many strong players in the United States,” he said, “we have to go out and recruit foreign players.”

Some of those college recruits have subsequently switched their allegiance, including Alejandro Ramirez (formerly of Costa Rica), Timur Gareev (Uzbekistan) and Fidel Corrales Jimenez (Cuba). Yaroslav Zherebukh, a grandmaster originally from Ukraine who is a sophomore at Texas Tech, has just finished transferring, according to Al Lawrence, the director of the program there.

But no matter who else the United States recruited, it would not have the impact of landing Mr. Caruana. That will not happen this year, Mr. Caruana said, but “it is open for the future.”

Appendix E - Feature Story about Controversial Scientist

Ill Wind

David Kirby

From: Discover

“There is not place called away.” It is a statement worthy of Gertrude Stein, but the University of Washington atmospheric chemist Dan Jaffe says it with conviction: none of the contamination we pump into the air just disappears. It might get diluted, blended, or chemically transformed, but it has to go somewhere. And when it comes to pollutants produced by the booming economies of East Asia, that somewhere often means right here, the mainland of the United States.

Jaffe and a new breed of global air detectives are delivering a sobering message to policymakers everywhere: carbon dioxide, the predominant driver of global warming, is not the only industrial byproduct whose effects can be felt around the world. Prevailing winds across the Pacific are pushing thousands of tons of other contaminants – including mercury, sulfates, ozone, black carbon, and desert dust – over the ocean each year. Some of this atmospheric junk settles into the cold waters of the North Pacific, but much of it eventually merges with the global air-pollution pool that circumnavigates the planet.

These contaminants are implicated in a long list of health problems, including neurodegenerative disease, cancer, emphysema, and perhaps even pandemics like avian flu. And when wind and weather conditions are right, they reach North America within days. Dust, ozone, and carbon can accumulate in valleys and basins, and mercury can by pulled to Earth through atmospheric sinks that deposit it across large swathes of land.

Pollution and production have gone hand in hand at least since the industrial revolutions, and it is not unusual for a developing nation to value economic growth over environmental regulation. “Pollute first, clean up later” can be the general attitude, says Jennifer Turner, director of the China Environment Forum at the Woodrow Wilson International Center for Scholars. The intensity of the current change is truly new, however.

China in particular stands out because of its sudden role as the world’s factory, its enormous population, and the mass migration of that population to urban centers; 350 million people, equivalent to the entire US population, will be moving to its cities over the next ten years. China now emits more mercury than the United States, India, and Europe combined. “What’s different about China is the scale and speed of pollution and environmental degradation,” Turner says. “It’s like nothing the world has ever seen.”

Development there is racing far ahead of environmental regulation. “Standards in the United States have gotten tighter because we’ve learned that ever-lower levels of air pollution affect health, especially in babies and the elderly,” Jaffe says. As pollutants coming from Asia increase, though, it becomes harder to meet the stricter standards that our new laws impose.

The incoming pollution has sparked a fractious international debate. Officials in the United States and Europe have embraced the warnings of the soft-spoken Jaffe, who, with flecks of red and gray in his trim beard, looks every bit the part of a sober environmental watchdog. In China, where economic expansion has run to 8 to 14 percent a year since 2001, the same facts are seen through a different lens.

China’s smog-filled cities are ringed with heavy industry, metal smelters, and coal-fired power plants, all crucial to that fast-growing economy even as they spew tons of carbon, metals, gases, and soot into the air. China’s highways are crawling with the newly acquired cars of a burgeoning middle class. Still, “it’s unfair to put all the blame on China or Asia,” says Xinbin Feng of the Institute of Geochemistry at the Chinese Academy of Sciences, a government-associated research facility. All regions of the world contribute pollutants, he noted. And much of the emissions are generated in making products consumed by the West.

Our economic link with China makes all the headlines, but Jaffe’s work shows that we are environmentally bound to the world’s fastest-rising nation as well.

Dan Jaffe has been worrying about air pollution since childhood. Growing up near Boston, he liked to fish in local wetlands, where he first learned about acid rain. “I had a great science teacher, and we did a project in the Blue Hills area. We found that the acidity of the lake was rising,” he recalls. The fledgling environmental investigator began chatting with fishermen around New England. “All these old-timers kept telling me the lakes had been full of fish that were now gone. That mobilized me to think about when we burn fossil fuels or dump garbage, there is no way it just goes somewhere else.”

By 1997 Jaffe was living in Seattle, and his interest had taken a slant: Could pollution reaching his city be blowing in from somewhere else? “We had a hunch that pollutants could be carried across the ocean, and we had satellite imagery to show that,” Jaffe says. “And we noticed our upstream neighbors in Asia were developing very rapidly. I asked the question: Could we see those pollutants coming over to the United States?”

Jaffe’s colleagues considered it improbably that a concentration of pollutants high enough to significantly impact American air quality could travel thousands of miles across the Pacific Ocean; they expected he would find just insignificant traces. Despite their skepticism, Jaffe set out to find the proof. First he gathered the necessary equipment. Devices to measure carbon monoxide, aerosols, sulfur dioxide, and hydrocarbons could all be bought off the shelf. He loaded the equipment into some university trucks and set out for the school’s weather observatory at Cheeka Peak. The little mountain was an arduous five-hour drive northwest of Seattle, but it was also known for the cleanest air in the Northern Hemisphere. He reckoned that if he tested this reputedly pristine air when a westerly wind was blowing in from the Pacific, the Asian pollutants might show up.

Jaffe’s monitors quickly captured evidence of carbon monoxide, nitrogen oxides, ozone, hydrocarbons, radon, and particulates. Since air from North America could not have contaminated Cheeka Peak with winds blowing from the west, the next step was identifying the true source of pollutants. Jaffe found his answer in atmospheric circulation models, created with the help of data from Earth imaging satellites, which allowed him to trace the pollutants’ path backward in time. A paper he published two years later summarized his conclusions succinctly. The pollutants “were all statistically elevated…when the trajectory originated over Asia.”

Officials at the US Environmental Protection Agency took note, and by 1999 they were calling Jaffe to talk. They were not calling about aerosols or hydrocarbons, however, as concerning as those pollutants might be. Instead, they were interested in a pollutant that Jaffe had not looked for in his air samples: mercury.

Mercury is a common heavy metal, ubiquitous in solid material on Earth’s surface. While it is trapped it is of little consequence to human health. But whenever metal is smelted or coal is burned, some mercury is released. It gets into the food chain and diffuses deep into the ocean. It eventually finds its way into fish, rice, vegetables, and fruit.

When inorganic mercury (whether from industry or nature) gets into wet soil or a waterway, sulfate-reducing bacteria begin incorporating it into an organic and far more absorbable compound called methylmercury. As microorganisms consume the methylmercury, the metal accumulates and migrates up the food chain; that is why the largest predator fish (sharks and swordfish, for example) typically have the highest concentrations. Nine-tenths of the mercury found in Americans' blood is the methyl form, and most comes from fish, especially Pacific fish. About 40 percent of all mercury exposure in the United States comes from Pacific tuna that has been touched by pollution.

In pregnant women, methylmercury can cross the placenta and negatively affect fetal brain development. Other pollutants that the fetus is exposed to can also cause toxic effects, "potentially leading to neurological, immunological, and other disorders," says the Harvard epidemiologist Philippe Grandjean, a leading authority on the risks associated with chemical exposure during early development. Prenatal exposure to mercury and other pollutants can lead to lower IQ in children – even at today's lower levels, achieved in the United States after lead paint and leaded gasoline were banned.

Among adults the University of California, Los Angeles, neuroscience researcher Dan Laks has identified an alarming rise in mercury exposure. He analyzed data collected by the Centers for Disease Control and Prevention on 6,000 American women and found that concentrations of mercury in the human population had increased over time. Especially notable was that Laks detected inorganic mercury (the kind that doesn't come from seafood) in the blood of 30 percent of the women tested in 2005-2006, up from just 2 percent of women tested six years earlier. "Mercury's neurotoxicity is irrefutable, and there is strong evidence for an association with the Alzheimer's and Parkinson's disease and amyotrophic lateral sclerosis," Laks adds.

Circumstantial evidence strongly pointed to China as the primary origin of the mercury; the industrial processes that produce the kinds of pollutants Jaffe was seeing on Cheeka Peak should release mercury as well. Still, he could not prove it from his data. To confirm the China connection and to understand the exact sources of the pollution, researchers had to get snapshots of what was happening inside that country.

One of the first scientists with feet on the ground in China was David Streets, a senior energy and environmental policy scientist at Argonne National Laboratory in Illinois. In the 1980s he was at the forefront of the study of acid rain, and in the 1990s he turned his attention to carbon dioxide and global warming as part of the Intergovernmental Panel on Climate Change. Streets began focusing on emissions from China about fifteen years ago and has since become such a noted expert that he helped the Chinese government clean up the smoke-clogged skies over Beijing before the Olympics in 2008.

In 2004, spurred by increased attention to mercury in the atmosphere, Streets decided to create an inventory of China's mercury emissions. It was a formidable undertaking. Nobody had ever come up with a precise estimate, and the Chinese government was not exactly known for its transparency.

Nevertheless, Streets considered the endeavor important because China is full of the two biggest contributors to human-generated mercury, metal smelting and coal combustion. Smelting facilities heat metal ores to eliminate contaminants and extract the desired metal, such as zinc, lead, copper, or gold. Unfortunately, one of the consistent contaminants is mercury, and the heating process allows it to escape into the atmosphere in gaseous form. Similarly, coal contains trace amounts of mercury, which is set free during combustion at power plants.

Streets began by studying reports from China's National Bureau of Statistics. China's provinces provide the central government with detailed data on industrial production: how much coal they burn, how much zinc they produce, and so on. "China is very good at producing statistical data. It's not always one hundred percent reliable, but at least it's a start," he says. Those statistics help the Chinese government monitor the economy, but for Streets they also quantified China's mercury-laden raw materials.

The numbers from the statistics bureau told Streets the total amount of mercury that might be emitted, but he also needed to know how much actually made it into the air. To obtain that information, he turned to pollution detectives – a group of professional contacts he had met at conferences, along with graduate students who spent time in his lab. Most of the time, Chinese factories turned these "spies" away. "Factory owners had nothing to gain and a lot to lose," Streets says. "They were nervous that the results would get leaked to the government."

Yet some of Streets's moles got through by guaranteeing that the data would stay anonymous. Once inside, they took samples of raw materials – zinc ore in a smelting facility, for example – and installed chemical detectors in smokestacks. After a few days of data collection, they passed the information to Streets.

The statistics Streets collected were hardly airtight. Factory foremen and provincial officials were not above providing inflated data to make themselves look more productive, and the managers who were willing to let his inspectors take measurements were often the very ones with nothing to hide. “There’s still a lot of uncertainty,” Streets concedes, “but we know more than we did before.”

In 2005, Streets and his team reported their first tally of human-generated mercury emissions in China, for the year 1999. The scientists estimated the amount at 590 tons (the United States emitted 117 tons). Almost half resulted from the smelting of metals – especially zinc, because its ores contain a high concentration of mercury. Coal-burning power plants accounted for another 38 percent of Chinese mercury emissions and that percentage may be going up. As recently as 2007, China was building two new power plants a week, according to John Ashton, a climate official in the United Kingdom. Streets’s team published a subsequent inventory estimating that China’s mercury emissions had jumped to 767 tons in 2003. “Mercury emissions in China have grown at about 5 to 6 percent a year,” he says. “It’s pretty much undeniable.”

Streets had show that China was churning out mercury, but he was left with a big uncertainty: What happened to it on its journey aloft? Finding the answer fell to Hans Friedli, a chemist at the National Center for Atmospheric Research (NCAR) who had spent thirty-three years working for Dow Chemical. Friedli had found his own path into the esoteric world of pollution forensics. Back in the early 1990s, a conversation with his neighbor, an NCAR scientist, sparked an interest in wildfires, a major source of mercury emissions. By 1998 he had a full-time job tracking the toxin for NCAR.

With its copious mercury emissions (not only from industry but also from volcanoes, wildfires, and dust storms), Asia drew Friedli’s interest. China would never allow him to do aerial studies in its airspace, but in 2001 he heard about research flights off the coasts of Japan, Korea, and China designed to track dust particles emanating from the mainland. Friedli convinced the research team to take him along to measure mercury concentrations in the atmosphere.

Throughout April 2001, nineteen researchers, professors, and grad students took sixteen flights aboard a cavernous retired Nave C-130 plane custom fitted with nineteen instruments for measure pollutants like carbon monoxide, sulfur, and ozone.

During each flight, Friedli sat at his station awaiting readouts from his mercury sensor: an intake valve that sucked in air and guided it over a gold cartridge within the plane. Any mercury in the air would be absorbed by the gold. Every five minutes the instrument rapidly heated the gold, releasing any trapped mercury. Plumes of mercury-laced air near Earth's surface are mixed with other pollutants, but at 20,000 feet Friedli discovered concentrated mercury plumes soaring eastward toward North America. He concluded that those plumes must have circled the entire globe at least once, releasing more ephemeral pollutants like carbon monoxide, so the mercury stood out even more.

Eager to follow the trail of Asian mercury plumes, Friedli set his sights across the Pacific off the West Coast of the United States. In a series of eleven research flights in 2002, he identified a plume that looked very much like the ones he'd found near China the year before. Specifically, the plume had a ratio of carbon monoxide to mercury that served as a fingerprint for gases from the same source.

What Friedli detected was just one detail of a much larger picture. Mercury plumes can wobble in latitude and altitude or park themselves in one spot for days on end. Emissions from China – and from the United States, and indeed from every industrial country – feed a network of air currents that, as equal-opportunity polluters, serve up toxic mercury around the world.

Drawing insights from research by Friedli and Streets, Jaffe looks at his data anew. If mercury was arriving from China, he should be able to detect it, yet his operation on Cheek Peak showed no such signal. Conducting reconnaissance from a place, he realized why. The peak, at 1,500 feet, was blow the mercury plume. Seeking a higher perch, he chose Mount Bachelor, a ski resort in central Oregon at an altitude of 9,000 feet.

In late winter 2004, Jaffe and his students huddled deep in their down jackets, bracing against a bitter gale that buffeted the chairlift ferrying them and their costly equipment to the summit. Inside the mountaintop lodge they installed a small computer lab and extended tubes outside to vacuum up the air. Later that year they conducted a similar experiment in Okinawa, Japan.

Back in Washington, they plotted their analysis of mercury in the air against satellite data showing wind currents. "My hypothesis was that we would see the same chemicals, including the same ratio of mercury to carbon monoxide, from Mount Bachelor and Japan," Jaffe says. The numbers showed exactly the expected similarity. "This was a real 'aha' moment for us, because the two regions were phenomenally close."

It was the first time anyone had decisively identified Asian mercury in American air, and the quantities were stunning. The levels Jaffe measured suggested that Asia was churning out 1,400 tons a year. The results were a shock to many scientists, Jaffe says, because “they still couldn’t wrap their heads around the magnitude or the pollution and how dirty China’s industry was.” They were only starting to understand the global nature of the mercury problem.

Over the years, Jaffe’s Mount Bachelor Observatory has also monitored many other noxious pollutants wafting across the Pacific. One major category is sulfates associated with lung and heart disease. When sulfur dioxide exits China’s coal and oil smokestacks, it converts into sulfates in the air. “Sulfates are water-soluble and get removed from the atmosphere relatively quickly creating acid rain that falls in China, Korea, and Japan,” Jaffe says. Yet some of the sulfates stay aloft, finding their way here and contributing to smog along the West Coast.

Another Chinese import is black carbon, the soot produced by cars, stoves, factories, and crop burning and a major component of Chinese haze. The small diameter of the carbon particles means they can penetrate deep inside the lungs, providing absorption sites for secondary toxins that would otherwise be cleared. This compounds the danger, making black carbon an especially potent risk factor for lung disease and premature death.

The biggest pollutant coming out of Asia, at least in terms of sheer mass, could be dust from the region’s swelling deserts. “It’s not a new phenomenon,” Jaffe says, but it has gotten worse with deforestation and desertification caused by poorly managed agriculture. About every three years, a huge dust storm over China sends enormous clouds across the Pacific. “We can visually see it,” Jaffe says. “It usually hangs around for about a week. We’ve tried to quantify how much how much it contributes to the particulate loading here, and it’s a little under 10 percent of the US standard on average each year. It’s a significant amount.”

Chinese dust has obscured vistas in US national parks, even on the East Coast. The amount of dust widely variable and can hit rare extreme peaks. The highest level recorded was from a 2001 dust event. “It reached approximately two-thirds of the US air quality standard at several sites along the West Coast,” he reports. One study from Taiwan tracked avian flu outbreaks downwind of Asian dust storms and found that the flu virus might be transported long-distance by air spiked with the dust.

Perhaps the most counterintuitive traveling contaminant is ozone, commonly associated with ground-level pollution in cities. Volatile organic compounds, carbon monoxide, and nitrogen oxides from Asian cars and industry mix in the atmosphere as they cross the Pacific Ocean and convert in sunlight into ozone, a main ingredient in smog, Jaffe explains. When air with high ozone concentrations touches down in North America, it can pose the classic dangers of urban smog: heart disease, lung disease, and death.

Jaffe recently coauthored a paper in Asian ozone coming to America. It found that ozone levels above western North America creep upward every spring. "When air was coming from Asia, the trend was strongest. That was the nail in the coffin," Jaffe says. "The increase was estimated at 0.5 part per pillion [ppb] per year. But that's huge. In ten years that's another 5 ppb. Let's say the EPA orders a 5-ppb reduction and we achieve that, and yet, because of the growing global pool, in ten years that gets wiped out. We'll have to keep reducing our emissions just to stay even."

The underlying message of Jaffe's detective work should not be all that surprising: all of the world's atmosphere is interconnected. People have accepted this notion when it comes to carbon dioxide or the chemicals that eat away at the ozone layer, but Jaffe is finding that they are still coming to terms with the reality that it applies to industrial pollutants in general.

The fact is, those pollutants are everybody's responsibility, not just China's. The EPA has estimated that just one-quarter of US mercury emissions from coal-burning power plants are deposited within the contiguous United States. The remainder enters the global cycle. Conversely, current estimates are that less than half of all mercury deposition within the United States comes from American sources.

Then again, the United States has spent considerable effort over the past half-century trying to clean up its act. China is still much more focused on production. To fuel its boom, China has become a pioneer in wind power but has also begun buying up huge inventories of coal from markets around the world. Streets recently estimated that China's use of coal for electricity generation will rise nearly 40 percent over the next decade, from 1.29 billion tons last year to 1,77 billion tons in 2020. That is a lot more pollution to come.

"It's a classic example of a tragedy of the commons," Jaffe says, referring to a dilemma in which individuals act in their own self-interest and deplete a shared resource. "If twenty people are fishing in the same pond, with no fishing limit, then you catch as many as you can because it will be empty in weeks. Nobody has an incentive to conserve, and the same goes for pollution."

The discovery of the global mercury cycle underscores the need for an international treaty to address such pollutants. Under the auspices of the United Nations, negotiations have at least begun. Jaffe, Streets, and Chna's Xinbin Feng are now consultants to the UN Environment Programme's Global Partnership on Mercury, Atmospheric Transport and Fate Research, which helped contribute data that led to a proposed UN mercury treaty in 2009.

When it comes to some pollutants, China has taken important steps. For instance, recent policies encourage desulfurization and other filtering technology in power plants. But convincing developing nations to move aggressively on mercury may be at least as tough as mobilizing them against carbon emissions. "This is not considered a pollutant that urgently needs to be controlled on the national level," Feng says. "It's not fair that you emitted so much mercury and other pollutants when you had the chance to industrialize. You had two hundred years, and now you want to stop other countries from developing too."

"We need to be concerned," Jaffe counters in his low-key way. "There is no Planet B. We all live downwind."

What was this article about?

- ❍ pheromones (1)
- ❍ genetics (2)
- ❍ pollution (3)
- ❍ I don't know (4)

What substance did Friedli track from Asia to North America?

- ❍ mercury (1)
- ❍ heroin (2)
- ❍ plastic (3)
- ❍ I don't know (4)

Why couldn't Jaffe detect mercury on Cheeka Peak?

- It was too high in altitude (1)
- It was too low in altitude (2)
- The air was too thin (3)
- I don't know (4)

In what country did Streets have "pollution detectives" collect data?

- China (1)
- Germany (2)
- Argentina (3)
- I don't know (4)

What ocean now contains fish contaminated with methylmercury?

- Pacific (1)
- Atlantic (2)
- Indian (3)
- I don't know (4)

Appendix F - Feature Story about Non-Controversial Scientist

The Scent of Your Thoughts

Deborah Blum

From: Scientific American

The moment that starts Martha McClintock's scientific career is a whim of youth. Even, she recalls, a ridiculous moment. It is summer 1968, and she is a Wellesley College student attending a workshop at the Jackson Laboratory in Maine. A lunch-table gathering of established researchers is talking about how mice appear to synchronize their ovary cycles. And twenty-year-old McClintock, sitting nearby, pipes up with something like, "Well, don't you know? Women do that, too."

"I don't remember the exact words," she says now, sitting relaxed and half-amused in her well-equipped laboratory at the University of Chicago. "But everyone turned and stared." It is easy to imagine her in that distant encounter – the same direct gaze, the same friendly face and flyaway hair. Still, the lunch-table group is not charmed; it informs her that she does not know what she is talking about.

Undaunted, McClintock raises the question with some graduate students who are also attending the workshop. They bet that she will not be able to find data to support her assertion. She returns to Wellesley and talks this matter over with her undergraduate adviser, Patricia Sampson. And Sampson throws it back at her: take the bet, do the research, prove yourself right or wrong.

Three years later, now a graduate student, McClintock publishes a two-page paper entitled "Menstrual Synchrony and Suppression" in the journal Nature. (Scientific American is part of Nature Publishing Group.) It details a rather fascinating effect seen in some 135 residents of Wellesley dormitories during an academic year. In that span, menstrual cycles apparently began to shift, especially among women who spent a lot of time together. Menstruation became more synchronized, with more overlap of when it started and finished.

Today the concept of human menstrual synchronization is generally known as the McClintock effect. But the idea that has continued to shape both her research and her reputation, the one that drives a still flourishing field of research, is that this mysterious synchrony, this reproductive networking, is caused by chemical messaging between women – the notion that humans, like so many other creatures, reach out to one another with chemical signals.

It has been harder than expected to single out specific signaling chemicals and trace their effects on our bodies and minds as precisely as entomologists have done for countless insect pheromones. But in the four decades since McClintock's discovery, scientists have charted the influence of chemical signaling across a spectrum of human behaviors. Not only do we synchronize our reproductive cycles, we can also recognize our kin, respond to others' stress, and react to their moods – such as fear or sadness or "not tonight honey"- all by detecting chemicals they quietly secrete. As researchers learn more about this web of human interaction, they are helping to bridge an arbitrary dividing line between humans and the natural world.

Animal Kingdom Chemistry

The very intriguing idea of animals sharing invisible chemical cues has a long and illustrious history, at least as far as other species are concerned. The ancient Greeks talked enthusiastically of the possibility that female dogs in heat might produce some mysterious secretion capable of driving male dogs into a panting frenzy. Charles Darwin, pointing to several famously smelly species, proposed that chemical signals were part of the sexual selection process. Throughout the late nineteenth century the great French naturalist Jean-Henri Fabre puzzled over evidence that the siren call of chemistry could stir winged insects into determined flight.

Still, it was not until 1959 that the science really began to gain traction. In that year Adolf Butenandt, a Nobel laureate in chemistry, isolated and analyzed a compound that female silk moths release to attract males. Butenandt dissected the insects and painstakingly extracted the chemical from their microscopic secretion glands. He collected enough to crystallize it so that he could discern its molecular structure by x-ray crystallography. He called the compound bombykol, after the Latin name for the silk moth.

It was the first known pheromone, although the term did not yet exist. Shortly after, two of Butenandt's colleagues, the German biochemist Peter Karlson and the Swiss entomologist Martin Lüscher, coined that name from two Greek words: *pherein* (to transport) and *horman* (to stimulate). They defined a pheromone as a type of small molecule that carries chemical messages between individuals of the same species. The compounds must be active in very tiny amounts, potent below a conscious scent threshold. When released by one individual in a species and received by another, the two researchers wrote, they produce a measureable effect, “a specific reaction, for instance, a definite behavior or a developmental process.”

Since then, an astonishing array of pheromones – the best-known and established class of chemical signaling molecules exchanged by animals – have been found in insects, not just in silk moths but in bark beetles, cabbage looper moths, termites, leaf-cutter ants, aphids, and honeybees. According to a 2003 report from the National Academy of Sciences, entomologists “have now broken the code for the pheromone communication of more than 1,600 insects.” And pheromones serve many more purposes than simply attracting mates: they elicit alarm, identify kin, alter mood, tweak relationships.

By the late 1980s pheromones had also been found to influence a wide spectrum of noninsect species, including lobsters, fish, algae, yeast, ciliates, bacteria, and more. As this new science of chemical communication grew – acquiring the more formal name of semiochemistry, from the Greek *semion* (meaning “signal”) – scientists extended the search to mammals. Almost immediately they rad into resistance from their colleagues.

“In the 1970s and 1980s people would jump at you if you said ‘mammalian pheromone,’” recalls Milos Novotny, director of the Institute for Pheromone Research at Indiana University. “They’d say, ‘There’s no such thing: mammals are not like insects. They’re too evolved and complex to be spontaneously responding to something like a pheromone.”

But by the mid-1980s Novotny had not only identified a pheromone in mice that regulated intermale aggression, he had synthesized it. Such compounds were also verified in rats, hamsters, rabbits, and squirrels. And as the list lengthened, it also became apparent that mammals’ pheromones were very like – if not identical to – those found in insects. As an example, most researchers cite the stunning work of the late Oregon Health and Science University biochemist L.E.L. “Bets” Rasmussen, who showed in 1996 that a sex pheromone secreted by female Asian elephants is chemically identical to one used by more than one hundred species of moths for similar purposes of attraction.

McClintock had proposed a similar idea in 1971 in her pioneering paper on menstrual synchrony. “Perhaps,” she wrote then, “at least one female pheromone affects the timing of other female menstrual cycles.”

Odorous Landscape

McClintock, now sixty-three, is sitting in a small, sunny room occupied by filing cabinets, computers, racks of stoppered vials and tubes, and scent sticks – all contributing to a faint, slightly sweet chemical aroma – and a dark-haired graduate student named David Kern. ("All the other graduate students would climb over my dead body to get in this room," he says.)

McClintock's lab is at the University of Chicago's Institute for Mind and Biology, of which she is a founding director. She wears a tweedy jacket over a bright patterned shirt, and she is thinking over a question: How far has the science of semiochemistry traveled since that day some four decades ago? The case for human chemical communication has been made, she says, and "our goal is to tackle identifying the chemical compounds. And then we can refine our understanding of what fundamental roles they play."

That task is anything but easy. Human body odor is estimated to derive from about 120 compounds. Most of these compounds occur in the water-rich solution produced by the sweat glands or released from apocrine, or scent, glands in the oily shafts of hair follicles. The apocrine glands concentrate the most under the arms, around the nipples and in the genital regions.

It is a complicated landscape, made even more complicated by our use of what researchers refer to as exogenous compounds, such as soap, deodorants, and perfumes, as Johan Lundström of the Monell Chemical Senses Center in Philadelphia points out. And yet Lundström marvels at how adeptly our brains sort through this chemical tangle. Neuroimaging work done at his lab finds a 20 percent faster response to known human chemical signals compared with chemically similar molecules found elsewhere in the environment. "The brain always knows when it smells a body odor," Lundström says.

This capacity is already present in infancy. Numerous studies in humans have shown that, as is true in animals, mothers and infants are acutely attuned to each other's scent. This scent knowledge is so precise that babies even prefer the parts of clothes worn by their mother (and their mother only) touched by sweat compounds. The recognition, interestingly, is more acute in breast-fed infants than in those raised on baby formula.

"We're still just mapping the influential compounds from those that are not," Lundström says. "I don't think we're dealing with one single compound but rather a range of different ones that may be important at different times." Pheromones operate under the radar, he says, and they influence – but do not necessarily completely control – numerous behaviors. "If we compare these with social cues, they may be less important that the obvious ways we communicate," Lundström says. But, he adds, the ability probably aided survival as we evolved, keeping us more closely attuned to one another.

Psychologiest Denise Chen of Rice University also argues that this kind of chemical alertness would have conferred an evolutionary advantage. In her research, she collects odor samples from individuals while they watch horror movies. Gauze pads are kept in viewers' armpits to collect sweat released during moments of fear. Later the pads are placed under volunteers' nostrils. For comparison, Chen has also collected sweat from people watching comedies or neutral films such as documentaries.

One of her early experiments found that participants could tell whether the sweat donor was fearful or happy at the time the sweat was produced. The subjects' guesses succeeded more often than they would by pure chance, especially for fear-induced sweat. Chen followed up with research showing that exposure to "fear sweat" seemed to intensify the alarm response – inclining participants to see fear in the faces of others. These exposures even enhanced cognitive performance: on word-association tests that included terms suggestive of danger, women smelling fear sweat outperformed those exposed to neutral sweat. "If you smell fear, you're faster at detecting fearful words," Chen explains.

In a recent study, she and Wen Zhou of the Chinese Academy of Sciences compared the responses of long-time couples with those of people in shorter-term relationships. Those results indicated – perhaps not surprisingly – that the longer couples are together, the better the partners are at interpreting the fear or happiness information apparently encoded in sweat. "What I hope that people will see in this is that understanding olfaction is important for us to understand ourselves," Chen says.

And evidence continues to accumulate that unconscious perception of scents influences a range of human behaviors, from cognitive to sexual. In January, for instance, a team of scientists at Israel's Weizmann Institute of Science in Rehovot, led by neurobiologist Noam Sobel, reported that men who sniffed drops of women's emotional tears felt suddenly less sexually interested in comparison to those who smelled a saline solution. Sobel found a direct physical response to this apparent chemosignal: a small but measureable drop in the men's testosterone levels. The signal may have evolved to signify lower fertility, as during menstruation. More generally, the discovery may help explain the uniquely human behavior of crying.

Hard Science

A major goal now is to identify the key chemicals that convey signals surreptitiously and to learn much more about how the body detects and reacts to those signals. George Preti, a Monell chemist, has mapped out a research project that would include tracking these messengers by analyzing sweat and aprocrine secretions and studies of hormone levels in those who sniff the chemicals. “We’ve yet to identify the precise signals that carry the information,” Lundström agrees. “And if we want a solid standing for this work, that’s what’s needed next.”

McClintock also sees this as a priority. In recent years she has focused on building a detailed portrait of one of the more potent known chemosignals, a steroid compound called androstadienone. She believes that this particular small molecule is potent enough to meet the requirements of being called a human pheromone: it is a small molecule that acts as a same-species chemical signal and influence physiology and behavior. Over the years, labs, including McClintock’s and Lundström’s, have found that this particular compound shows measurable effects on cognition and that it can alter levels of stress hormones such as cortisol and evoke changes in emotional response.

In one recent study McClintock and her colleague Suma Jacob of the University of Illinois at Chicago explored androstadienone’s propensity to affect mood. They mixed a trace amount into the solvent propylene glycol and then masked any possible overt odor with oil of clove. They then exposed one study group to a solvent containing the compound and another group to a plain solvent. Subjects were asked to smell gauze pads containing one version; they were told only that they were participating in olfaction research. All the subjects went on to fill out a long and tedious questionnaire.

Overall, the subjects exposed to androstadienone remained far more cheerful throughout the fifteen- to twenty-minute test. A follow-up study repeated the same process but included brain imaging as well. The neuroimages showed that brain regions associated with attention, emotion, and visual processing were more active in those exposed to the chemosignaling compound. McClintock sees this as a classic pheromonal effect, the kind that she speculated about decades ago.

Even so, she and other researchers continue to carefully talk of “putative” pheromones. Humans are complicated, and any causal links between specific chemicals and changes in behavior are hard to demonstrate conclusively. Indeed, no one can say for certain yet what chemical or chemicals account for McClintock’s original discovery, the synchronization of women’s menstrual cycles. Even the phenomenon itself has proved somewhat elusive: it has been confirmed in numerous follow-up studies but contradicted by others, and it is still not accepted unanimously by the scientific community.

Much of the discussion centers on what exactly is being synchronized – perhaps timing of ovulation, perhaps length of cycle. A review of human data from the 1990s by the father-and-son team of Leonard and Aron Weller of Bar-Ilan University in Israel found that synchrony sometimes occurs and sometimes does not. “If it exists,” Leonard Weller reported, “it is certainly not ubiquitous.”

Although she still retains the assertiveness of her college days, McClintock agrees that the effect is subtler than she thought at first. But she also believes that the critics tend to miss the more important point: that evidence for chemical communication between humans has steadily accumulated since her study. And that it is not surprising that our chemical messaging is turning out to be as intricate as every other form of human communication.

What was this article about?

- ❍ pollution (1)
- ❍ pheromones (2)
- ❍ genetics (3)
- ❍ I don't know (4)

What observation led McClintock into her field of research?

- ❍ Women synchronize their menstrual cycles (1)
- ❍ Some people smell different than others (2)
- ❍ People with blue eyes can smell fear better than those with brown eyes (3)
- ❍ I don't know (4)

What happened to research subjects who smelled fear sweat during Chen's study?

- ❍ They were calmer than those who smelled neutral sweat (1)
- ❍ They did better on word association tests than those who smelled neutral sweat (2)
- ❍ They became tired faster than those who smelled neutral sweat (3)
- ❍ I don't know (4)

What is the concept of human menstrual synchronization called today?

- ❍ The McClintock Effect (1)
- ❍ The Dorm Syndrome (2)
- ❍ Cycle Synching (3)
- ❍ I don't know (4)

What species was the first pheromone isolated from?

- ❍ Dogs (1)
- ❍ Moths (2)
- ❍ Elephants (3)
- ❍ I don't know (4)

Appendix G - Public Trust in Science

Directions: Rank your level of agreement to each of the statements on a 5-point Likert Scale from Strongly Agree to Strongly Disagree. *Indicates reverse-coded item.

1. When scientists change their mind about a scientific idea it diminishes my trust in their work.*

2. Scientists ignore evidence that contradicts their work.*

3. *Scientific theories* are weak explanations.*

4. Scientists intentionally keep their work secret.*

5. We can trust scientists to share their discoveries even if they don’t like their findings.

6. Scientists don’t value the ideas of others.*

7. I trust that the work of scientists to make life better for people.

8. Scientists don’t care if laypersons understand their work.*

9. We should trust the work of scientists.

10. We should trust that scientists are being honest in their work.

11. We should trust that scientists are being ethical in their work.

12. Scientific theories are trustworthy.

13. When scientists form a hypothesis they are just guessing.*

14. People who understand science more have more trust in science.

15. We can trust science to find the answers that explain the natural world.

16. I trust scientists can find solutions to our major technological problems.

17. We cannot trust scientists because they are biased in their perspectives.*

18. Scientist will protect each other even when they are wrong.*

19. We cannot trust scientists to consider ideas that contradict their own.*

20. Today’s scientists will sacrifice the well-being of others to advance their research.*

21. We cannot trust science because it moves too slowly.*