Among the Authentic Audience: Young Adults' Perceptions and Responses to Youth as Scientists

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AMONG THE AUTHENTIC AUDIENCE: YOUNG ADULTS' PERCEPTIONS AND RESPONSES TO YOUTH AS SCIENTISTS

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ABSTRACT

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Lifelong science learning is important for making informed decisions on science topics, and there is a need to engage broader and more diverse audiences with science. One opportunity for engagement occurs when students share science topics with a public audience. Research indicates this interaction can have benefits for students, but little is known about the impact it may have on audience members' thoughts about science. Youth are different from typical sources of science information, and may elicit different reactions. This dissertation examines the impact youth sources may have on adults' perceptions of and responses to science topics.

Young adults (N = 399) were randomly assigned to one of two scenarios. Both scenarios stated two individuals would describe research they had done about local air quality on the news. One scenario identified the individuals as local high school students, and the other as research scientists from a local institution. Dependent variables included perceptions of the warmth and competence of the presenters, expectations of the quality of the information they would share, willingness to take action based on that information, and general trust in scientists. A subset of participants (*N*=22) was selected for cognitive interviews and asked to explain the thoughts that influenced their survey responses.

Results showed multiple reactions to the scenario. Three groups were identified in the perceptions data: one expressed trust in the presenters, one expressed skepticism, and one based their perceptions on personal experiences doing science. Participants said intertwined thoughts about trust in scientists and assumptions about the presenters' intentions influenced perceptions, with an overall assumption that youth would have good intentions while adults might not. Participants did not appear to separate their expectations of the information from the people who would share it. However, their willingness to take action was related to the action, not the presenter or information. Findings suggest youth may be an avenue for engaging individuals who have lower trust in typical science information sources. Implications for science education and communication are discussed.

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CHAPTER 1: INTRODUCTION

The Problem: Science Literacy and Engagement among Public Audiences

Current U.S. society is full of issues rooted in science (National Research Council, 2011; Roth & Barton, 2004). Issues such as climate change, genetically modified food, stem cell research, polluting or green energy sources, and nutrition and health care impact individuals' lives and the structure of society. Making informed public or private decisions around these topics requires some understanding of the relevant science. Developing individuals who are able to understand and engage with science for the purpose of maintaining a democratic community has long been a goal of science education (e.g., Dewey, 1916). There has been extensive debate over precisely what knowledge or skills individuals need to fully participate, and definitions of 'science literacy', as it has been called, have included various degrees of focus on content knowledge, scientific practices, and community debate (Feinstein, 2010; Lewenstein, 2015). Regardless of the precise definition, an ability and willingness to engage with the relevant science is necessary for individuals to make informed decisions on a range of personal and public topics (Feinstein, 2010; Jenkins, 1999; Tate, 2013). However, the rapid rate of change in knowledge and application related to science topics indicates that schools cannot possibly teach students sufficient details about all of the science topics that will become relevant across their lifetimes (Falk & Dierking, 2010). This necessitates lifelong science learning if individuals are to make informed decisions in their personal and democratic lives.

There is a growing body of evidence that suggests individuals do, in fact, learn a great deal of their science knowledge through informal experiences with science (National Research Council, 2009). Outside of formal schooling, individuals engage with science through a variety of sources, formats, and interactions, collectively referred to as the 'STEM learning ecosystem' (Falk, Osborne, Dierking, Dawson, Wenger, & Wong, 2012; National Research Council, 2009, 2014). Current understanding in the field is that learning about science is not the result of a single or series of activities or sources, but rather a conglomeration of multiple experiences, encounters, and events spread over individuals' lifetime. For adults, personal interest and professional need are the major motivators for engaging in these activities (Falk, Storksdieck, & Dierking, 2007). However, the range and scope of science topics that are personally or politically relevant at the local or national level goes beyond what we can reasonably expect everyone to learn out of interest. Consequently, to foster full participation in decision making on science topics, science education must develop ways to engage broad audiences in science topics that they may or may not find inherently interesting (Mejlgaard & Stares, 2010; Stilgoe, Lock, & Wilsdon, 2014).

Engaging public audiences with science topics has historically been undertaken by two fields; informal science education and science communication. Although they share a goal of engaging a broad public with science topics, these fields have evolved out of separate fields of practice, with separate questions and methods, and consequently developed separate research bases (Lewenstein, 2015). While informal science education has primarily focused on the impact designed or unstructured free-choice learning environments have on cognitive or affective outcomes for individual learners, science communication has primarily examined factors that influence societal or community interactions with science, with a particular focus on participation in the governance of science through shared decision-making. Despite their differences in goals and levels, both fields seek to engage people in thinking about science topics. However, research in both fields has suggested that their recent efforts have not been effective at reaching broad and diverse audiences.

The disparities in success in formal science contexts have been well documented, with White and Asian men outperforming other individuals in most STEM academic and career fields (National Research Council, 2011; National Science Foundation, 2013). Explicit attention has been given to this issue, and the need to increase access to quality science education and diversity in the STEM fields has been effectively argued in terms of both economic and democratic justice (Lee, 2001; Tate, 2001) and developing a strong knowledge base and workforce in STEM (National Research Council, 2011). Informal science education has contributed to these efforts by developing programs with the specific focus of engaging individuals who are typically underrepresented in science, but engaging broad audiences has been found to be challenging when science conflicts with the culture, language, or identity of individuals and communities (Heath, 2007; National Research Council, 2009). The achievement gap has been ameliorated somewhat, particularly related to representation of women in biological fields (National Science Foundation, 2013), but disparity remains. This disparity has concurrently been noted in science centers and science museums, the mainstays of informal science institutions. Despite a common mission of providing science experiences to as wide a public as possible, and a call by a major report from the American Association of Museums (1992) to expand their audiences, visitors to these institutions continue to be less diverse, and more non-Hispanic White, than the general American public (Farrell & Medvedeva, 2010). Feinstein and Meshoulam (2014) have suggested that unless they find a way to engage more diverse audiences, "museums and science centers could even worsen the inequities of science education" (p. 369) by providing additional enrichment to an already privileged audience.

The disparities in engagement have also been felt in science communication, where a recognition over the past 20 years that their methods were unsuccessful has forced the field to reconsider their approach. Historically efforts to communicate scientific knowledge and findings with broad audiences took a deficit approach. Called public understanding of science, research and practice in this arena assumed that negative attitudes toward science were based on a lack of knowledge or understanding and could be remedied by educating an uniformed public about science matters (Jasanoff, 2014). However, extensive efforts by science communicators over half a century to 'educate the public' produced little to no effect on public knowledge and attitudes toward science (Miller, 2001). In fact, far from leading to an informed public, this approach has been found to lead to widening gaps in knowledge and engagement between the information rich and information poor (Nisbet & Scheufele, 2009).

In their seminal paper on the current path and future directions of science communication, Nisbet and Scheufele (2009) suggested that 'traditional' (deficit-model) communication activities are most effective at reaching an audience that is already interested, informed, and engaged. This 'elite' science audience is just one part of a diverse group of many publics, and activities that selectively (whether intentionally or not) target them lead to a widening gap between the knowledge or engagement rich and poor. This, in turn, leads to a widening gap in who participates in and governs science activities and decisions (Scheufele & Brossard, 2008). Nisbet and Scheufele (2009) argued that it is up to communicators to find ways to engage broader audiences (beyond the science 'elite') to ensure all publics have access to relevant science topics. This, they suggested, should be based on "a systematic empirical understanding of an intended audience's existing values, knowledge, and attitudes, their interpersonal and social contexts, and their preferred media sources and communication channels" (p. 1767) and necessitates "connecting a scientific topic to something the public already values or prioritizes, conveying personal relevance" (p. 1774). Indeed, they argued that the widening knowledge gaps between the science 'elite' and the many other diverse publics mean "it may be unethical if we *did not use all* communication tools at our disposal to connect with hard-to-reach audiences" (p. 1774, emphasis in original; see also Scheufele & Brossard, 2008).

Youth as Sources of Engagement with Science

An unexplored avenue for science engagement is the impact youth may have on the adults and communities in their lives. This is not meant to position youth as a 'tool' for science communication, but rather to suggest that youth's engagement with science topics bring a valuable contribution to their communities' relationships with science that has not been reflected in the research literature. To show this, the following sections will examine research on youth engaging their communities with science, the importance and complexity of those interactions, and the very limited research on how youth are perceived and received by adults when they talk about science.

Getting Youth Involved in Community Science

Adult-youth interactions around science occur in a variety of ways. From interactions at home about everyday activities to co-exploration of museums to adult attendance at youth science fairs, different types of interactions are influenced by different contexts and interpersonal relationships. This study will look specifically at the interactions that occur when youth share, present, or seek to engage with their communities about science topics. For individual, democratic, or justice reasons, facilitating the development of youth who can engage with science topics in their communities is undeniably important (Basu & Calabrese Barton, 2010; Calabrese Barton, 2003; Jenkins, 1999; Lee & Roth, 2003; Roth & Lee, 2004; Schusler & Krasny, 2008; Tate, 2001; Zahur & Calabrese Barton, 2002). This type of interaction is a common outcome in project-based or place-based learning, particularly when the projects focus on local or community contexts (Mueller & Tippins, 2015; Smith, 2012; Sobel, 2004), and in projects where science educators concerned with social or environmental justice explicitly seek to teach youth to speak up and engage in activism related to science topics (Roth & Calabrese Barton, 2004; Schusler & Krasny, 2008). In these projects, educators embed science content in community contexts, teach science through solving community problems, and teach youth to engage with and facilitate change in their communities (e.g., Birmingham & Barton, 2014; Mueller & Tippins, 2015; Tompkins, 2005; Volk & Cheak, 2003).

The belief that youth can and should impact their communities is an implicit aspect of encouraging them to engage with an audience beyond the classroom. However, although research on adults' learning ecosystems (described below) suggests that encountering science in this manner may have a non-trivial impact on adults, research from science communication (described below) suggests the interaction may be nuanced and complex. Unlike interactions that occur at informal institutions, where individuals or families interact with and around science content that is curated by professionals, in these interactions youth serve as the source of science information. This is an unusual source that is different from the more typical professional, institutional, or media sources of information on science, and consequently may have a unique effect on community responses. Despite this, the impact youth scientists may have on adults' attitudes, relationship, or understanding of science has not been well examined. Understandably for programs focused on youth development, research on these studies has focused on the youth. The questions are asked about the youth, the data is collected from and about the youth, and the focus is on youth's actions within the context of their community (e.g., Birmingham & Calabrese Barton, 2014; Gautreau & Binns, 2012; Tompkins, 2005). If we believe youth can engage in actions that impact their communities, then we must also believe their actions are having some impact on the communities' relationships with science. The perceptions, responses, attitudes, and beliefs of community members about the youth as sources of science information, and the impact they are having on the community, are typically absent in the research literature on these projects. Knowledge of how this interaction may impact adults is missing from the research-based understanding of adults' encounters with science.

Learning from Youth Science

Far from being incidental or primarily to serve the youth, research on continued science learning in other contexts suggests that the types of encounters with science topics facilitated by youth can be an important piece of science engagement for adult audience members. Once the mandated science courses in formal schooling end, adults primarily learn about science through a range of informal encounters. These include searching for information about a specific topic (often online), designed spaces such as museums or science centers, programs organized by schools, interest groups, or participatory science research, and through mass or social media (National Research Council, 2014; National Science Board, 2014). These activities are primarily engaged in voluntarily out of personal interest (Falk & Needham, 2013; Falk et al., 2007), but, as previously described, engaging only individuals who are already interested leads to a widening gap in who is able to make informed decisions around science topics (Nisbet & Scheufele, 2009). Engaging broad (non-'science elite') and hard-to-reach audiences involves engaging individuals who did not seek out science learning experiences (Crettaz von Roten, 2011). When youth share science topics with their communities, they offer a new opportunity for adults to engage with and learn about a topic they may not have encountered, or sought information about, on their own. This suggests that encountering science from youth may contribute to adults' engagement with science topics.

Publics' Reactions to Science

What we do not know from the research literature is the way youth voices are heard. Efforts to share science and engage members of a broader public with science have produced a great deal of evidence that the interaction is not simple. The "community" is not a blank slate that will listen to and accept what the youth say. Instead, research in science communication has found that the multiple publics' interactions with science are influenced by myriad personal, social, and communication factors (e.g., Davis & Russ, 2015; Miller, 2001). Adults may certainly engage with and learn from the science introduced by the youth, but assuming that the adults hear only what the youth are saying underestimates the complexity of the interaction. Specifically, this underestimates both the complexity of adult relationships with science and the particular impact youth voices may have on adult reactions and responses.

Following the shift away from the deficit model, science communication began working with a dialogue or engagement model that aimed to foster conversation, debate, and co-construction related to science topics between science and diverse publics (Holliman & Jensen, 2009; McCallie, et al., 2009; Stilgoe, et al., 2014). Research has found that multiple factors that influence multiple 'publics' (Nisbet & Scheufele, 2009) engagement with and attitudes toward science, including aspects of the communicator, communication, audience, and surrounding culture (Davis & Russ, 2015). One strand of this research has examined how audiences' trust in the source of information or communication impacts their responses to the message. Drawing on research in opinion formation (Bromme & Goldman, 2014), this strand is rooted in the idea that individuals do not always form opinions based on a detailed understanding of the relevant facts, but rather use heuristics to simplify the process. Researchers have directly examined audiences' trust in different sources of information (e.g., scientists, governmental organizations, advocacy groups) (Bickerstaff, Lorenzoni, Pidgeon, Poortinga, & Simmons, 2008; Brewer & Ley, 2013, Lang & Hallman, 2005; Nisbet & Myers, 2007), and examined the impact different sources have on audiences' responses to the same message (Gunther & Liebhart, 2006; Gunther & Schmitt, 2004; Schultz, Utz, & Goritz, 2011). Across these studies they have found that audiences have different levels of trust in different sources, and the messenger influences responses to the message.

The Particular Power of Youth Voices: Reactions to Science from Youth

There is very limited evidence about how adults may view youth as sources of science information. Although studies suggest that youth impact the communities' thoughts about science (e.g., Birmingham & Calabrese Barton, 2014) or describe the specific physical outcomes of youth's projects (e.g.,Tompkins, 2005), evidence of the impact on adults' attitudes, perceptions, knowledge, or engagement related to science is rare. The little evidence available in the research literature, however, suggests that youth may be perceived differently than other sources of science information, and may facilitate positive engagement with science topics. In two studies of individuals' responses to written text about a controversial issue, Gunther and colleagues (Gunther & Liebhart, 2006; Gunther & Schmitt, 2004) found that partisan individuals felt the same text was biased when the 'author' was a journalist, but fair and neutral when the 'author' was a student. In interviews with community members about a student environmental action project, Volk and Cheak (2003) found the adult community members felt the students were articulate, trustworthy experts about their topic who provided an example for the community.

These few studies suggest that youth have the ability to positively engage adult community members with science topics, and further do so in a way that is different than more typical sources of science information. Conversely, two studies of youth's perceptions of their abilities to impact their communities suggest that youth do not expect to be listened to, trusted, or taken seriously by adults in their wider communities (Bencze, Aslop, Ritchie, Bowen, & Chen, 2015; Valaitis, 2002). However, while these studies hint at a complex and interesting interaction between adults and youth when youth share science information, they do not paint a complete picture. Missing from the literature is a detailed understanding of how adults view youth as sources of science, and how their perceptions may impact their responses to the information youth bring.

Research Questions

Understanding perceptions, particularly when adults first encounter the youth in the context of the science topic, involves understanding adults' impressions of the youth. The field of social cognition offers a useful model for examining first impressions and the impact they have on later responses. The Stereotype Content Model (SCM) (Cuddy, Fiske, & Glick, 2007; Fiske, Cuddy, & Glick, 2007) is based on extensive research into immediate judgements individuals make when they encounter an 'other' in a social interaction. These judgements include perceptions of the warmth (friend or foe) and competence (ability to carry out intentions) of the 'other.' The SCM further links combinations of perceived warmth and competence to emotional and behavioral outcomes, which indicate a predisposition to help and support or dismiss and harm the encountered 'other'. Utilizing this model to examine adult perceptions of youth as sources of science information allows for an examination of both how adults view youth, and how they may respond to youth in terms of their willingness to trust and support youth's projects. This study begins to explore this interaction by examining the different perceptions of and responses to youth or adult scientists among a public audience made up primarily of young adults.

To that end, the research questions guiding this study are as follows:

1. What are young adults’ perceptions of the warmth and competence of youth or adult scientists?
    a. Are perceptions of youth and adult scientists different?
    b. In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the importance of air quality, and the presenters’ identities predict perceptions?
2. What are young adults’ expectations of the information quality and willingness to take action related to the science information (hereafter called ‘responses’) provided by youth or adult scientists?
    a. Are these responses different when the information is presented by youth or adult scientists?
    b. In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the importance of air quality, perceptions of the warmth and competence of the presenters, and the presenters’ identities predict these responses?
3. What are the reasons driving young adults’ perceptions of the warmth and competence of youth or adult scientists, and their willingness to take action based on and expectations of the quality of the information the youth or adults present?

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

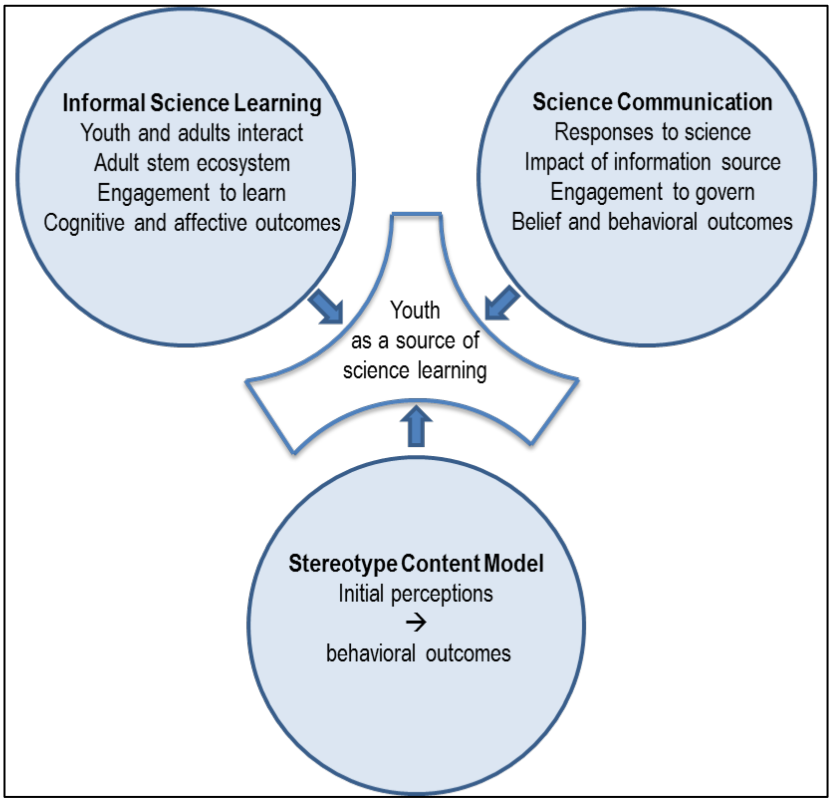
Introduction: Overview and Conceptual Model

This project is framed by the literature from the parallel fields of informal science education and science communication. Although both fields have at their centers the goal of engaging people with science topics outside of formal schooling, they have developed in different contexts with different questions, assumptions, and methods, and consequently with little overlap in literature, research, or practice. Whereas, broadly speaking, informal science education focuses on engaging individuals with and as participants in the existing community of practice in science, science communication focuses on understanding the factors that influence individuals' and communities' responses to and participation in the governance of science. It is only in the last few years that there have begun to be intentional efforts to connect the fields, primarily through informal educators looking for lessons that can be learned from research in science communication (Baram-Tsabari & Osborne, 2015). While reading across the fields it became apparent that despite recent efforts at connections there is a significant division, and the two fields operate independently of each other. However, as others have noted (e.g., Baram-Tsabari & Osborne, 2015; Feinstein, 2015), they also have aspects in common and could learn much from each other. It is in that spirit that this study will draw on the literature from both.

As will be seen in the review that follows, an area that appears to be missing from both fields is the role that youth play as a source of science information. There is extensive research that examines youth learning in informal environments, but little that looks at how youth contribute to the science learning and engagement of those around them, particularly in regards to adult learning and engagement. There is, therefore, limited research in either field that speaks directly to the questions raised in this project. However, pieces of both fields suggest a complex and interesting interaction, in the way surrounding puzzle pieces suggest the colors of a missing piece. When taken together they provide a structure for understanding the specific questions examined in this project. This conceptual model (see Figure 2.1) draws from research on adult-youth interactions around science, adult learning in the STEM ecosystem, factors that influence responses to science, interpersonal perceptions and bias, and the importance of the source in science communication. In this chapter, rather than reviewing a coherent body of literature related to my topic (as one does not exist), the most relevant research from each of those aspects will be used to outline the shape of the topic under study, and suggest that youth represent an interesting, and underexplored, source of adult engagement with science.

To do this the review first examines literature that describes the ways adults might interact with youth around science topics and situates those interactions in the informal science learning literature as potentially important pieces of the adult STEM learning ecosystem. It then examines research from science communication that outlines factors that influence adults' interactions with science, giving particular attention to the impact the source of information has on audiences' responses. These separate sources together suggest that youth may elicit different responses to science content than more typical sources of information and thus offer a unique contribution to the STEM learning ecosystem and efforts to engage a broad audience with science topics. Finally, the review examines a theoretical model from social cognition that is used to examine adults' perceptions and responses to youth as sources of science information. Additionally, as the two major fields of informal science education and science communication have developed separately, this review makes connections between them as appropriate but different sections draw more heavily from one field than the other.

Figure 2.1: Conceptual framework: Existing research outlining the missing piece



Youth as Active Contributors to Community Science

This study is based on the premise that adults can learn about science topics through interactions with youth. As will be seen, the research shows that interactions between adults and youth occur in a variety of contexts, and can be influential pieces of youth's science learning. This is particularly true of contexts where youth seek to engage with a public or community audience around a science topic. This section first examines research on potential adult-youth interactions around science, then focuses specifically on settings in which youth serve as the source of information and intentionally seek to engage community members with science topics. The research that has been conducted on these interactions is then examined to show that there is a lack of attention in the research to the potential impact the youth may have on their communities' interactions with science.

Adult-Youth Interactions around Science

Interactions between youth and adults around science topics can take a variety of forms and occur across context, locations, and time. Research has suggested that adults and kids engage in and talk about science at home, and adults can be a critical part of youth's experiences (e.g., Bricker & Bell, 2013; Zimmerman, 2012). Indeed, providing experience and opportunity to kids is a common reason adults engage in informal science experiences (Falk & Dierking, 1992), and there is a substantial body of research on how families interact with the science they encounter at informal institutions (e.g., Crowley, Callanan, Jipson, Galco, Topping, & Shrager, 2001; Ellenbogen, Luke, Dierking, 2004). Additionally, it is not uncommon to have students produce something aimed at engaging with a public audience as part of a structured science learning experience, such as through science fairs or festivals, or sharing their learning with their community (e.g., Birmingham & Calabrese Barton, 2014; Thompson, 2000). These contexts and the interactions they facilitate are different. While there are many aspects that could influence each type of interaction, related research suggests there are two underlying conditions that would impact the nature of the interactions: the relationship between the audience and youth, and the source of the science information.

First, adults' relationship with the youth would certainly be a major factor in the interactions. Most interactions could reasonably be placed into one of two categories in terms of that relationship: interactions in which the adults and youth have a pre-existing relationship (known youth), and interactions in which they do not (unknown youth). The context and relationships surrounding interactions with known and unknown youth are different. With known youth, as described in the museum literature (Ellenbogen et al., 2004), the interaction would be embedded in the relationships and non-science interactions of the adults and youth. This may be particularly true when there is a close relationship between the adults and youth, such as parents with their children. This is supported by research into family interactions in museums, which found that when parents and children encountered science together, parents took on the role of explainers, situated the content in their past experiences, and used the science content and experiences to support their pre-existing family agenda rather than focusing specifically on the science content (Crowley & Jacobs, 2002; Crowley et al., 2001; Ellenbogen et al., 2004). This suggests that when adults encounter science with known youth, their relationships with the youth play a larger role in their responses than reactions to the science content.

With unknown youth, the interaction would logically be less tied to personal connections and based more on adults' first impressions of or existing beliefs about youth as a group, not the specific youth as individuals. The formation and consequences of first impressions have been studied extensively in the field of social cognition, which examines how we process and engage in social interactions (Fiske, 2013a). This is based on the idea that humans are essentially social animals who must quickly determine intentions and threat (i.e., friend or foe) when encountering others. Work in the field suggests that individuals form immediate impressions of unknown others, seeking to fit the other into existing patterns, to quickly determine the others' intentions and an appropriate response (e.g., flight, fight, ignore, or cooperate?) (Fiske et al., 2007). These impressions cue stereotypes, which in turn influence emotional, attitudinal, and behavioral responses (Cuddy, Fiske, & Glick, 2008). This suggests that when audience members do not have existing relationships with the youth scientists, their responses will be guided, in part, by the immediate perceptions and judgements they make about the youth.

Second, the source of information—who introduces, develops, or holds the science knowledge—is different in the different contexts. As will be described in detail below, perceptions of the source of information influence responses to science topics (Brewer & Ley, 2013; Bromme & Goldman, 2014; Brossard & Nisbet, 2007; Nisbet & Myers, 2007). In informal institutions, individuals and families primarily interact with content that has been developed and curated by professionals. Although families may bring in background knowledge or connect to diverse previous experiences, the content they encounter is typically part of exhibits that were designed by museum or science staff. Professional staff, or the institution they work for, are therefore the source of information. In contrast, when youth produce content for a science fair or community project, the youth are the source of science information. In these contexts, the youth take the position of the scientists, and adults encounter the content through the youth. Additionally, the interactions in this context may be influenced by the relationship between the adults and youth, as it seems reasonable, for example, to expect adults to respond differently to their own child than to an unknown youth.

These two underlying variables set up different types of interactions, and consequently raise different questions. This study focuses on one of these contexts, when unknown youth are the source of science information. This context is particularly interesting because it is likely to be encountered by youth who seek to take action around science topics in their communities. As an educator interested in empowering youth to engage with science topics in society, it is important to understand the responses the youth may encounter, how the youth may be received, and how their actions may influence the community.

Youth Engaging with Community Science

Engaging youth in locally-relevant science topics is a common, and important, format for science learning. These projects can take a variety of forms, and fall under various titles including *place-based education, community-based education, socioscientific issues, democratic science pedagogy,* and *environmental education or action*. Regardless of title, projects typically involve youth engaging in collecting and analyzing data around a (frequently environmental) science-related topic and sharing their findings with an audience beyond the classroom. For example, Tompkins (2005) engaged high school students in efforts to improve and maintain the health of a local waterway. The students determined that the water quality in the stream was good, but erosion was becoming a problem. To address this, students researched methods for limiting erosion, determined which method was best for the stream in question, and applied for and were awarded funds from the state to implement their plan. Buxton

(2010) described a project engaging middle school students in learning about health and environmental impacts of water use. Students examined topics related to local water use and public health, and developed public service announcements to share their findings with their school and community. Roth and Lee (2004) engaged middle school youth over several years in conducting research projects related to a local creek. Students selected topics, conducted research, and presented their findings to an environmental group working in the community. These projects occurred in different contexts and with somewhat different focal topics, but have at their heart youth developing scientific knowledge around a topic and seeking to engage members of a broader community with their findings. In the projects, youth produce and are the source of the science information encountered by the public audience.

Educators engage students in these projects for a variety of reasons, but project goals often involve a combination of content learning, youth empowerment, developing scientifically literate and active citizens (democratic participation), and specific action around a science issue. For example, developing scientifically literate citizens for the purposes of democratic participation has long been a goal of science education as a whole (Feinstein, 2010; Jenkins, 1999). (The nuances of "science literacy" and participation will be discussed in greater detail below). Lee and Roth (Lee & Roth, 2003; Roth & Lee, 2004) have suggested that participating in community-based science endeavors is a fundamental aspect of science literacy, and that science education should therefore be based on "learning environments that allow students to become knowledgeable by participating in and contributing to the life of their community" (Roth & Lee, 2004, p. 64). Calabrese Barton and colleagues (Basu & Calabrese Barton, 2010; Calabrese Barton, 2003; Calabrese Barton & Tan, 2010; Zahur, Calabrese Barton, & Upadhyay, 2002) have similarly argued for community-based learning environments, but for the purpose of student empowerment and justice rather than democratic functioning. They have suggested that science education should be situated in local contexts relevant to students' lives in order to develop students' belief that they are already experts who can and do participate in and contribute to the science community. They aim to empower students to work for social justice by "becoming subject-matter experts and leveraging knowledge to reflect and act on injustice in their lives" (Basu & Calabrese Barton, 2010, p. 75). Others have focused more on topic-based outcomes. For example, Gautreau and Binns (2012) focused on content-knowledge, and compared outcomes for students in a 'traditional' course to students working on a place-based project developing management recommendations for a local ecosystem. In a study of the reasons practitioners engaged students in environmental education projects, Schusler and colleagues (2009) found that practitioners cited both influencing individual environmental behaviors and developing sustainable communities as motivating goals. While theoretically different, in practice these goals overlap. Although individual projects may be more explicit in their pursuit of some goals over others, well run projects may produce outcome across the goal types regardless of their specific intent (e.g., Schusler & Krasny, 2010).

Inherent in these projects is engagement in science content beyond the science "classroom" (i.e., the confines of the program participants). Examination of projects shows that youth engage with multiple types of audiences in multiple ways through these projects, including writing letters to the newspaper, developing public service announcements or videos, contributing knowledge to community efforts, presenting their findings to school or community boards, putting on events or fairs for the community, seeking external funding, and implementing their plans for community actions (Bencze et al., 2015; Birmingham & Calabrese Barton, 2014; Buxton, 2010; Roth & Lee, 2004; Tompkins, 2005). Termed an 'authentic audience', evidence across contexts has suggested that preparing science content for an audience that is in some way public enhances students' interest, motivation, and learning (Chen, Hand, & McDowell, 2013; McDermott & Kuhn, 2011; Thompson, 2000). Schusler and Krasny (2008) highlighted the importance of the public audience by suggesting that beyond beneficial, engagement with a broader audience is fundamental to positive student outcomes. In the context of environmental projects, Schusler and Krasny suggested that effective youth participation depends on six characterstics: youth as contributors, genuine participation, deliberate action, inquiry, critical reflection, and positive youth development. All of these are important, but genuine participation is most relevant for the current study. Drawing on Freire's (1973) suggestion that an understanding of the functioning of democracy can only be assimilated through experience, Schusler and Krasny (2008) suggested that in order to be effective, environmental action projects need to occur in "authentic situations where youth can contribute and influence outcomes" (p. 272). This means that if youth are to believe they can take actions around science topics that impact their communities, they need to have opportunities to actually engage around science with members of a public (non-program) audience.

Research on Youth as Active Contributors to Community Science

Despite the importance of the authentic opportunity to engage with and influence a public audience, the actual impact on the audience has not been a focus of research. As these are primarily education programs, research has understandably emphasized the experiences and outcomes for youth. In an excellent example, Birmingham and Calabrese Barton (2014) described a project in which high school age youth held a ‘green carnival’ to share their growing environmental and sustainability knowledge with their community. This occurred as part of a year round after-school program in which youth research authentic local environmental problems in order to “take on relevant green energy issues and communicate findings to their community” (p. 291). The authors described in extensive detail how youth developed the locally-based ideas for the carnival, planned the activities that would occur at the event, and worked the booths to capture community members’ attention and engage them in thinking about the science. For example, the youth’s exhibits focused on topics such as persuading community members to switch to energy efficient light bulbs, sharing the youth’s design for a new LEED certified (green and sustainable building program) teen activity center, and understanding the health impacts of energy production. Additionally, the article details how youth considered and attended to community members’ concerns, needs, and knowledge by planning interactive activities that would be locally and personally relevant to carnival visitors. The researchers reported that the carnival attracted over 100 visitors, was a lively and energetic event, and generally a success.

It is clear from the study (Birmingham & Calabrese Barton, 2014) that youth were deeply engaged with the project, learned a great deal about energy science, and were thinking carefully about the roles of both science and themselves in their community. The impact on the community, however, is less clear. The researchers suggested that the accessible, relevant design of exhibits “allowed the green carnival to open dialogue and foster interaction within science among community members" (p. 306) and argued that "the youth altered the relationship between science and community in Great Lakes City through opening up new spaces of participation for visitors" (p. 309). Despite these claims and the apparent success of the event, the study does not present data examining community members' knowledge of, attitudes toward, or relationships with science. Although the researchers mentioned a youth-authored survey that was given to carnival visitors, contents and analysis of the survey were not described in the study and data taken from it were limited to a handful of quotes.

While this example of youth bringing science to their community is an excellent one, it is also typical of such studies in that it documents youth's engagement with the community but not the community's engagement with the youth. The National Research Council recently commissioned an extensive review of the research literature addressing informal science learning. The result, the 300 page *Learning Science in Informal Environments* (National Research Council, 2009) detailed the state of knowledge in the field. Although the report discussed learning for both adult and youth learners, and described research on settings that included interactions between youth and adults, it did not examine the potential of youth as a source of adult science learning. Throughout, youth are positioned only as learners, whereas adults (particularly parents and teachers) are positioned as both individual learners and sources of children's learning. For example, the report described how science learning may happen in everyday settings, such as when children ask questions about the science found in everyday activities. The report suggested that

> such questions often emerge in conversations that become potential learning situations for children. Although the children themselves are not likely to be thinking about the domain of science, their questions engage other people in the exploration of ideas, creating an important context for early thinking about science. (p. 94)

This is certainly true. However, drawing on the ideas of frame analysis[1] to examine the positioning of the actors highlights the underlying beliefs about youth. In the above quote, although both children and adults are engaged in the conversation, the report identified this as a potential learning situation only for the children. This implies that adults would not engage in meaningful learning through the interaction. The framing of youth-as-only-learners continues throughout the report, suggesting that youth-as-sources-of-adult-learning has not been valued in the research literature the report was based on. Examining individual studies shows that youth's impact on the adult audience members is often absent. Projects may report on physical outcomes of youth's efforts (e.g., external funding, physical implementation of youth's plans (Calabrese Barton & Tan, 2010; Tompkins, 2005)), but do not systematically examine with evidence the deeper impact youth may be having on the community's relationship with science or science topics.

A notable exception, and the only one encountered thus far, is Volk and Cheak's (2003) examination of a middle school environmental education program. Over five

[1] Frame analysis is a form of discourse analysis that is used to examine the beliefs embedded in the communication of a topic. Based on the work of Goffman (1974), it holds that frames are lenses or sets of beliefs that are used to shape and interpret messages, actions, and events. When used to shape an issue, intentionally or subconsciously, framing involves highlighting particular pieces and drawing specific connections. As an analytic technique, frame analysis involves identifying those cues in a specific communication, to understand the underlying frames used by the author to shape the issue. Additionally, beyond examining what is present in a communication, frame analysis also asks what is missing (Patel-Stevens, 2003) to further highlight what was valued by the writers.

years, Volk and Cheak engaged 101 5^{th} and 6^{th} grade students in Molokai, Hawaii, in investigating local environmental issues. Students selected topics, conducted investigations, made recommendations for action, and participated in trying to resolve the problems with the community. Along with research on student outcomes, the researchers conducted interviews with parent (12 individuals) and non-parent (7 individuals) community members on their reactions to students' efforts and perceptions of the importance of the student projects for the island community. Through the interviews, Volk and Cheak found that:

> adults put a lot of faith in the fifth and sixth grade children who are in this program, so much faith as to turn particular problems over to them, listen to what they have to say at public hearings, and be aware that they can actually teach the adults something about issue resolution (p. 17)

Non-parent community members quoted in the study stated that the youth gave convincing presentations to government officials that were "more factual than what adults [were] saying" (p. 21), and the students "really took command of the subject. They were thorough. They taught. We learned." (p. 20). Other quotes stated that the youth's efforts resulted in community members who were not affiliated with the youth or school participating in the conservation efforts, that the youth were contracted by the local paper to write articles about their efforts, and the youth were "setting the example for the entire island" (p. 23). It is clear from these findings that the students successfully engaged the broader community in thinking about their chosen topics. The study does not, however, address the particular impact the science information coming *from youth* had on the community's responses. If the presentations and articles were instead developed by adult community members, or non-community scientists, would the community have listened in the same way? Would they have learned? Would they have viewed the adults as setting an example for the entire community? How did sharing science information through youth voices impact the community's engagement and response? These questions were not addressed by Volk and Cheak's study, and are similarly absent in the broader research literature examining encounters with science outside of school.

Section Summary

While it is clear from the research that youth are engaging their communities around science topics, the impact they are having is not clear. Throughout the literature, by focusing on youth engagement and outcomes, research has positioned youth as recipients, not contributors, in science learning. Events and interactions such as the ones described certainly have potential to impact the community, and, based on research on informal learning and science communication (described in the following sections), that impact may go well beyond a single event or environmental action step. However, research in science communication suggests that individuals' attitudes toward and relationships with science are multi-faceted, deeply-rooted, and complex. Adults' engagement with and learning about science topics through interactions with youth is likely to be equally complex, but the potential demonstrated by youth through multiple projects suggests the impact they are having is valuable and worth exploring.

Adult Encounters with Science

Far from being trivial, research on informal encounters with science suggests that interactions similar to the ones initiated by youth may be important contributors to adults' relationships with science. As will be seen in the following review, research from informal science education shows that adults learn about science topics from a variety of contexts and interactions throughout their lives, and that short informal encounters (such as news stories or in person conversations) can play an important role in adult engagement with science. Although the literature has not yet examined adult science learning specifically from interactions with youth, the research from other contexts suggests that engaging with science topics in the ways they are introduced through youth projects has the potential to influence adults' knowledge, attitudes, interest, and engagement related to science. Additionally, as research shows that adults' intentional learning about science topics is primarily voluntary and based on personal interest, youth-introduced topics presents a potential avenue for engaging adults who may not have sought out learning on those topics on their own—an important goal in efforts to enable broad participation in informed decision making around science. In this section research on the importance of informal science learning is examined first, followed by the ways and reasons adults may encounter science in informal settings. It ends with a discussion of the reasons practitioners in informal science education and science communication seek to engage adults with science topics, focusing on the different meanings of the terms 'engagement' and 'science literacy' in the two fields, and the resulting goals or outcomes of engagement with science.

Importance of Informal Encounters with Science

Learning about science and the natural world occurs all the time. In their seminal paper, Falk and Dierking (2010) suggested that life-long informal science learning plays a much larger role in American learning and science literacy than had previously been recognized. Falk and Dierking began by pointing out that on average Americans spend only 5% of their lives in formal education, and with the current climate of high stakes testing privileging math and literacy only a small part of that 5% is spent in formal science education. They suggested that "non-school resources—used by learners across their lifetimes from childhood onward—actually account for the vast majority of Americans' science learning" (p. 486), over and above formal education.

There is abundant evidence that individuals can learn through informal science encounters (National Research Council, 2009). The particular importance of informal learning relative to formal schooling is examined in a set of studies by Falk and colleagues (Falk & Needham, 2013; Falk et al., 2007). In these studies, telephone surveys on science learning were conducted with large samples designed to be representative of the population of greater Los Angeles, California. In the first study (Falk, et al., 2007), 877 participants were asked whether there was a science topic they felt knowledgeable about, and how they came to be knowledgeable in that topic. A vast majority (91%) of respondents said there was a science or technology topic that they knew more about than the "average" person. When asked how they came to be relative experts in their topic, 23% said they learned about the topic through work or work-related training, 34% said through formal schooling, and 43% of participants said they had learned about the topic in their leisure time, through free-choice learning experiences such as the internet, books, going to museums or science centers, or joining clubs that addressed their interests. While formal schooling was mentioned often, it was not as frequent a source of science learning as informal or free-choice learning.

In the second study (Falk & Needham, 2013), adult participants (N = 1018) were asked to rate their own knowledge of science and technology, and their experiences with five categories of sources of science learning: formal science schooling, childhood or adult informal science experiences, workplace science learning, and "privilege" (gender, income, ethnicity). For example, for the informal experiences participants were asked how often they engaged in activities such as visiting museums, reading books related to science, watching science programs on television, or participating in science programming as a child or currently as an adult. The researchers examined the relative impact each of the five source categories had on participants' self-reported knowledge. All five sources were found to significantly contribute to science knowledge, with adult informal experiences accounting for the greatest amount of variance in knowledge (39%), privilege accounting for 23%, workplace experiences for 20%, and formal schooling and childhood informal experience each accounting for 17%. While formal schooling did contribute to science knowledge, adult informal experiences accounted for almost twice the variance in knowledge as formal schooling, and the combination of childhood and adult informal experiences accounted for more than half the variance. Although these studies are limited by the self-reported nature of the measures of science knowledge and correlational (not causative) relationship between experiences and knowledge, as the authors suggested the amount of variance explained by informal experiences, and the frequency with which informal experiences were cited as sources of knowledge highlight the importance of informal experiences in science learning.

Avenues for Adult Engagement

Where do adults encounter science? Banks and colleagues (2007) described learning across the lifetime, encompassing both formal and informal settings, as life-long (across the life span), life-wide (across contexts in individuals' lives), and life-deep (connecting to moral, religious, and social values that shape beliefs). Building on this, informal science learning encompasses all forms of learning about science that occur outside of formal instruction, and covers a broad range of settings, activities, participants, outcomes, and goals. The National Research Council (2009) report identified three major venues or configurations through which informal science learning often occurs. These include programs (a range of more to less structured activities, where individuals come intending to participate), designed settings (most commonly zoos, aquariums, museums, where individuals come intending to participate but participation is free-form and self-directed), and everyday or family settings (a wide range of activities including reading about or discussing science topics (such as the weather, health topics, energy bills) with others). Additionally, the report highlighted the media (radio, television, movies, and both print and digital media) as a separate influential source of informal science learning.

A complex interaction of personal and social factors influences interactions with science throughout individuals' lives. For adults, personal and professional interest or need are major motivations for continued science learning. In Falk and colleagues' (2007) study (described earlier), personal interest and curiosity was cited by most participants as the reason they pursued learning about their topic. Multiple studies have shown that adults are quite capable of becoming knowledgeable experts in science topics when they want to be, such as through hobbies (Liu & Falk, 2014) or need to be, as with medical topics (Layton, Jenkins, Macgill, & Davey, 1993). Outside of medical or personal crises, these informal science experiences, including activities such as visits to science museums, reading about science in books or online, and participation in clubs, are primarily activities that adults engage in voluntarily. This is equally true of engaging in formal science learning beyond K-12 schooling. While adults enrolled in science-focused higher education may not be able to select the topics covered in their courses, for the most part they voluntarily elected to pursue further education in a specific field. In fact, interest in the field has been identified as a major factor in pursuing and succeeding in a science field (Tai, Liu, Maltese, & Fan, 2006). However, the rapid rate of change in knowledge related to science topics necessitates continued science learning about multiple topics, both personally interesting and not, if individuals are to engage with science decision-making in their personal and public lives (Jenkins, 1999).

When not driven by personal interest or professional need, adults' engagement in science topics depends on intentional outreach by science organizations and accidental encounters with science experiences. There is a small body of research on engaging adults with science experiences in unexpected locations, when they did not seek out or intend to learn about science. Termed Public Science (Arcand & Watzke, 2011), these outreach projects attempt to engage individuals who are not actively pursuing a science experience (Crettaz von Roten, 2011; Norsted, 2010). For example, previous projects include astronomy exhibits and activities at ball games (Norsted, 2010), exhibits explaining the science of daily life on New York City streets (Cole & Cutting, 1996), placing astronomy images in non-traditional locations such as parks or airports (Arcand & Watzke, 2011), and placing sustainability and water conservation messages in hotel rooms (Storksdieck, Ellenbogen, & Heimlich, 2005). Crettaz von Roten (2011) suggested that projects such as these are a means for reaching broader audiences for science by engaging ‘casual visitors’ in unexpected encounters with science.

These events, however, are limited in both number and the range of topics they cover. Outside of such events, encounters with science topics frequently occur when a topic is raised in the news media or through personal conversations. The importance of news media as a source of science information can be seen through the Science and Engineering Indicators report, a biannual nationally representative overview of the state of the science enterprise. In the 2012 survey (National Science Board, 2014), 33% of participants cited newspapers (either print or online editions) and 32% cited television as their primary source of new information about science and technology. Although the percentage of Americans relying on television has decreased in recent years (down from 39% in the 2008 survey), together television and news media are a major source of science information for roughly two-thirds of Americans. Additionally, individuals may turn to the news for any number of reasons (not specifically to learn about science news), making news consumers more similar to Crettaz von Roten’s (2011) casual visitors than intentional science learners. This suggests that news media plays a major role in reaching and engaging a broad audience with science topics.

Current understanding in the field of informal science learning is that these multiple contexts for interacting with science work together to form an “ecosystem” of science learning. The report on a recent convocation on STEM learning organized by the National Research Council (2014) described how individuals encounter STEM topics through concentric circles of influence across multiple sectors of society. These include formal and informal, personal and public, structured and free-form, interest and need-based interactions. For example, an individual may encounter the topic of space though high school earth science class, religious texts or sermons on the creation of heaven and earth, news stories about developments at NASA, observations of the stars at night, and popular media such as movies like *Armageddon* (Bruckheimer, Hurd, & Bay, 1998) or *Contact* (Zemeckis, Starkey, & Zemeckis, 1997). Together, these diverse, unconnected experiences influence individuals' STEM-related attitudes and knowledge throughout their lifetime. While this diversity of experiences presents a challenge for coordinating, analyzing, and measuring the impact of individual or multiple interactions, the convocation speakers emphasized the potential of this ecosystem to enhance STEM learning by harnessing "the unique contributions of different settings to deliver STEM learning for all" (National Research Council, 2014, p. 11). This echoes an earlier report on the science education community in the United Kingdom (Falk et al., 2012) that suggested "it is not the one-off, individual experiences that matter as much as the totality" (p. 10) of experiences and encounters for individuals' thoughts, attitudes, and knowledge related to science topics.

Together, this suggests that short encounters with science, such as the types that often happen when youth share their science work with public audiences, could in fact be important pieces contributing to adult science learning. Additionally, these youth-initiated encounters may be an avenue for adults to engage with topics that are important for the community, but that the adults did not find inherently interesting enough to pursue independently. However, while research has examined the impact of various pieces of the ecosystem, and coordination across pieces, on individual (adult or youth) learners (National Research Council, 2009, 2014), research on adult-youth interactions has focused on adults' impact on the youth, not youth's impact on adults. This is a missing connection in the learning ecosystem, and a potentially valuable source of adult engagement with science.

Purpose of Engaging with Science

Following from the 'unique contributions' of the diverse experiences (National Research Council, 2014), the goals of informal encounters with science vary greatly across contexts. Additionally, this is one place where the different traditions of science education and science communication can be seen. Although the overarching goal of engaging individuals with science topics is common to both (McKinnon & Vos, 2015), the focus, framing, and purpose of engagement differ. Lewenstein (2015) suggested that 'engagement' means different things in the two fields, with education using the term to mean engaged with learning materials, while in science communication it has come to mean public participation in the development or knowledge and governance of science.

The difference in meaning may be due to the different contexts in which the fields developed. Informal science education developed in and around the study and practice of formal science education. While there is a long history of both research and practice in learning science in informal settings, it is only recently that the field has attempted to define itself as a separate entity rather than a subsection of formal science education (National Research Council, 2009; Rahm, 2014). Because of these roots, educating students in the knowledge, practices, and norms of science is often the major focus. In this context, 'engagement' is seen as a tool to promote learning, or a way of interacting with and becoming part of the science community of practice (Lave & Wenger, 1991). In contrast, science communication initially grew out of scientists' perception that the ‘general public’ was deficient in knowledge about and respect for science, and developed in the context of scientists’ efforts to ameliorate that deficit (Bucchi & Trench, 2008). The field has evolved a great deal in the past 40 years, in particular through a major paradigm and cultural shift in the last 15 years (this will be described in detail in a later section), and presently tends toward critique of the institution of science and its interactions with a diverse and complex society (Lewenstein, 2015). Due, perhaps, to the dramatic nature of this shift, science communication has been hesitant to use the language of teaching or learning, as it resembles the earlier deficit-based model (Davis & Russ, 2015). Instead, researchers promote ‘engagement’ as diverse publics participating in the social construction of knowledge, a process in which science offers just one form of knowing. Consequently, the goals of informal science education focus on developing individual students’ interest, competence, and participation in, and empowering students as members of, the existing community of science practice (National Research Council, 2009), while the goals of science communication have shifted to focus on understanding and manipulating social patterns, social group learning, and the dynamics of interaction, knowledge building, and power that exist between science and multiple diverse publics (Baram-Tsabari & Osborne, 2015; Davis & Russ, 2015; Lewenstein, 2015).

Specifically, in informal science learning, the National Research Council (2009) proposed a framework comprised of six strands for understanding the potential cognitive, social, developmental, and emotional outcomes of informal science experiences. Strands 2-5 align tightly to the four strands in the learning framework for formal science education proposed by the comprehensive report, *Taking Science to School* (National Research Council, 2007). These four focus primarily on the cognitive content, practice, and epistemological aspects of science learning. Strands 1 and 6 focus on the more affective factors of excitement, motivation, interest, and self-concept related to science. The National Research Council (2009) suggested that strands 1 and 6 are particularly relevant for informal environments, and informal environments are well-suited to develop them. Additionally, given the importance of non-cognitive factors to success in formal science learning (Farrington et al., 2012), developing individuals' interest, excitement, and self-concept in science represent a particularly important contribution of informal environments to overall science learning.

In contrast, the goals of science communication are nominally less concerned with particular cognitive, or even affective, outcomes. Instead, they focus on fostering social processes involving dialogue and engagement with science. Broadly, the intended outcomes of these processes include fostering democratic governance of science policy (including dialogue, debate, and policy making) (Stilgoe et al., 2014), the co-construction of knowledge (connecting multiple ways of knowing where both science and non-science individuals contribute and learn) (Davies, McCallie, Simonsson, Lehr, & Duensing, 2009; Lehr, McCallie, Davies, Caron, Cammon, & Duensing, 2007) and engaging broad and diverse audiences with science (Nisbet & Scheufele, 2009). However, despite the current stated commitment to engagement and dialogue, other authors have suggested that the initial goals of informing public audiences about the knowledge, practices, and developments, of 'sound science' is still embedded in much of science communication (Irwin, 2006), and still an important piece of the larger purpose of communicating science (Sturgis & Allum, 2006).

Building on this, 'science literacy' has often been touted as a major motivating goal in both fields, though again their understandings of the term are somewhat different. Interestingly, the definitions are in some ways flipped from the two fields' other goals. Lewenstein (2015) provided a concise overview of the different definitions (p. 255). In science communication, 'science literacy' has typically meant public knowledge of scientific facts, as measured on large scale surveys. These surveys have been a focus and had a large influence on the field, and science communication has made little effort to develop a more complex definition of science literacy. Conversely, Lewenstein described how education has vigorously debated the meaning and measurement of science literacy. Definitions have focused on the science content or practices that students will need to know to fully participate and make informed decisions around personal or social issues. Although this has a social participatory aspect more closely aligned with the other goals of science communication, Lewenstein suggested that education has missed a critical piece of the issue by focusing almost exclusively on individual, rather than group or community, learning.

Drawing on research from both education and communication, Feinstein (2010) developed an interesting alternative interpretation of science literacy. Feinstein suggested that it is unreasonable to expect any individual (including scientists) to develop sufficient content knowledge to make informed decisions about every science topic that arises. Instead, he proposed that a scientifically literate individual should be a *competent outsider* who is able to recognize when science knowledge is relevant to their goals, and know how to engage with the science when that happens. Feinstein later extended this idea through an examination of an extended written debate between John Dewey and

Walter Lippmann (a contemporary of Dewey's) on whether it was realistic to expect 'ordinary' citizens to develop sufficient content knowledge to contribute to complex policy decisions (Feinstein, 2015). Feinstein built from Dewey's position to suggest that rather than turning every individual into an 'expert', the goal of science literacy should be to produce people with diverse expertise (in a variety of topics) who can interact in groups related to relevant science topics. Working with others around science topics, he suggested, is how democratic participation and engagement with science can occur. Regardless of the definition, participating and making decisions related to science, alone or in groups, requires people to engage with science topics when they become relevant. As Jenkins (1999) rightly said, "a citizen who wishes, individually or as part of a group, to engage seriously in a debate about an issue which has a scientific dimension sooner or later has to learn some of the relevant science" (p. 704).

Despite their different foci, education and communication have in common a goal of inspiring individuals to engage in some form of action related to science topics. The purpose of sharing information with public audiences is rarely to simply share it with a passive audience, but rather to catalyze thinking, learning, or follow-up action about the topic. Informal science education experiences often aim to create a situation that inspires individuals to learn (National Research Council, 2009), either in the moment by actively thinking about and attending to the content in the science event, or by looking up information and pursuing opportunities later to independently learn more about the topic. In both science communication and outreach education projects (like the ones youth are involved in when they connect science to their community) prompting the audience into some form of action is a common goal. Projects and communicators seek to get people to vote for particular legislation, support a particular policy (Stilgoe et al., 2014), participate in co-producing knowledge (Davies et al., 2009), or change particular behaviors to be in line with sustainable practices (Schusler et al., 2009). Although the target actions might be different, they both depend on individuals being willing to extend the interaction beyond the initial encounter and actively engage in thinking or acting related to the topic.

It is clear from the literature that the understanding of engagement, the particular knowledge or skills needed to participate, and the methods for developing them are viewed differently in education and communication. However, they have in common a sense that engaging with science means actively thinking about a topic when it is encountered, and taking some form of action beyond passive observation. Whether this is through trying to learn about the topic (immediately or later), contributing to knowledge or discussion around the topic, or participating in community governing related to the topic, the essential component is stopping to actively think rather than passively dismissing or ignoring the science encounter. For the purposes of this study, engagement is used to mean this idea of engaging in active thought and some form of action. This broader definition encompasses the understandings from both education and communication, and aligns with the overarching questions driving this study of how youth may contribute to their communities' thoughts about science, and how people may think about science topics if they encounter them through youth.

Section Summary

The research presented in this section showed that informal interactions are an important means of science learning, and that a wide variety of interactions, including short encounters, contribute to adults' relationships around science. The purposes of engagement with science are different from the informal science education and science communication perspectives, and suggest that encountering science may lead to knowledge, attitude, behavioral, or democratic outcomes, or result in the co-construction of knowledge across multiple ways of knowing. Each of these outcomes are important, and experiencing them requires a variety of different formats and avenues for engaging with science topics.

Reacting to Science Encounters

Learning about and engaging with science from informal interactions, however, is not a simple matter of taking in and accepting the information presented through the interaction. As will be seen, reactions to science encounters are influenced by multiple aspects of both the presentation of information and the members of the audience. Research from science communication suggests that, as it is not possible to develop an in-depth understanding of every science topic individuals encounter in their lives, instead of relying on facts and reason individuals rely on various heuristics to form opinions and make decisions related to science. As the review will show, individuals' opinions about and trust in the source of the science information is an influential factor in their responses, and at times the messenger is more important than the message. This section begins with a brief overview of the recent shift in science communication that led to consideration of personal, social, and contextual factors that influence responses. Research on opinion formation and decision making related to science based on trust in the messenger is then examined, followed by the limited literature on adult trust in youth, which focuses primarily on youth's perceptions of whether adults will trust them.

Factors and Goals in Science Communication

Research in science communication suggests that learning about and responding to science in informal encounters is influenced by multiple factors that include aspects of both the event and the individual. Findings from research on various factors suggests public audiences may respond differently to youth than they would to other encounters with science information. The development of understanding and foci in the field helps to highlight and explain the variety and importance of different factors in current research.

Historically efforts to communicate scientific knowledge and findings with broad audiences did not recognize the importance of these factors. Initially referred to as public understanding of science, research and practice in this arena assumed that the non-science public did not know or understand the details of science research, and distrust or negative attitudes towards science could be remedied by educating an uniformed public about science matters (Jasanoff, 2014). However, in the last two decades the field has come to understand that this approach is ineffective. At the national level, this failure has been felt in the public response to issues such as climate change, where extensive data and general scientific consensus have not led to political will or action (Nisbet, 2009; Fiske, 2013b). Extended efforts to ‘educate’ the public and improve science literacy at the end of the 20th century were found to have produced no change on national surveys assessing the broader publics’ understanding of and attitudes toward science topics (Miller, 2001).

This realization prompted a paradigm shift in science communication, away from the old ‘deficit model’ and toward a ‘contextual approach’ based on understanding factors that influence public audiences’ engagement with science (Holliman & Jensen, 2009; McCallie, et al., 2009; Stilgoe, et al., 2014). In the new model, the 'public' is seen as a diverse set of multiple publics defined by social, cultural, and personal factors. Individuals form opinions and make decisions about science topics based on an equally diverse array of previous knowledge, experience, and beliefs (Baram-Tsabari & Osborne, 2015; Jasanoff, 2014; Nisbet & Scheufele, 2009). Additionally, scientific understandings are no longer seen as the sole authoritative source of knowledge about science topics that need to be shared with the public. Instead,

> this approach sees the generation of new public knowledge about science much more as a dialogue in which, while scientists may have scientific facts at their disposal, the members of the public concerned have local knowledge and an understanding of, and personal interest in, the problems to be solved. (Miller, 2001, p 117).

Although widely supported in the literature, the transition between approaches has been complicated in practice. This is partly due to the fact that although the dialogue model is favored in policy, in practice it is difficult to do effectively and there is a fine line that separates dialogue from deficit (Davies, 2009; Holliman & Jensen, 2009). Irwin (2006) suggested that the challenges in practice may be due to the fact that the beliefs that motivated the initial deficit-based model of science communication—the privileging among those who work in science of scientific knowledge and expertise over other ways of knowing—is deeply embedded in the culture and institutions of science and not so easily dismissed. Bauer, Allum, and Miller (2007) extended this to suggest that instead of a foundational shift in approaches, the advent of the dialogue model represented a third period in the history of science communication. They suggested these periods are characterized by their “diagnosis of the problem that science faces in its relationship with the public,” as defined by their “attribution of a deficit” (p. 80). Specifically, the first period, which they called Science Literacy, began in the 1960s and was focused on addressing the public deficit in science knowledge. This was followed by the Public Understanding period beginning around 1985, which focused on the public deficit in (positive) attitudes toward science. The third period, Science and Society, began in the 1990s and focused on the public deficit in trust and confidence in science. Each of these periods brought a new set of research agendas that focused primarily on ameliorating the current ‘deficit’. However, rather than a true cultural/paradigm shift, in which a new set of beliefs replaced an old set, Bauer and colleagues suggested that these paradigms are concurrently active and continue to inform research and practice. Together, this suggests that science communication efforts are currently aiming to enhance a combination of knowledge, attitudes, and trust among members of multiple publics, as well as foster participation and debate in science decisions.

To achieve these goals, recent research has focused on identifying and understanding the factors that influence the dynamic between science and multiple publics. Within this new model, research and practice have examined both the conceptual and practical aspects of dialogue-based encounters with science. On the practical side this has included work on designing, facilitating, and evaluating dialogue based encounters (Holliman & Jensen, 2009; Holliman, Thomas, Smidt, Scanlon, & Whitelegg, 2009; Rowe & Frewer, 2000, 2004, 2005). The conceptual work has focused on identifying factors that may impact individuals’ engagement with and responses to science. A complete review of factors studied to date would be extensive and beyond the scope of this study, but research has included topics in each of Entman's (1993) four "locations" in a communication event: the communicator, the receiver (audience), the culture, and the text (although at the time of writing Entman may have meant literal text, following Davis & Russ (2015) this is interpreted to mean the message or event through which individuals encounter science). For example: 'communicator' factors have included trust in the communicator or source (Brewer & Ley, 2013) and beliefs about the communicators' intentions (Rabinovich, Morton, & Birney, 2012); 'receiver' factors have included individuals' values (Dietz, 2013) and understanding of the topic (Scheufele, 2013), nature of science (Rabinovich & Morton, 2012), or uncertainty and risk (Fischoff, 2013); 'cultural' factors have included cultural beliefs (Medin, 2013) and intended or potential outcomes of the event (Davis, 2009); and 'text' factors have included message framing (Nisbet & Mooney, 2007), the nature and structure of the message (Stocklmayer, 2013), and the medium of communication (i.e., newspaper, online blog, twitter, etc.) (Schultz, et al., 2011). This list is not meant to be exhaustive, but rather to give a sampling of the potential topics that may influence responses to encounters with science. Combining several of these factors suggests that youth may elicit different responses to science than more typical sources of science.

Deciding Who (not What) to Trust.

Extensive research has been conducted (in science and beyond) on the ways individuals form opinions about topics. There is a substantial body of research that suggests individuals typically do not form opinions by first becoming knowledgeable experts on relevant topics, but instead rely on heuristics, or cognitive shortcuts, wherein complex or unknown information is approximated with simple and familiar ideas to facilitate decision making (e.g., Popkin, 1994). In examining the dynamics of heuristics in responses to science topics, researchers have found that personal values and trust in the source are important criteria for decision making (Bromme & Goldman, 2014; Brossard & Nisbet, 2007; Nisbet & Scheufele, 2009; Wynne, 1992).

Drawing on the idea of *bounded reality* from psychology, Bromme and Goldman (2014) suggested that all individuals have a *bounded understanding of science* that is limited by their knowledge and experience with the topic at hand. This means that instead of making decisions or forming opinions based on complete and detailed understandings of the topics, individuals rely on the knowledge and experience they do have related to the situation, including heuristics based on experience in other contexts. This, they suggested, should be seen not as a deficiency but as an adaptive problem solving strategy for functional reasoning in a hugely complex world, where decisions must often be made without 'complete' knowledge. In this context, determining 'what is true' is an important part of processing and responding to science information. Citing their earlier work (Bromme, Thomm, & Wolfe, 2013), Bromme and Goldman (2014) described how individuals have two fundamentally different strategies for evaluating what is true: first-hand evaluation, that relies on examination of evidence, reasoning, and experience to directly evaluate the claim; or second-hand evaluation, that relies on determining whose evaluation to believe. They suggested that individuals often need to rely on second-hand evaluation as direct evaluation of the complete body of relevant evidence is either not possible or beyond the individuals' time or ability. For example, this type of evaluation is common when deciding what type of treatment to pursue for medical conditions, where individuals may choose to rely on a doctor they trust rather than becoming experts in the requisite anatomy, physiology, or biochemistry. Bromme and Goldman suggested that in these situations "the question "Which knowledge claim is true?" often has to be transformed into the question "Which source of knowledge is credible?"" (p. 65).

There is a growing body of literature that examines the impact of different factors on who individuals choose to believe about science topics. Studies have examined the impact of both different media (e.g., television, social media, or posted flyers) and different actors (e.g., governmental, non-profit, or your primary care doctor) as sources of science information. In an online experiment with 1677 participants, Schultz and colleagues (2011) found that different source formats (twitter, blogs, or traditional media) of an identical message provoked different perceptions of an issue, communication responses (e.g., sharing or responding to the information), and reactions (e.g., willingness to boycott). This led them to conclude that the medium through which the message was received was more influential than the message itself. Different media formats and organizational actors have also been found to elicit different levels of trust from public audiences (Brewer & Ley, 2013). Through a phone survey of 851 individuals around Milwaukee, Brewer and Ley examined the impact of multiple variables on trust in various sources of science information. They determined that gender, age, education, income, ethnicity, political ideology, and attendance at religious services were associated with varying levels of trust in scientists, news media, science media, environmental organizations, and governmental organizations.

Numerous studies have examined trust in specific organizations or types of science communicators. For example, in two surveys Nisbet and Myers (2007) found that roughly a third (32%) of U.S. participants (N = 1002 in each) said they trusted what scientists say about the environment "completely" or "a lot", while just over 40% (41% and 43% in separate surveys) said "a moderate amount" and the remainder said "a little" or "not at all". Bickerstaff and colleagues (2008) asked 1547 participants in Britain to what extent they expected different actors to "tell the truth" about environmental topics, and found that environmental organization and university scientists were more trusted than governmental organizations as sources of information. In an analysis of public trust in multiple actors related to information about genetically modified food, Lang and Hallman (2005) found that purpose and intention influenced public trust, with the most trust placed in organizations that act as evaluators (i.e., scientists, medical professionals), a moderate amount of trust in 'watchdog' organizations (environmental or consumer advocacy organizations, media sources), and the least trust in organizations seen as merchants (farmers, industry, grocery stores).

There is additional evidence that trust in particular sources is not static, and may be influenced by the perceived intentions of the source. In a set of experimental studies, Rabinovich and colleagues (2012) examined the relationship between expectations of the communicator's intentions and responses to the communication. They found that participants who were told most climate scientists aimed to inform the public about climate change had higher levels of trust in the scientists than participants who were told the scientists' intentions were to persuade the public to take specific actions. However, when participants were also shown a message from climate scientists, their trust in the scientists was moderated by whether the message style matched the expected intentions. In both the persuade and inform groups, participants reported higher trust in scientists when the message matched their expectations. Interestingly, when the messages matched participants also expressed higher willingness to take action related to climate change. The researchers suggested that this implies that science messages are not considered in isolation from the source, and both expected and perceived intentions influence responses.

This can further be seen in a pair of studies by Gunther and colleagues (Gunther & Liebhart, 2006; Gunther & Schmitt, 2004), that additionally highlight the potential impact of having youth as sources of science information. In these studies, the researchers examined the hostile media effect (the perception that the media is hostile to one's position on an issue) by comparing responses to the same science message about genetically modified (GM) food in news media channels and student essays. In the first study, Gunther and Schmitt (2004) aimed to examine the differential triggering of the hostile media effect or biased assimilation (the tendency to interpret evidence to be supportive of one's existing views). In one reaction, information is seen as supportive of one's position while in the other it is seen as biased against it. They posited that triggering one of these contradicting reactions would be based on the potential reach of the text (i.e., how many other people might see it). To study this they randomly assigned 151 individuals from partisan groups to read an identical balanced text (containing both sides of the issue) portrayed as either a national news story or a college essay. They found that individuals from both sides of the issue viewed the identical text to be biased against their position when it was portrayed as a news story, but slightly in favor of GM foods when it was portrayed as a student essay. In the second study Gunther and Liebhart (2006) extended this to examine whether the source (journalist or student ‘author’) or reach (size of the expected audience) influenced responses. To do this they randomly assigned 413 partisan individuals to one of 4 scenarios portraying an identical balanced text as either a course essay or national news story written by either a journalist or student author (2x2 matrix). The results showed that both source and reach impacted perceptions of the science message. In the student/course essay context, members of both partisan groups perceived the text to be relatively neutral, but when the author was a journalist or the text was portrayed as a national news story, members of both partisan groups perceived the same text to be significantly biased against their position.

This suggests that individuals’ perceptions of the intentions of the communicator influence their perceptions of the content of the communication. Although these studies define the student as an adult college senior and did not intend to study the student as a source of information (in fact, they frame the student as a non-source), the results suggest that students or youth may trigger different reactions to science topics than more public sources would produce. Further, the perception in the second study that the student’s essay was neutral suggests that youth could potentially be an avenue for engaging diverse audiences with controversial topics. If youth are perceived as having a smaller reach (potential audience) than professional scientists or journalists, they may also be perceived as non-hostile and thus facilitate more open encounters with partisan or contentious science topics.

Trust in Youth as Sources of Science

Research on trust in youth as messengers of science content is limited. Youth were not considered as potential sources in the science communication studies described above, and Gunther and colleagues (Gunther & Liebhart, 2006; Gunther & Schmitt,

2004) chose a student essay as a context specifically because it was a format that they perceived would have little reach or potential impact. Although Volk and Cheak's (2003) study of youth in Hawaii (described earlier) suggested that adults did trust the youth when the youth displayed expertise, two studies of youth's perceptions suggest that youth do not feel generally trusted by adults. In an ecojustice focused program, Bencze and colleagues (2015) found that youth were hesitant to engage with adult audiences. In their program, 10 teenagers met weekly over a school year to discuss, investigate, and develop action plans related to science topics in their communities. Despite encouragement from the researchers, the teenagers unanimously decided to "limit their advocacy to local and friendly contexts (e.g., schools) or remote and anonymous ones (e.g., via YouTube™)" (p. 342). One student explained that if he attempted to engage with adults in the company related to their topic, the adults "would say, "'He's just a school boy, [We needn't listen to him.']. … I am not old enough to get people's support. People will think that I am just a kid and won't be serious'"" (p. 343). Interestingly, Bencze and colleagues describe how the students preferred to engage with public audiences through the internet specifically because they would not have to mention their age. This suggests that the youth felt their content knowledge and expertise in the topic were sufficient for their plan to be taken seriously, but their age would change the way audiences responded.

This belief is supported and extended in Valaitis' (2002) study of 23 youth in an inner city high school in Canada. In the context of health promotion and empowerment with youth, Valaitis found that the youth felt they would not be taken seriously as community health advocates because they were "just kids" (p. 257) and not trusted by adults. This was mediated by the youth's perception that they were trusted by adults who knew them, such as parents and teachers, and that they were seen as decision makers within the school who could make a difference within their immediate community. Returning to Volk and Cheak's (2003) study, which was conducted in a small, close-knit island community, this raises the question of whether adults responses were based on their relationships with the youth, and whether the community outcomes would have been different in a larger, less connected, community. However, similar to the students in Bencze and colleagues's (2015) study, Valaitis (2002) described how the youth felt they would have more influence on their wider community by "disguising themselves as being older, or getting adults to lobby for them, to overcome their perceived problem of being 'just kids'" (p. 261). Again, this suggests the youth did not feel incapable of contributing, but rather that their age would influence and limit adults' responses. These studies of youth perceptions cannot, of course, be used to infer adults' actual perceptions. However, in combination with Volk and Cheak's (2003) evidence of adults' trust in youth, and Gunther and colleagues' (Gunther & Liebhart, 2006; Gunther & Schmitt, 2004) evidence of perceptions of youth as neutral sources on controversial issues, they do suggest that adults' trust in youth, and their related perceptions of youth as sources of science information, should be examined instead of assumed.

Section Summary

The youth's beliefs that they would not be taken seriously as science contributes on account of their age (Bencze et al., 2015; Valaitis, 2002) contrasts with educators' assertion that youth can and should engage as active participants who impact their communities around local science issues (Calabrese Barton, 2003; Birmingham & Barton, 2014), and further with Gunther and colleagues (Gunther & Liebhart, 2006;

Gunther & Schmitt, 2004) findings that youth were seen as fair and neutral authors around controversial topics. Taken together, the research described in this section raises questions about adults' perceptions of youth, and the impact youth may have when they engage adult audiences with science content. Research from science communication suggests that the messenger influences responses to the message, and that youth may elicit different responses than adult messengers. In terms of expertise, experience, and social authority, youth are a substantially different messenger for science than adult scientists or professional organizations. Rather than dismissing youth as sources, this difference suggests that youth may elicit different perceptions and responses than more traditional sources of science information, and may have a unique contribution to offer efforts to engage broad and diverse publics with science topics. However, beyond Volk and Cheak's (2003) study, research is sparse on perceptions of, opinions about, or trust in youth as sources of science information.

Theoretical Framework: Stereotype Content Model

Research from the field of social cognition is used as a framework to examine perceptions of youth as sources of science information. As has been described, perceptions of unknown others are influenced by first impressions and pre-existing patterns to form immediate determinations of others' intentions. Extensive research in the nature of immediate determinations has identified two dimensions, perceptions of warmth and perceptions of competence, that are universally present in first impressions (Fiske et al., 2007). Additionally, these dimensions have been linked to emotional and behavioral responses, and predict whether individuals will respond in positive and supportive or negative and dismissive ways when they encounter an 'other' (Cuddy et al., 2007). Examining adults' perceptions of the warmth and competence of youth scientists could, therefore, provide a means for understanding responses and predicting adults' reactions to the youth. This section examines the theoretical model linking perceptions of warmth and competence to attitudinal and behavioral outcomes.

The theoretical underpinnings of this project come from the field of social cognition. Social cognition examines how people process and understand information about other people in social interactions. It is the study of first impressions and immediate judgements, and the resulting attitudes, bias, stereotypes, and behaviors. In the introduction to the multi volume compilation of major works in the field, Fiske (2013a) asserted that "first impressions count. People instantly and unconsciously judge each other, often based on superficial features (facial structure), stereotypical categories (gender, race, and age), irrelevant prior experiences (priming), and immediate contexts (temperature)" (Overview, Practical Implication, para 1) and that societies "must acknowledge the power of first impressions – often fast and superficial – in high-stakes decisions: whom to educate, whom to hire, whom to convict, whom to elect" (Overview, Policy Implication, para 1). This focus on first impressions offers a means for examining adults' perceptions when they encounter science through youth.

A framework for understanding interpersonal reaction and response is offered by the Stereotype Content Model (SCM) (Fiske, Cuddy, Glick, & Xu, 2002), which examines perceptions and their connection to emotions or actions. The model suggests that there are two universal and fundamental dimensions that shape social perception: warmth and competence. These two dimensions shape individuals' perceptions of others in both intergroup and interpersonal interactions. The dimensions come from two fundamental needs of social beings—the need to anticipate the 'others'' intentions towards the self (friend or foe- warmth dimension) and the need to anticipate the 'others'' ability to enact those intentions (competence dimension). The model suggests that the four possible combinations of perceived warmth and competence elicit specific emotions from individuals: individuals or groups perceived as warm and competent (for example, in-groups, doctors, firefighters) elicit admiration, cold and incompetent (ex: homeless people) elicit contempt, cold and competent (e.g., lawyers) elicit envy, and warm and incompetent (ex: elderly or disabled people, housewives) elicit pity (See Figure 2.2 below).

An extension of this model, the Behaviors from Intergroup Affect and Stereotype (BIAS) Map (Cuddy et al., 2007), further suggests that the combinations of warmth and competence and associated emotions elicit specific patterns of behavioral responses. According to the model, perceived warmth is the primary (subconsciously more important) dimension, and triggers active facilitation or harm, while perceived competence triggers passive facilitation or harm. Specifically, warm and competent groups trigger active and passive facilitation (helping and agreeing), cold and incompetent groups trigger active and passive harm (attack and neglect, dismissing or ignoring), warm and incompetent groups trigger active facilitation and passive harm (ex: patronizing behavior, concurrent over-helping and neglect of elderly or disabled people), and cold and competent groups trigger active harm and passive facilitation (ex: supporting 'others' in your neighborhood in times of peace, and turning on them in times of conflict—Muslims in the US and Jews in Europe have experienced this, for example) (Group examples from Cuddy et al., 2008).

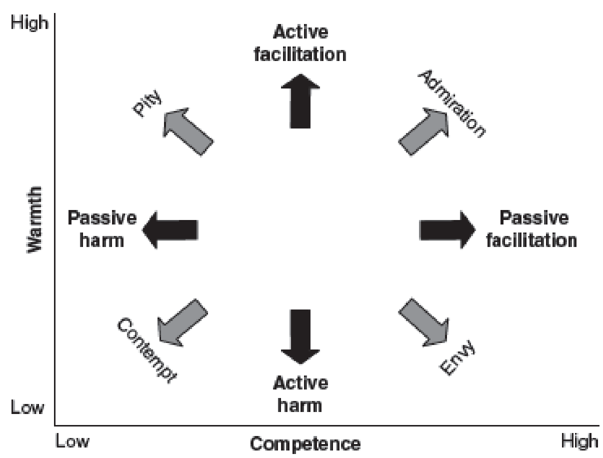


Figure 2.2: Emotions and behaviors elicited by perceptions of warmth and competence. Source: Cuddy et al., 2007, p. 634.

The SCM has been used to examine perception and bias in several dozen correlational and experimental studies in multiple countries (Cuddy et al., 2008). Two studies are particularly relevant for the current project. In the first (Fiske & Dupree, 2014), 116 individuals completed a survey about how different professions were perceived in the United States. The results showed that scientists were perceived as having high competence and moderate warmth. In the second (Kervyn, Fiske, & Yzerbyt n.d., as cited in Fiske, 2013b), individuals were asked about perceptions of different social groups in the U.S. The results showed that poor people and teenagers were perceived as having low competence and moderate warmth. The large difference in perceptions of competence of scientists and teenagers poses a question about positioning teenagers as scientists. According to the model, these perceptions trigger different passive behaviors: passive facilitation (agreeing and not interfering) for the scientists and passive harm (ignoring and neglect) for the teenagers. If youth or scientists are perceived in these ways when they talk about science topics, this could lead to different responses to the respective groups as sources of science information. This, in turn, could lead to different responses to the science content.

Summary

This review of the literature suggests that youth represent an underexplored and currently undervalued source of adult engagement with science. It is clear from the literature in science and environmental education that through multiple types of projects youth seek to, and succeed at, engaging adult audiences in their communities with science content. It is additionally clear that the short, informal, interactions between youth and adult community members that occur through these projects could contribute to adults' engagement and learning related to science topics, and further could provide an avenue for adults to engage with locally relevant topics they may not have pursued on their own. However, research in science communication has suggested that interactions with science are complex, and that, among other factors, that perceptions of the source influence individuals' decisions on who and what to believe, and in turn influence responses to science information.

What is not clear from the research literature is the impact youth are having on society's relationship to science and the environment. Youth are a substantially different source of information than adult scientists, governmental organizations, or informal institutions, the more typical producers and custodians of science knowledge, and additionally different from professional journalists, the more typical conveyers of that knowledge through news media. Consequently, they may elicit different perceptions and responses from adult community members than more traditional sources. Education research believes youth can and should impact their communities, but across both education and science communication literature there is a lack of follow up to determine what, exactly, that impact is. Understanding this impact is important both because it addresses the experiences of youth in education programs and because of the potential influence it could have on adult engagement with science topics, particularly topics of personal, local, or national importance. This study aims to begin exploring youth's impact by examining adults' perceptions of youth as sources of science information, and associated responses to the science content introduced by youth.

CHAPTER 3: METHODOLOGY

Introduction

This project was framed around understanding the interactions with science that happen when youth are the source of science information. The research questions aimed to explore the perceptions, emotions, and behaviors elicited by teen-scientists for the purpose of beginning to understand how teens as sources of science information may impact the informal STEM learning ecosystem of adults. To address these questions young adults' perceptions of the warmth and competence of youth or adult scientists, young adults' expectations of the quality of the information and willingness to take action based on the information from youth or adult sources, and the relationships between perceptions, responses, and participant factors that influenced them were examined. This was done through a sequential explanatory mixed methods study (Creswell, 2009) utilizing quantitative survey data and qualitative interview data. This chapter first describes the overall study design and why this was an appropriate approach for this study, and then examines the quantitative and qualitative instrumentation, data collection, recruitment, sample, and analysis methods in depth. As a reminder for the reader, the research questions guiding this study, discussed in Chapter 1, are as follows:

1. What are young adults' perceptions of the warmth and competence of youth or adult scientists?
    a. Are perceptions of youth and adult scientists different?
    b. In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the

importance of air quality, and the presenters' identities predict perceptions?

2. What are young adults' expectations of the information quality and willingness to take action related to the science information (hereafter called 'responses') provided by youth or adult scientists?
    a. Are these responses different when the information is presented by youth or adult scientists?
    b. In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the importance of air quality, perceptions of the warmth and competence of the presenters, and the presenters' identities predict these responses?
3. What are the reasons driving young adults' perceptions of the warmth and competence of youth or adult scientists, and their willingness to take action based on and expectations of the quality of the information the youth or adults present?

Study Design

This study used a sequential explanatory mixed methods design (Creswell, 2009), utilizing quantitative survey and qualitative interview data. This approach utilizes a two phase design in which quantitative data is collected and analyzed in the first phase, and the quantitative results are used to guide the second qualitative phase of the study. This study used the follow-up explanations model of the explanatory design (Creswell & Plano Clark, 2007) in which the qualitative data was used to expand on and explain differences in the quantitative data. The research began with a survey to collect quantitative data on participants' perceptions of and responses to youth or adults as sources of science information from the target participant group at two schools, one private elite liberal arts college and one public two-year community college. Next, survey data were analyzed to identify groups of participants with similar views of the youth or adults and responses to the science. A smaller number of individuals were selected from within each of these groups to participate in the follow up qualitative phase of the study, and interviews were conducted to dig deeper into participants' views. The interview data were analyzed with the aim of understanding what influenced participants' perceptions and responses, and identifying themes within or across groups. Finally, both the quantitative and qualitative results were interpreted to address the research questions on perceptions of and responses to youth or adult scientists, and the factors that influence them. An overview of the phases can be seen in Table 3.1, and each piece is described in detail below.

This was a useful design for this study as the theoretical framework and literature background suggested that there would be differences in perceptions of and responses to the youth versus adults as sources of science information, but the nature of those differences and factors that motivated them were uncertain. By first collecting and examining a larger quantitative data set, this design allowed for the identification of patterns in perceptions and responses across participants. Conducting follow up in-depth interviews with a smaller sample based on the patterns in the larger data set allowed for a deeper exploration into participants' views that could potentially illuminate underlying motivations that would not be captured by the quantitative data. Identification of differences followed by deeper examination of those differences was a useful way to address this topic. Together, this approach provided a richer understanding of the participants' perceptions and responses, and the factors that may influence them, than either data source would be able to provide alone.

Table 3.1: Study Design Overview

	Step	Procedures	Products
Phase 1: Quantitative	Quantitative Data Collection	• Survey: 6 scales + demographic items	• Survey data
	Quantitative Data Analysis	• Principal Components Analysis • Reliability • Cluster analysis • Group comparisons: MANOVA, logistic regression, multiple regression	• Factor loadings • Cronbach's alpha coefficients • Scale scores • Group membership • Group differences • Regression coefficients
	Quantitative Results		• Description of results • Identify follow-up participants
Phase 2:	Qualitative Data Collection	• Cognitive interviews	• Interview Transcripts
	Qualitative Data Analysis	• Coding • Thematic Analysis	• Within and cross case themes
	Qualitative Results		• Description of results
	Overall findings and interpretation	• Explain quantitative differences with qualitative findings	• Discussion of findings

Instrumentation

Survey Scenario

The survey consisted of a short scenario and follow up questions. The scenarios (see Box 1) described that two individuals from the community were going to appear on the local news that night to talk about a science project they had been working on in the local area. Participants were randomly administered one of two scenarios when they enter the survey. One scenario said that the two individuals were teenagers from a local high school who had been working on the project over the course of the school year. The other scenario said that the two individuals were scientists from a local research institution who had been researching the topic for the past year. Both scenarios included a brief paragraph describing what the scientists (teen or adult) had been studying and what they were intending to talk about on the news. Other than the introduction identifying either teen or adult scientists, the text of the scenarios was identical.

Box 1: Scenario

> Two *high school students from the local high school* will be appearing on the news tonight to talk about air quality in Boston. The two *teenagers* have been working on a project researching air quality over the past year. Through the project, they have distributed air quality monitors and collected data on ozone, carbon monoxide, nitric oxides, and particulate matter around the city. Tonight, they will tell us about their data, the concentrations of different pollutants in different areas of the city, and the impact the pollutants have on health and well-being for residents of different neighborhoods.
>
> *Text in italics would be replaced with "scientists from a local research institution" and "scientists"

The project described in the scenarios focused on air quality. The scenario listed the pollutants the scientists had been studying, and said that they were going to describe the concentrations of those pollutants across the local area and potential impact on residents' health. It is possible that focusing the scenarios on air quality, rather than on a 'generic' locally-relevant science topic, impacted participants' responses. This may be particularly true for responses on the *willingness to take action* scale (described below), in which participants' willingness to engage in action related to air quality may be more related to their interest or belief in the importance of air quality than their responses to the presenters. Knowledge, attitudes, and responses to science topics have been consistently found to be topic-dependent. Large scale analysis of national United States (National Science Board, 2014) and cross-cultural (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008) data sets have found that knowledge and attitudes, and the relationship between them, vary across domains of science. In fact, when asked their willingness to engage in actions about three different topics, Hwang, Pan, and Sun (2008) found that the same individuals responded differently about the different topics on the scale that served as the model for the *willingness to take action* scale in the current study. Logically this makes sense, as science issues such as climate change, stem cell research, or nanotechnology touch on different political, ethical, and personal beliefs that elicit different responses.

However, rather than avoiding focusing on a specific topic, the evidence suggesting that the topic influences participants' responses highlighted the importance of presenting a specific topic in the scenario. Situating a study within a single topic context is the norm in science communication research, where topic-specific studies are regularly used to explore aspects of larger relationships between science and publics (see, for example, Frewer, Howard, Hedderley, & Shepherd, 1999; Lee, Scheufele, & Lewenstein, 2005; Liu & Priest, 2009; Nisbet, 2009). While individuals may certainly have had differing beliefs and interest related to air quality, knowing that their reactions were in response to a single topic allowed for clearer interpretation than if the scenario presented a 'general' science project and responses were based on the single topic or combination of topics participants' imagined. Additionally, including items in the survey to measure participants' interest in air quality (described below) allowed for analysis of the variation in their interest and potential correlation to the other variables.

Air quality was chosen as the topic for the scenario for several reasons. First, it is an environmental issue that directly impacts everyone and thus is not difficult to relate to (we all have to breathe). Additionally, mentioning the health impacts of pollutants in the scenario framed the topic as a public health issue, a framing perspective that has been found to highlight personal relevance and promote engagement for other issues (Maibach , Nisbet, Baldwin, Akerlof, & Diao, 2010; Nisbet & Scheufele, 2009). Second, at a basic level air quality is conceptually simple, and a deep understanding of the content is not required to understand the central idea presented in the scenario of pollutants impacting health. This is supported by a study examining public perceptions of air quality in which 57% of respondents (N=378) reported becoming aware of poor air quality through direct personal experience such as health impacts, sensory evidence (e.g., visibility, smell), or weather conditions (e.g., haze, smog) (Bickerstaff & Walker, 2001). The primacy of personal experience rather than news or scientific sources suggested that respondents had a personal conceptual understanding of good versus bad air quality. Third, air quality is not as politically or morally charged as topics such as climate change or stem cell research, and thus less likely to trigger strongly held beliefs associated with the topic. This was beneficial because it may have helped isolate reactions to the scientists rather than to emotional responses (Lee, et al., 2005) about the topic. Finally, previous work related to engaging individuals in an unexpected encounter with air quality information found that individuals were interested in learning about the air quality in their neighborhoods, and more than half (N = 209) believed air quality was a problem in their city (Patchen, Debay, Rooney, & Barnett, 2014). Together, this suggested that participants would have sufficient conceptual and experiential understandings of air quality to engage in thinking about the topic.

Survey Items

The follow up questions included scales measuring participants' perceptions of the warmth and competence of the communicator; participants' responses to the communication including willingness to engage with the topic and expectations about the quality of information; and individual variables including trust in scientists in general, interest in and importance of air quality, political affiliation, as well as several demographic questions. Scales and items can be seen in Table 3.2. All scales, except the demographic items, used a 5 point Likert response format. Each of the scales, their sources, modifications, justification for use in this study, and performance with the study sample are described below.

Warmth and competence scales. The warmth and competence scales were adapted from scales developed by Fiske and colleagues (2002) as part of the Stereotype Content Model (SCM). These two scales measure the respondents' perceptions of the warmth and competence of the students or scientists described in the scenario. The modifications from the original scales included adding "when they talk about science" to the items in order to focus more specifically on perceptions of the presenters as sources of science information. Additionally, the phrase "members of this group" was replaced with "people like the two teenagers/scientists" (respectively) in order to clarify the focus on the presenters. In SCM, the scales aim to access respondents' initial or underlying perceptions of target subjects by asking about societal perceptions (rather than the respondents' perceptions) and social groups (rather than single or identified individuals).

This is done to decrease the impact of social desirability on responses, as previous studies suggested people tend towards fairness by assuming individuals they don't know well (but not social groups) are high on one scale if they are low on the other (Judd, James-Hawkins, Yzerbyt, & Kashima, 2005). This structure was maintained in the current study by asking about "people like" the presenters rather than the presenters specifically.

As the items in both scales were modified from the original versions, principal components analysis was conducted to evaluate the performance of the scales. Principal components analysis of the warmth scale (n= 397) extracted a single factor that explained 52.019% of the variance. The five items in the scale had a reliability (Cronbach's alpha) of .760. Removing Item 3 would have increased the reliability to .773. However, as the reliability of the complete scale was sufficiently high and principal components analysis revealed that Item 3 loaded adequately (.560) on the single factor, this item was retained to facilitate comparisons with other work using this scale. Similarly, principal components analysis of the competence scale (n=399) extracted a single factor that explained 68.90% of the variance. The six items in the scale had a reliability of .909. Removing any item would not increase the reliability of this scale. Reliabilities of all scales are reported in Table 3.2.

Willingness to engage in action. Willingness or intention to engage in particular actions or behaviors is a common outcome in science communication research, where the goal is often to elicit behavior change or support for a particular topic (e.g., Feldman, Hart, Leiserowitz, Maibach, & Roser-Renouf, 2015; Schultz et al., 2011). The willingness to engage in action scale in the current study was based primarily on the *willingness to engage in discursive action* scale developed by Hwang and colleagues

(2008) for use in a similar context with a similar population. In their study, Hwang and colleagues asked a sample of undergraduate students at a large Midwestern university about their perceptions of and responses to news media coverage of three controversial issues: stem cell research, domestic surveillance programs, and social security reform. After responding to questions about their perceptions of media coverage, students were asked how likely there were to do each of the actions in the *willingness to engage in discursive action* scale related to each of the three issues. Their analysis showed high reliability in the scale for each of the three issues ($N = 696$; $M=4.3$, $SD=1.29$, Cronbach's $\alpha=.88$ for stem cell research; $M=4.09$, $SD=1.48$, Cronbach's $\alpha=.91$ for domestic surveillance programs; $M=3.86$, $SD=1.45$, Cronbach's $\alpha=.91$ for social security reform). Additionally, their results found that perceptions of the media coverage corresponded to differences in willingness. Specifically, negative perceptions of media coverage (high indignation at how the issue was covered) "had a significant and positive effect on willingness to engage in discursive activities across all three issues ($\beta= .14$, $p < .01$ for stem cell research; $\beta=.20$, $p < .001$ for domestic surveillance program; $\beta=.18$, $p < .001$ for social security reform)" (p. 87). Overall, this suggested that the scale was a good model for the current study as it had demonstrated reliability with a similar population and an ability to measure reactions to perceptions of news-based communication about different topics.

For this study, the items in the scale were modified in the following ways. First, as Hwang and colleagues focused on three separate issues in their study, the items referred to the 'issue' rather than each specifically. This was modified to focus specifically on air quality for the current study. Second, as Hwang and colleagues were interested in responses to controversial issues, several of the items were framed around interactions with individuals or opinions the respondents agreed or disagreed with (e.g., "sign a petition representing their position on the issue" or "talk about the issue with others who may have a different view"). The focus on positions did not seem as relevant for air quality, which has not received as much polarizing attention from the news media and consequently for which opposing positions are not as clear. Thus, these items were edited to be more neutral (e.g., "sign a petition about air quality" or "talk to someone else about air quality"). Additionally, this meant that two of the original items about talking to others were combined into one. Third, an additional item ("donate money to support the project") was added to the scale. This item is dissimilar to the others in that it is not a discursive action. However, willingness to donate money is a common measure in science communication research (Feldman et al., 2015, Schultz et al., 2011).

The final scale used in this study included eight items. Principal components analysis of the eight items (n=388) extracted a single factor that explained 51.43% of the variance. All eight items had factor loadings above .65 on the single factor. Reliability of the eight items was .863, and removing any item led to a decrease in Cronbach's alpha. This indicated that the scale measured a single latent trait and could be used as written.

Expectations of information quality. The expectations of information quality scale was adapted from a scale developed by Ter Mors, Weenig, Ellemers, and Daamen (2010). Ter Mors and colleagues developed a three item scale asking about participants' expectations of how valuable, complete, and accurate science information would be from different sources. Although Ter Mors and colleagues did not report the performance or reliability of the scale, they did find a significant difference in expectation of the quality of information from three different sources (ANOVA outcome: $F(2,63)=.768$, $p=.001$, $\eta^2=.20$). The significance and large effect size found in their work suggested that the scale can capture differences in expectations about information from different sources. This suggested that the scale was a good model for the scale in the current study as participants were asked to consider expectations of information about air quality, but not actual data, from youth or adult scientists. In the current study, the terms "teenagers'/scientists' air quality [information]" (respectively) were added to the questions to focus the items more specifically on the presenters in the scenario. Additionally, as the scale was rather short, a fourth item was added asking about the expected credibility of the science information. Inclusion of this item in the final scale was assessed through principal components analysis, which extracted a single factor that explained 74.58% of the variance. All four items loaded strongly (above .8) on the single factor. Reliability of the four items in the scale was .883 (n=393). Removing any item did not increase the reliability.

Trust in scientists. The trust in scientists scale was adapted from a scale developed by Lang and Hallman (2005). Trust in scientists is a common factor used in studies of science communication to understand responses and reactions to science information (Brewer & Ley, 2013). Lang and Hallman (2005) developed a four item scale to measure participants' trust in ten different sources of information about genetically modified foods. Their sources included multiple stakeholders and agencies associated in different ways with genetically modified foods. In a telephone survey with follow up questionnaire of individual in the United States (n=409), Lang and Hallman found the scale had high reliability and was able to distinguish between levels of trust in different sources among the same individuals. Specifically, the scales showed a range of scores from a high trust in scientists (M=3.95, SD=0.81) to low trust in industry (M=2.53, SD=0.90). Cronbach's alpha for the scale ranged from 0.81 to 0.91 across the ten source categories. The high reliability across sources and ability to distinguish levels of trust between sources suggested that the scale was a good model for measuring trust in scientists in the current study. In this study, the phrase "groups listed below" was replaced with "scientists" to focus specifically on that group, and "GM foods" was replaced with "air quality."

Principle components analysis of the four items extracted a single factor that explained 60.74% of the variance, with all four items loading strongly (above .75) on the single factor. Reliability of the scale was .779 (n=389).

Air quality items. Since, as described earlier, responses to science communication events and attitudes toward science topics vary for individuals across topics, two items were included to measure individual reactions to air quality specifically. These items asked whether individuals were interested in air quality and whether they believed it was an important topic. These items were used independently in the analysis as self-reported indicators of participants' thoughts about air quality.

Alternative scenario items. Two items were included regarding whether participants felt they would have responded differently had they seen the alternative scenario. These were included at the end, to avoid influencing responses to the scale items. The first asked participants to indicate (yes/no) whether they would have answered differently had the scenario stated that the project was done by the alternative group (teenagers/scientists, depending on the scenario they saw first). The second was an open ended question asking participants to explain their response.

Demographic items. Demographic items included questions about participants' school, age, gender, and ethnicity, as well as two factors that have been found to influence science communication events in other work. First, individuals' understanding of science topics and practices (Scheufele, 2013) and the nature of science (Rabinovich & Morton, 2012) have been correlated to different responses to aspects of science communication practices. This was addressed in the current study by asking participants their major (categorized into science/non-science) as a rough proxy for science background. Second, political affiliation and beliefs have been found to be associated to individuals' responses to science communication or act as mediators of other outcomes (Feldman et al., 2015; Nisbet, 2005; Hart & Nisbet, 2012). Asking about participants' political affiliations allowed for exploration of this factor in the current study.

Table 3.2: Survey scales

Scales[1]	Source[2]	Factors extracted[3]	Variance explained[3]	Cronbach's Alpha
Competence of Communicator				
As viewed by society, how competent are people like the two teenagers when they talk about science? As viewed by society, how confident are people like the two teenagers when they talk about science? As viewed by society, how capable are people like the two teenagers when they talk about science? As viewed by society, how efficient are people like the two teenagers when they talk about science? As viewed by society, how skillful are people like the two teenagers when they talk about science? As viewed by society, how intelligent are people like the two teenagers when they talk about science?	Fiske et al., 2002	1	68.90%	.909
Warmth of Communicator				
As viewed by society, how friendly are people like the two teenagers when they talk about science? As viewed by society, how well-intentioned are people like the two teenagers when they talk about science? As viewed by society, how trustworthy are people like the two teenagers when they talk about science? As viewed by society, how good-natured are people like the two teenagers when they talk about science? As viewed by society, how sincere are people like the two teenagers when they talk about science?	Fiske et al., 2002	1	52.019%	.760

Table 3.2 (continued): Survey scales

Scales[1]	Source[2]	Factors extracted[3]	Variance explained[3]	Cronbach's Alpha
Willingness to Take Action				
If you saw the teenagers' report, how likely would you be to…				
… sign a petition about air quality in your community?				
… attend a public forum about air quality in your community?				
… post a comment about air quality on social media?				
… meet with an elected official to discuss air quality?	Hwang et al., 2008	1	51.43%	.863
… do some volunteer work related to the air quality project?				
… look for more information about air quality?				
… talk to someone else about air quality?				
… donate money to support the project?				
Expectations of information quality				
How valuable do you expect the teenagers' air quality information would be?				
How complete do you expect the teenagers' air quality information would be?	Ter Mors et al., 2010	1	74.58%	.883
How accurate do you expect the teenagers' air quality information would be?				
How credible do you expect the teenagers' air quality information would be?				
Trust in scientists				
In general, scientists have the expertise to make competent judgments about air quality.				
In general, scientists are a useful source of information about air quality.	Lang & Hallman, 2005	1	60.74%	.779
In general, scientists will do what is right for society regarding air quality.				
In general, scientists will tell you the truth about air quality.				

[1] For participants who received the adult scientists scenario, "teenagers" was replaced with "scientists")
[2] As described in the text, scales were based on these sources but edited for this study
[3] Through principal components analysis as described in text

Pilot Testing of Scenarios and Surveys

The content of the scenarios and survey items were examined through pilot testing with a small sample of undergraduate students at both colleges. This included 5 students at the private college (2 female, 3 science majors, age range 20-22) and 5 students at the community college (2 female, 3 science majors, age range 19-41). The pilot test was conducted individually with each student. The students were asked to take the survey and underline anything they found confusing or they were unsure how to answer. They were then asked to describe what they felt was confusing, and describe what they thought about as they were answering the items in each scale. Overall, participants did not find the text in the scenario or items in the scales to be confusing, and felt that they had enough information from the scenario to respond to the items. Several students had questions about the phrasing on the introductory text (i.e., the instruction before each page), but this did not seem to interfere with their responses. They consistently said that for the perceptions scales they had thought about how they believed society would view the people in the scenario (not their personal opinions), while in the information quality, willingness to take action, and trust in scientists scales and air quality items they had thought about their personal opinions to respond to the items. This aligned with what I hoped they would think about for each of the scales and suggested the phrasing of the items and scenario was clear. Additionally, this result suggested that the topic of air quality was sufficiently familiar to enable participants to think about the scenario, and was neither too complicated nor too controversial to distract from the main purpose of considering the messenger. Further supporting this is the fact that, when asked to describe what they thought about while they were answering different scales, 5 of the respondents independently (without prompting) mentioned that the age of the youth impacted their perceptions of or trust in the students and influenced their responses, and all 10 participants said they would definitely have answered differently had the scenario said adult scientists instead of youth. Based on these responses, the introductory text at the beginning of the scales was edited to provide clearer directions for each section. The scenario and scale items were not edited as the responses suggested the text and items were sufficiently clear and elicited the intended thought processes and responses from participants.

Survey Format

The survey link opened to the online consent form, which described the project and asked individuals to consent to participate. Following this, individuals were randomly administered either the adult or youth version of the survey. As both the scenario and the wording of specific items were different, the survey versions were completely separate until the demographic items. Qualtrics was asked to administer equal numbers of each version. The separate part of the survey contained six pages. The first four contained the scenario and the competence, warmth, willingness to take action, and information quality scales (one per page). The fifth page included the air quality items and trust in scientist scale, and the sixth page included the two items asking whether participants' responses would have changed for the alternative scenario. As the SCM theory (Fiske et al., 2002) is based on initial impressions of the warmth and competence of others, the pages were not randomized in order to present these two scales before participants spent time thinking about the scenario in relation to the other scales.

After this point, all participants saw the same items asking about demographics, willingness to be interviewed, and entry in the gift card drawing.

Interview Protocol

The interviews took an elaborative or expansive cognitive interview approach (Willis, 2005). In cognitive interviews participants are asked to reflect on specific survey items, their interpretation of those items, and their thoughts as they respond to the items. Interviews typically include both a think-aloud format, in which participants are asked to describe their thought process as they consider answering specific items, and verbal probing, in which the interviewer asks specific questions to elicit additional information. Although initially developed and extensively used as a means for identifying problems in order to improve survey items (Sudman, Bradburn, & Schwarz, 1996; Willis, 2005), in practice cognitive interviews often go beyond the purely item-based cognitive probes and ask participants to elaborate on the topic under study. This has been recognized by researchers as both a component and extension of the traditional survey-development purpose of cognitive interviews, in which the interviews are also used "as a means to extend our understanding of the phenomenon under study" (Willis, 2005, p. 103). According to Willis (2005), expansive cognitive interviews typically include both item-focused probes (e.g., "What, to you, does [*term in the item*] mean?") and open-ended probes (e.g., "Tell me more about [*your experience with the phenomenon under study*]"). This combination of item-focused and open-ended probes allows for elaboration of both the participants' interpretation of the survey items and a deeper exploration of their thoughts and experiences related to the focal topic. The utility of this method in an educational context can be seen in Desimone and La Floch's (2004) work developing instruments related to standards, assessments, and professional development for teachers. In this work cognitive interviews both identified participants' interpretation of survey items and illuminated complex conceptual connections between phenomena that had been framed differently by researchers and participants. This work led Desimone and La Floch to call for an increase in the use of cognitive interviews in education research.

While improving a survey instrument was not the goal of this project, understanding participants' thoughts about youth or adults as sources of science information was. As many of the items in the perception and response scales depended on participants' interpretation of specific terms (e.g., competence, warmth, valuable), and the relationship between those interpretations and their views of scientists, the cognitive interview approach was a particularly useful one for this study. Asking participants to reflect on their thoughts about the survey items illuminated their interpretation of the meaning of the perception and response scale items, and enabled a deeper exploration of the factors that influenced their reactions to these items in relation to the youth or adult scientists. Consequently, the follow up interviews included: item-focused probes asking about participants' interpretation of the meaning of items; think-aloud prompts in which participants describe their thought process related to their answers, and open-ended probes to elicit more information about the phenomenon.

Specifically, in the interview participants were asked to re-read the scenario to remind them of the context, as it had been several weeks since they completed the survey. They were then asked to describe what image came to mind or what they imagined about the presenters when the read the scenario to explore their initial thoughts. Next they were asked about items on each of the perceptions and response scales, one scale at a time. To do this participants were given a print out of their responses to the items on the survey. They were asked to describe what they thought about as they read each of the items, and what led them to respond the way they did. This process was repeated for each of the warmth, competence, action, and information quality scales. After discussing each scale, participants were told that there were multiple versions of the scenario, and asked about their thoughts about one particular different version that included the other presenters than they had initially seen. They were reminded that the survey had asked how this change might impact their responses, and asked to further explain their thoughts about the change. This question was not intended to gather number responses for different items, but rather comments about relative reactions (e.g., "Well if they were adult scientists, they'd probably be less..."). The interview protocol can be seen in Table 3.3.

Table 3.3: Interview Protocol

Items	Purpose	Question type
Question 1:		
"In the survey you read a scenario about youth/adults sharing science information on the news. People sometimes imagine a visual image of a scenario like this. Did you have an image when you read the scenario of what the teens/scientists looked like? Can you describe for me what you imagined?"	Explore participants' initial thoughts about the presenters.	Open-ended

Table 3.3 (continued): Interview Protocol

Items	Purpose	Question type
Questions 2-5 (for warmth, competence, action, and information quality scales separately):		
"You were asked a series of questions about the scenario. I'd like to ask you about your reactions by looking at groups of your responses. Here is a graph showing your responses to several questions about the teens/scientists. There is a bar for each question, and the bar shows your response. For example this question asked about how *competent* people like the presenters were, and you answered "*moderately*". • Can you tell me about your responses to these questions? • What do these terms mean to you, and what were you thinking about the presenters when you picked the responses?" Follow up probes: • What, to you, does "*trustworthy*" mean? • Why did you pick "*somewhat*" for that question? • What was it about the *teenagers* that made you pick that response?	Explore how participants interpreted the terms and items, and the factors that motivated or influenced their responses.	Item-focused Think-aloud Open-ended
Question 6:		
Finally, there are several different pieces in the scenario, and I am interested in how the different pieces were related to people's thoughts. I would like you to consider a scenario in which I have changed one piece. • Can you tell me what you think about as you read this scenario? • Would you have answered the survey items differently if you had read this scenario instead? What items? • Can you tell me about why you would/would not answer differently?	Explore relative reactions to the other scenario, and differences participants' see between the teens or adults.	Think-aloud Open-ended
General additional probes:		
• Can you tell me more about that? • Can you explain how you thought about that? • Can you tell me why you thought that?		

Interview Procedure

Interviews were conducted over a four week period on campus at either the private college or community college, at times and locations convenient for the participants. During each interview, participants were told again that the project was exploring how different factors impact how people think about science topics, the interview format was described, and participants were given an opportunity to ask questions. Participants were then asked to read and sign two consent forms, one consenting to be interviewed and one consenting to have the interview audio-recorded. The interviews ranged from 10 to 27 minutes, with an average of 17 minutes.

Participants

Survey Participants

Participants (n= 399) were students enrolled in undergraduate coursework at a private liberal arts college and a local two-year community college. The two schools were similarly located near a large urban center in the northeastern United States, but diverse in their student populations. Demographics of the sample can be seen in Table 3.4. The sample was not intended to be representative of a "general" adult or undergraduate population as the literature in science communication holds that there is not a single "general public" to engage in science learning, but rather multiple publics defined by numerous factors (Nisbet & Scheufele, 2009), including amount of formal schooling (Falk & Needham, 2013). While it is not possible to control or measure all the variables that have been found to impact responses to science communication, particularly individuals' cultural beliefs (Medin, 2013) and values (Dietz, 2013), including only participants who were currently enrolled in undergraduate study was done to potentially help isolate the primary variables of interest for this examination.

Table 3.4: Survey Participant Demographics

	Total sample	**Private College**	**Community College**
N[1]	399	272 (68.2%)	114 (28.6%)
Gender Identity			
Male	48.1%	44.9%	59.6%
Female	48.9%	54.8%	40.4%
Other	.3%	.4%	--
Ethnicity[2]			
African-American	5.8%	5.1%	7.9%
Hispanic	9.0%	8.1%	12.3%
White	67.2%	73.2%	59.6%
Asian-American	11.8%	14%	7.0%
Native-American	1.0%	1.1%	0.9%
Other	5.3%	4.4%	7.9%
Prefer not to answer	2.5%	1.1%	6.1%
Political Affiliation			
Republican	16.3%	22.4%	3.5%
Democrat	30.6%	31.3%	32.5%
Unaffiliated	36.1%	36.0%	39.5%
Other	7.0%	6.6%	7.9%
Prefer not to answer	7.3%	3.7%	16.7%
Age *average (range)*	22 (18-63)	20 (18-27)	28 (18-63)
Major			
Science	52.4%	41.2%	84.2%
Non-science	44.9%	58.8%	15.8%

1 Totals may not equal 100% due to missing data
2 Total may be greater than 100% as participants were allowed to select multiple ethnicities

As with any 'public', individuals enrolled in undergraduate programs have particular characteristics that might influence their views and responses. Two characteristics of the current sample that could have potentially influenced this study in interesting ways were the age of the participants and their particular relationship with science professors. First, undergraduate students are typically closer in age to high school students than the "general" adult population. Because of this, they are perhaps more likely to view teenagers as similar to themselves, and therefore members of their ingroup, than older adults. This could lead to greater warmth perceptions if the participants saw the teenagers as "like me". If this was true, it was additionally possible that this would decrease as participants' age increased. Given the range of ages particularly among undergraduate students at the community college, with an average age of 28 (see Table 3.4), it was possible that this effect could be seen through a correlation between warmth perceptions and participants' age. Participants' age could also be associated with their perceptions of teenagers' competence, but the direction is less clear. This could, perhaps, be related to participants' views of themselves. If participants viewed the teenagers as similar to them, and they believed they were competent in science, this could have increased their perceptions of the competence of the teenage scientists ("I could do it, and so could they"). If, however, participants were not confident in their own science abilities, they may also have doubted the abilities of the teenage scientists ("I couldn't do it, so neither can they"). Conversely, it was also possible that participants saw undergraduate study as substantially different from high school, and thus viewed high school students as less competent ("They aren't even in college yet…"). Having a large sample across ages close to teenagers, particularly including the slightly older students at the community college, could illuminate this impact.

Second, participants may have associated adult scientists in the scenarios with science professors, a group with which the participants had a particular relationship while they were enrolled in courses. Although the terms "scientist" and "research institution" were used in the scenario and survey instead of "science professor" and "research university" to avoid a direct association, it was possible that students' relationships with and perceptions of their professors impacted their responses on the survey. For warmth, the direction was uncertain, as the association could lead to either an increase (professor as mentor) or decrease (professor as uncaring authority) in their perceptions of scientists' warmth. The impact on perceptions of competence was, perhaps, more certain as participants would (hopefully!) view their professors, and therefore scientists, as competent experts. However, this may have had less of an impact on the perceptions data overall, as it was in line with various previous studies that found participants typically thought scientists were highly competent (Brewer & Ley, 2013; Fiske & Dupree, 2014; National Science Board, 2014).

Recruitment took place through courses at both participating schools. At both schools, professors were contacted to request permission to visit their classes, and then classes were visited to recruit students in person. Students were told that the project was for a dissertation and included a short survey and follow up interviews. To avoid biasing responses, the project was described as focusing on how different factors worked together to influence responses to science information, but examining adult or youth scientists specifically was not mentioned. The survey was administered online via Qualtrics. At the private college class email lists were obtained from the professors and the survey link was sent to the students after class. Two reminder emails were sent in the days following the initial email to each class. At the community college, professors were unable to share class email lists so each professor either sent the link to students directly or posted the link on the class website. Three professors at the community college (with a total of seven classes) gave their students time to take the survey in class. Additionally, one professor at the community college shared the project with several colleagues (who shared it with their students on their own) and also sent the link to students who had taken his classes in the last several years. In every class (and particularly the ones where students took the survey during class) it was emphasized that the survey was voluntary and while their help would be appreciated students were not required to complete it. As an incentive a drawing for four $50 Amazon gift cards was offered. At the end of the survey participants were invited to enter their email address to be entered in the drawing. Additionally, at the end of the survey participants were asked to indicate whether they would be willing to participate in a follow up interview (selection described below).

At the private college large lecture classes aimed at both science and non-science majors were targeted. Large courses were selected to facilitate reaching large numbers of students. Courses aimed at both science and non-science majors were targeted to recruit both students who were majoring (or intended to) in a science and those who were not, in order to use major as a proxy for interest in science and include it as an individual variable. Specifically, students were recruited from the following courses:

- An environmental science course that met core requirements for non-science majors. ~150 students.
- An introductory core physics course for science majors. ~ 300 students.

- A biology course that met core requirements for non-science majors. ~100 students.
- A geology course that met core requirements for non-science majors. ~300 students.

At the community college there were no large lecture classes, so the larger core courses were targeted. Initial contact with professors was facilitated by a Dean in the science and engineering department, and most of the professors who responded to the email request taught science courses. This resulted in the majority of participants from the community college being science majors, though a few of the courses were introductory courses that fulfilled general science requirements for non-science students. Specifically, students were recruited from the following courses:

- Two introductory and two advanced environmental science courses. ~15 students/class.
- Two anatomy and physiology classes. ~10 students/class.
- Two introductory biology classes. ~10 students/class.
- Four introductory and five advanced computer science courses. ~ 15 students/class.

While there was an obvious bias in that responses were only collected from individuals who chose to participate, there was no reason to expect that choosing to participate was related to individuals' views of youth versus adults. It was, however, possible that individuals who were more interested in science were more likely to participate as the study was described as focusing on science communication, though this was mitigated by intentionally targeting both science and non-science focused classes for recruitment.

Power Analysis

A priori and observed power analyses were conducted for each analysis. The analyses are described in detail below, but a brief overview will facilitate understanding the sample size calculations. Based on extensive work with the warmth and competence scales by Fiske and colleagues (Fiske et al., 2007), it was expected that the perceptions data would form clusters on the two dimensional warmth and competence plot. Cluster analysis and MANOVA were used to determine whether these clusters of individuals' perceptions were significantly different, as well as whether perceptions of youth and adults were different. Multinomial logistic regression was used to determine which, if any, personal or science-related independent variables predicted cluster membership. Finally, t-tests and multiple linear regression analyses were used to explore differences in information quality and willingness to take action, and the personal or study variables that predicted responses on those scales.

Before data collection, the sample size needed to be large enough to achieve power of 0.8 at the $\alpha = .05$ level for both small and medium effects for each analysis was calculated using G*Power 3.1 (MANOVA, ANOVA, t-tests, multiple regression) or methods book suggestions (logistic regression) (see Table 3.5). For logistic regression, the calculations in G*Power based sample size on several assumptions about one 'main' predictor and a binomial outcome variable. The outcome for this analysis was cluster membership in the warmth and competence perceptions clusters. With this in mind, two possible 'main' predictors were used to estimate required sample size a priori: presenter (binomial: youth vs adult) and general trust in scientists (scale). For the binomial predictor, the calculation required input of the predicted probability of being in one outcome group for each of the two possible predictor categories. These values were estimated based on the potential probability of being in a high trust (high warmth/high competence) or low trust (low warmth/low competence) outcome cluster for participants who saw a youth compared to an adult scientist. For the adult scientist, the probability ($Pr(Y=1|X=1)H_0$) was estimated to be .5, as perceptions would likely be based on general attitudes about scientists. Following Cohen (1988) an odds ratio of 1.5 was considered a small effect and 3.45 considered medium for the probability of being in the high trust group among participants who saw the youth version of the survey. Additionally, the calculation requires input of the expected correlation between the other predictor variables in the model. It was estimated that the correlation between the various personal and science-related variables would be low, and .04 was entered as the R^2 other X value (this indicated a correlation of R=.2). These estimates produced required sample sizes of 811 for a small effect and 101 for a medium effect (Table 3.5).

Additionally, in case presenter was not a major predictor of perceptions, power analysis was also conducted with trust in scientists as a 'main' predictor. For a scale predictor, the calculation again required input of the predicted probability of being in one outcome group over the other at the mean of the 'main predictor. A rough assumption was made that if trust in scientists was normally distributed, being at the mean would result in a .5 probability of being in one particular outcome group. Additionally, it was assumed that there would be low correlation between the various predictor variables, and

.04 was entered as the R^2 to other X value. These estimates produced required sample sizes of 216 for a small effect and 38 for a medium effect (Table 3.5).

However, as these estimates were based on a number of assumptions, sample size recommendations in methods books were also used. Hair and colleagues (2013) suggested that each group in the dependent variable should have ten observations for each independent variable. As there were 9 potential independent variables, this indicated 90 participants per outcome group. It was expected that there would be 2-4 perceptions clusters, leading to required sample sizes from 180 (2 clusters) to 360 (4 clusters).

For many of the analyses the required sample size increased exponentially as the effect size decreased, and resulted in required samples for detecting small effects that were beyond the reach of the study. Examination of the graphs produced through G*Power relating sample size to effect size indicated that a sample of around 400 would approach, though not reach, the ability to detect the small effect "cut-off" with power of 0.8. A sample of 400 was additionally greater than the number suggested by Hair and colleagues (2013) for logistic regression with the maximum expected outcome groups. This number of participants was deemed to be a reasonable and realistic goal and selected as the target sample size.

Following data collection, the observed power for small and medium effect sizes given the final sample sizes and the minimum effect size detectable at the 0.8 power level were calculated for the MANOVA, t-test, and linear regression analyses (Table 3.5). (Calculations were not performed for the logistic regression as the outcome variable contained three groups and power analysis for multinomial logistic regression was not possible with existing software programs.) The study achieved sufficient power for detecting medium effects. As expected from the a priori calculations, the minimum effect sizes detectable with 0.8 power for each analysis were close to but not below the small effect size "cut-off", indicating the study was somewhat underpowered for detecting small effects.

Table 3.5: Power Analysis

Criteria[1]	A priori: required sample size: Small Effect[2]	A priori: required sample size: Medium Effect	Observed: n	Observed: Small Effect: Achieved Power	Observed: Medium Effect: Achieved Power	Observed: Minimum Detectable Effect (at power = .8)
MANOVA: Perceptions clusters, 3 groups						
Partial eta^2: Small = .01 Med = .06	600	102	397	0.6	1.0	0.015
MANOVA: Perceptions of youth vs adults, 2 groups						
Partial eta^2: Small = .01 Med = .06	968	164	397	0.41	0.99	0.024
Multinomial logistic regression: Predicting perceptions[3]						
Odds ratio: Small = 1.5 Med = 3.45	811/216[4]	101/38[4]	381			
t-test: Information quality youth vs adults						
Cohen's D: Small = .2 Med = .5	788	128	393	0.51	1.0	0.283
t-test: Action youth vs adults						
Cohen's D: Small = .2 Med = .5	788	128	388	0.50	1.0	0.285
Linear regression: Predicting information quality						
Cohen's f^2: Small = .02 Med = .15	1022	150	388	0.31	1.0	0.054
Linear regression: Prediction action						
Cohen's f^2: Small = .02 Med = .15	1043	153	384	0.30	1.0	0.056

[1]: Criteria for small and medium effect sizes based on Cohen (1988)
[2]: All calculations based on power = 0.8, $\alpha = 0.05$
[3]: A priori calculation based on binomial logistic regression. Observed calculations not performed for multinomial logistic regression.
[4]: (Sample size based on binomial main predictor)/(Sample size based on scale main predictor)- see text.

Interview Participants

Based on the survey responses, a smaller sample of participants was invited for follow up interviews. Interview participants were selected through a mix of purposive and random sampling from the larger survey data set from those individuals who indicated in the survey that they would be willing to be contacted for a follow up interview. Cluster analysis of the warmth and competence data (described in the Data Analysis section) identified three meaningful clusters in the perceptions data: high warmth, high competence (Group 1); low warmth, high competence (Group 2); and high warmth, low competence (Group 3). Each group further contained a mix of participants who had seen the adult or youth version of the survey. Interview participants were randomly selected from within each group, with a goal of obtaining roughly equal numbers of participants who had seen each version of the survey in each group. However, as the clusters came together at the center (see Fig 4.1 and Fig 4.2 in Chapter 4), participants identified through the random selection who were very close to inside cluster borders were skipped. This was done because cluster analysis is not a definitive statistical analysis and is highly dependent on the composition of the particular sample. While the three clusters were found to be statistically different, it is possible (and likely) that small changes in the sample would result in small shifts in the cluster borders. As the goal of this phase was to identify themes and patterns in participants' thoughts both within and between clusters, it seemed prudent to select individuals who were representative (from the center of the cluster) or extreme (from the outside edges) of each cluster. Participants who were close enough to the inside borders that small changes in the sample may have resulted in a switch in cluster membership were less useful for the study purposes and consequently skipped. To select individual participants, the data were copied to Excel, each participant was assigned a random number using the random number function in Excel, and participants were sorted by willingness to be interviewed, then cluster membership, then youth or adult survey, then random number. Beginning with the lowest random numbers in each group, participants whose warmth and competence scores were in the center or outside edges of their clusters were invited to interview.

Selected individuals were sent an email inviting them to participate in the interview, and a follow up email two days later if they had not responded. Individuals who did not respond to the second email were not contacted again. A tentative goal of 6-8 interviews per group (with 3-4 per adult/youth subgroup) was initially targeted. The initial random selection was heavily weighted toward students at the private college. This was not unexpected, as the survey sample contained more participants from the private college and thus there were more to draw from. In an effort to increase representation from the community college, for groups that were entirely composed of students from the private college, the individual from the community college with the lowest random number that fit the selection criteria was also contacted. This included six individuals, three of whom agreed to be interviewed.

A total of 34 individuals were contacted before obtaining sufficient participants in each group, resulting in a total of 22 interviews (65% response rate). This tentative number was based on the idea of data saturation, which suggested that after this number of interviews new ideas would stop emerging and similar responses would be obtained (Guest, Bunce, & Johnson, 2006). This number appeared sufficient, as after roughly 15 interviews (4-6 per group), responses became repetitive and new ideas did not emerge. Consequently, the 22 individuals who had initially agreed to participate were interviewed and additional participants were not recruited. This included at least three individuals who saw the youth version and three who saw the adult version of the survey in each group, with the exception of Group 3. This group only contained three participants who saw the adult version and indicated in the survey they were willing to be interviewed, but only two of these individuals responded to email requests. The demographics and number of interview participants in each group can be seen in Table 3.6.

Table 3.6: Interview Participants

Group	Survey Version	School	Gender Identity	Age	Major	Political Affiliation	Ethnicity	ID
Group 1 N = 7	Adult	PC	F	21	Non-Sci	Dem	Hispanic	G1A1
	Adult	PC	M	21	Non-Sci	Unaff.	White	G1A2
	Adult	PC	F	19	Non-Sci	Ind.	White	G1A3
	Youth	PC	F	22	Non-Sci	Unaff.	White	G1Y1
	Youth	PC	M	21	Sci	Dem	White	G1Y2
	Youth	PC	F	19	Non-Sci	Dem	White/Asian-American	G1Y3
	Youth	PC	F	20	Sci	Dem	White	G1Y4
Group 2 N = 7	Adult	PC	F	19	Non-Sci	Ind.	White	G2A1
	Adult	PC	M	21	Non-Sci	Rep	White	G2A2
	Adult	PC	F	18	Non-Sci	Rep	White	G2A3
	Adult	CC	M	23	Sci	Dem	White	G2A4
	Youth	PC	M	19	Non-Sci	Rep	White	G2Y1
	Youth	PC	F	21	Sci	Unaff.	White	G2Y2
	Youth	PC	F	20	Sci	Unaff.	Asian-American	G2Y3
Group 3 N = 8	Adult	PC	F	20	Non-Sci	Dem	Hispanic	G3A1
	Adult	PC	M	20	Sci	Unaff.	Other	G3A2
	Youth	PC	F	22	Non-Sci	Dem	White	G3Y1
	Youth	PC	F	21	Sci	Rep	Asian-American	G3Y2
	Youth	PC	F	20	Sci	Unaff.	White	G3Y3
	Youth	PC	M	20	Sci	Dem	Asian-American	G3Y4
	Youth	CC	F	25	Sci	Dem	White	G3Y5
	Youth	CC	F	23	Sci	Unaff.	Other	G3Y6

Validity

In any study, internal and external validity need to be considered. Internal validity refers to the degree to which inferences drawn from the data are correctly based on true relationships between the variables, rather than confounded by variables or aspects that were not considered (Creswell & Plano Clark, 2007). In this study, the internal validity of the survey was strengthened by basing the scales closely on scales that were developed by experts in the field, used in varied contexts to address similar questions, and published in peer-reviewed journals. This speaks to the content and construct validity of the survey scales. The validity (or accuracy and credibility (Lincoln & Guba, 1985)) of the data gathered through the interview instrument was similarly strengthened by closely basing the interview questions on suggested strategies for conducting cognitive interviews (e.g.,Willis, 2005) and external expert review of the interview protocol. The internal validity of the conclusions drawn from the data were strengthened by triangulation between the survey data and interview responses, and specifically looking for disconfirming evidence as themes took shape (Miles et al., 2014). A potential threat to the internal validity of this study was selection bias, as participation in both the survey and interviews was voluntary and may have resulted in individuals who were inherently more interested in the described topic participating. This was mitigated by recruiting from a wide range of classes (science and non-science), and the random selection for recruitment of interview participants.

External validity refers to the degree to which inferences and conclusions from the study can be generalized to other people (Creswell & Plano Clark, 2007). Following the science communication literature, this study did not attempt to generalize to a generic broad ‘public’, but rather viewed each audience as made of diverse publics defined by multiple factors. Consequently, the findings from the study would potentially only be generalizable to a population similar to the target populations. That is, adults enrolled in undergraduate study in the northeastern United States. Recruiting from two very different undergraduate schools assisted in determining external validity, as it allowed examination of the impact these two particular schools had on participants’ responses and extrapolation to the potential impact (or lack thereof) of similar schools.

Data Analysis

This section describes the data analysis in three phases: quantitative, qualitative, and integration of data. The quantitative section first describes the steps taken to prepare the data for analysis, followed by a brief description of each analysis performed. The first step in the survey analysis included an analysis of the performance and reliability of the scales through principal components analysis and Cronbach’s alpha calculations. Second, the spread of data on each scale was examined through descriptive statistics and plots, and correlations between the scales were examined. Third, cluster analysis was used to identify clusters in the perceptions data. Fourth, MANOVA, t-tests, multinomial logistic regression and multiple linear regression were used to examine the relationships between survey version, perceptions, responses, and demographic factors. As a guide to the reader, the headings of each analysis are the same as the corresponding sections in the quantitative results chapters. The qualitative section describes the analysis of the open ended survey question, followed by description of the coding and analysis of the interview data. The alignment of the interview and survey measures and quantitative analyses to the specific research questions can be seen in Table 3.7.

Table 3.7: Research Question Alignment

Quantitative analysis	Quantitative Outcome variable	Quantitative Potential Predictors	Primary Interview Measure
RQ1: What are young adults' perceptions of the warmth and competence of youth or adult scientists?			
Descriptive statistics of Warmth and Competence scales			Q2 (competence items) Q3 (warmth items)
RQ1a: Are perceptions of youth and adult scientists different?			
MANOVA	Warmth and Competence vector	Survey version	Q6
RQ1b: In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the importance of air quality, and the presenters' identities predict perceptions?			
Multinomial Logistic Regression	Perceptions cluster	Gender, ethnicity, school, political affiliation, age, trust in scientists, air quality interest, air quality importance, survey version	
RQ2: What are young adults' expectations of the quality of the information and willingness to take action based on the science information from youth or adult scientists?			
Descriptive statistics of Information Quality and Action scales			Q4 (Information Quality items) Q5 (Action items)
RQ2a: Are these responses different when the information is presented by youth or adult scientists?			
t-tests	Information Quality, Action	Survey version	Q6

Table 3.7 (continued): Research Question Alignment

Quantitative analysis	Quantitative Outcome variable	Quantitative Potential Predictors	Primary Interview Measure
RQ2b: In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the importance of air quality, perceptions of the warmth and competence of the presenters, and the presenters' identities predict these responses?			
Linear Regression	Information Quality	Gender, ethnicity, school, political affiliation, age, trust in scientists, air quality interest, air quality importance, survey version, perceptions cluster	
Linear Regression	Action	Gender, ethnicity, school, political affiliation, age, trust in scientists, air quality interest, air quality importance, survey version, perceptions cluster, information quality	
RQ3: What are the reasons driving young adults' perceptions of the warmth and competence of youth or adult scientists, and their willingness to take action based on and expectations of the quality of the information the youth or adults present?			
			All

Quantitative Data Analysis: Preparing the Data for Analysis

Coding and transfer to SPSS. Items were coded in Qualtrics before downloading the data. There were no reverse-coded items. For each scale, the positive end of the scale ("strongly agree", "extremely") was coded with a 5 and the negative end ("strongly disagree", "never") was coded with a 1. This coding makes intuitive sense for all the scales, with higher values corresponding to positive agreement with the items. Additionally, individual items were given titles that would be clear and informative in SPSS. For example, the first item in the competence scale in the adult version of the survey was titled CompAd_1, while the first competence item in the youth version was titled CompStu_1, and so on. The data were then downloaded from Qualtrics as an SPSS file.

Cleaning data. Qualitrics records all participant responses, even when the survey was not completed. This included 70 participants who consented to participate in the survey but did not answer a single item. These responses were deleted. Additionally, two participants reported their age as under 18 (one 10 and one 17). These two were deleted as they were minors and not covered by the IRB protocol.

Combining versions and new variables. As there were two versions of most of the items in the survey, one for the adult scenario and one for the youth scenario, and each participant saw only one version of the survey, all of the scale items had responses from only half of the participants. Items that were in the versions not shown to an individual participant were coded as missing in the SPSS file. The first step in the analysis was, therefore, creating combined versions of each item. This was done using the compute variable function of SPSS, where for each item a new variable was created (e.g., CompAll_1) that equaled the adult version of that variable (e.g., CompsAd_1) unless there was a value in the student version of the variable (e.g., CompStu_1) in which case the student value was included.

Next, a variable was created indicating which version of the survey was shown to each participant (youth or adult) by computing a variable that equaled 0 for individuals with any value in the first item in the adult version of the scenario, and 1 for individuals for whom the first item in the adult version was missing. A manual check identified one individual who had seen the adult version of the scenario but skipped the first item, and was consequently miscoded. This individual was manually recoded to be in the correct group.

Finally, a variable was created to categorize participants' majors into science or non-science. The intention with this variable was to use major as a proxy for interest in science, based on the assumption that individuals who majored in science fields were more likely to be interested in science than individuals who elected to major in other fields. Consequently, a broad definition of 'science' was used for categorization. Majors that fell under the umbrella of STEM (science, technology, engineering, and mathematics) were categorized as science majors. This included life sciences (e.g., pre-med, nursing) and technical fields (e.g., computer science, information technology), as well as the more typical natural science majors (e.g., biology, chemistry). This was done both because these fields are commonly grouped as STEM fields in research and policy, and because interview participants in these fields described themselves as 'science-y' or majoring in research-based science fields. Majors in the non-science category included humanities, social science, business, theology, and education. This was done because, although these fields may have strong research bases, they are not typically considered part of the STEM fields, and multiple interview participants from these fields described themselves as 'not science people'. Participants who identified multiple majors were categorized as science majors if at least one of their majors was in a STEM field.

Scale analysis and reliability. A precursor to analysis was to determine the performance and reliability of the scales. As all of the scales were based on established scales that have performed well in previous work, it was expected that they would perform fairly consistently in this context. However, in this study the sample, question phrasing, and relationship between the participants and object in question (scientists and science information) were different from the previous contexts in which these scales were used. Consequently, principal components analysis was conducted on each of the five scales to examine the scales. Principal components analysis addresses whether the items in the scale respond to the same latent variable in respondents by determining the number of factors that account for the correlations between items (Netenmeyer, Bearden, & Sharma, 2003). Eigenvalues, scree plots, and factor loadings were be used to determine if the items in the scales responded to one or multiple latent variables, and whether any individual items need to be removed. As described earlier, each of the scales had only one factor extracted. The variance explained by the single extracted factor for each of the scales can be seen in Table 3.2. This suggested that each scale was addressing a single latent variable in participants, and consequently the scales could be used as written.

Additionally, Cronbach's alpha was calculated to assess the reliability of each of the five scales. Cronbach's alpha measures the internal consistency of the items in the scale (inter-relatedness among items) by determining the proportion of total variance that is due to actual variation on the variable among participants (DeVellis, 2012). Cronbach's alpha values for each of the five scales are shown in Table 3.2. Following convention, Cronbach's alpha values above .7 were considered sufficiently reliable. As all five of the scales had alpha values above .7 the scales were used as written.

Calculating composite scores. Composite scores were calculated for each participant on each scale. This was done by taking the average of participants' responses to the individual items in each scale. As the scales had different numbers of items, taking the average also put all the composite scores on the same scale (1-5), which facilitated interpretation.

Checking for suspicious responses. To eliminate responses that were obviously meaningless, composite scores were examined for participants who had the same score for each scale, and further examined these participants to determine if they had selected the same value for each item. This identified one participant who had selected 1 ("strongly disagree", "never") for all items. Qualtrics reported that this individual completed the survey in less than one minute, suggesting he or she had not read or considered the survey questions. This participant was removed from the analysis.

During the initial cluster analysis of the warmth and competence scales (described below), the scatter plot of participant responses identified one participant that was distant from the rest on the plot. This participant was within the spread of the competence scale, but well below all others on the warmth scale. Examination of this participant's responses revealed that he or she had selected responses from 2-5 on the first scale (competence), but every response after that was either 1 or 2. This was suspicious, as the participant had seen the adult scientist version of the scenario and rated perceptions of the competence of the scientists to be moderate, but subsequently reported very low (1-2) trust in scientists and expectations of the quality of the scientists information. The inconsistency in logic combined with the gap between this participant's warmth ratings and all others in the data set suggested that this participant had stopped responding seriously to the items, and led to this participant being removed from the analysis.

Missing data. As participants were not forced to respond to any item (except the consent question), it was possible to leave individual items blank in the survey. Missing values analysis of the scale and demographic variables in SPSS identified 15 participants who had left at least one item blank. Eleven of these were participants who stopped after one or more scales and did not answer any further items. (As the scales were shown on separate pages in the Qualtrics format, it is likely they completed the page and then either forgot or did not want to continue.) Participants' age was the variable with the greatest number of cases of missing data (15, 3.8%), followed by school, major, gender, political affiliation, ethnicity, and willingness to take action (all 11, 2.8%), then trust in scientists, air quality interest, and air quality importance (10, 2.5%), information quality (6, 1.5%), and warmth (2, 0.5%).

Examination of the other responses provided by these participants suggested that they had responded seriously to other items. Given the low percentage of missing data and the apparent validity of these participants' other responses, participants with missing data were retained for analysis. Listwise deletion in SPSS, a procedure that removes cases from individual analyses when relevant data are missing, was used for all analyses. This enabled including participants in any analysis for which they had provided complete data.

Dummy variables. Several of the demographic categorical variables needed to be recoded as dummy variables in order to use them in the logistic and multiple regression analyses. Single dummy variables were created for gender (DGender, female = 1), major (DMajor, science major = 1), and school (DSchool, community college = 1). For political affiliation, "unaffiliated" was selected as the reference category and dummy variables were created to represent Republican (DRepublican), Democrat (DDemocrat), "other" (DPolOther), and participants who preferred not to answer (DPolNA).

Additionally, cluster analysis of the perceptions data (described below) resulted in three perceptions groups. To use this variable as a predictor in the linear regression analyses, Group 1 was selected as the reference category and dummy variables were created for Group 2 (DGroup2) and Group 3 (DGroup3).

For ethnicity, the categories presented in the survey included African-American, Hispanic, White, Asian-American, Native American, other, and prefer not to answer. Participants were allowed to select as many categories as they wished. Unfortunately the sample was not highly diverse, and the majority (67.2 %) of participants identified as White. The Native American (4 participants), Other (21 participants) and Prefer not to answer (10 participants) groups were particularly small. Very small group size can be a problem in both logistic and multiple regression (Tabachnick & Fidell, 2007). Crosstabs analysis showed that each of these groups had expected and actual counts of less than 5 for either the survey version (youth vs adult) or perceptions cluster, or both. The Native American group had expected counts of 2 or less for each cell in the analysis. Tabachnick and Fidell (2007) recommend combining categories when more than 20% of expected cell counts are less than 5. Consequently, the Native American, Other, and Prefer not to answer categories from the survey were combined into a general Other category for the purposes of analysis. This brought the expected and actual counts above 5 for all cells. Dummy variables were created for African-American (DAfAm, yes = 1), Hispanic (DHispanic, yes = 1), Asian-American (DAsAm, yes = 1), and Other (DEthOther, yes = 1) with White as the reference category.

Quantitative Data Analysis: Statistical Analyses

Descriptive statistics. Descriptive statistics and histograms were generated to examine the range and distribution of the data on the scale variables.

Correlation matrices. Pearson product correlations were calculated for all the composite scale variables as an initial examination of the relationships between the constructs, to determine whether they were related in ways that made sense in terms of the theoretical framework and the context of the current study.

Cluster Analysis. Based on previous research using the warmth and competence scales, it was expected that the perceptions data would form clusters on the warmth/competence plot, and further that the clusters would be different for perceptions of youth vs adult scientists. As the Stereotype Content Model (Cuddy et al., 2007) holds that it is the combination of warmth and competence perceptions that are associated with behavioral outcomes, it was appropriate and important to analyze these variables together. This step of the analysis was done to determine whether there were in fact meaningful clusters in the perceptions data, and if so, which cluster each individual was part of. This was done through cluster analysis to determine clusters and cluster membership, and MANOVA to determine if the clusters were significantly different in terms of perceptions.

Cluster analysis is a method for identifying groupings in data, in which observations within a group are similar to each other but different from other groups. Unlike other classification methods, in cluster analysis the number and nature of groupings are not known in advance (Rencher & Christensen, 2012). Although cluster analysis has been criticized for the fact that it will always form clusters, whether or not they are meaningful, it is a useful technique for identifying segments of a population that have similarities on certain variables when there is strong conceptual support for the variables used (Hair et al., 2013). This was an appropriate method for this study because, while potential clusters in perceptions were supported by a strong theoretical model and extensive previous work, the number of clusters and where they may have fallen on the warmth/competence plot was unknown.

Since there were only two variables (warmth and competence), a scatterplot was first used to conduct a visual examination for the potential presence of outliers or uneven cluster sizes. As described earlier, this led to the removal of one participant who was well below the others on the warmth scale. Next, following previous work with these scales (Fiske & Dupree, 2014), Ward's method of hierarchical cluster analysis to identify the number of clusters followed by *k*-means non-hierarchical analysis to determine cluster membership were conducted. Ward's method is one of several agglomerative hierarchical techniques that begin with each observation as a separate cluster and group similar clusters until all observations are in one cluster. In Ward's method, similarity is determined by the combination that would result in the smallest within-cluster sum of squares across all clusters (Hair et al., 2013). This method was selected both because it aligned with previous work with these scales and because it was mathematically more robust and produced cleaner clusters than the other common methods including the centroid (similarity determined by distance between cluster centroids) and average linkage (similarity determined by the average distance between all observations in different clusters) methods. Next, k-means analysis was used to assign individual participants to clusters. K-means analysis begins with the number of clusters specified through the hierarchical approach, and then iteratively assigns individual observations to clusters until the within-cluster distance is minimized and between-cluster distance is maximized. This two-step approach capitalizes on the flexibility, simplicity, and speed of hierarchical methods, while allowing for reassignment of the cluster membership of individual observations to refine and optimize the final membership solution (Hair et al, 2013; Rencher & Christensen, 2012). This analysis identified three theoretically meaningful groups and resulted in the creation of a variable identifying the cluster membership of each participant. The final clusters were named as Group 1 (high warmth, high competence), Group 2 (moderate warmth, high competence), and Group 3 (high warmth, low competence).

Finally, as cluster analysis identifies clusters but does not address the significance of those clusters, the perceptions data were analyzed to determine if the perceptions in different clusters were significantly different. This was done through MANOVA analysis which allows for the analysis of difference among groups on multiple dependent variables (Rencher & Christensen, 2012). In the analysis the warmth/competence vector was used as the outcome variable and the cluster membership as the independent variable, for a 3x1 design. The analysis determined that all three clusters were significantly different from the others on both the warmth and competence variables. This meant that the clusters identified through the cluster analysis were statistically as well as conceptually meaningful, and could reasonably be used as groupings in the subsequent analyses. The composition of the groups and mean values on the Warmth and Competence scales are shown in Table 3.8.

Table 3.8: Cluster Composition

Cluster (Group)	Total N	Youth version (%)	Mean Competence (stdev)	Competence variance	Mean Warmth (stdev)	Warmth variance
Group 1	166	55 (33%)	4.39 (.44)	.195	4.01 (.40)	.159
Group 2	104	36 (35%)	3.66 (.47)	.222	3.02 (.44)	.195
Group 3	127	113 (89%)	2.76 (.51)	.261	3.7 (.53)	.278

Examining perceptions of youth and adults: MANOVA. Research Question 1a focused on whether the warmth and competence perceptions of youth were different than perceptions of adult scientists. To address this, a MANOVA was conducted using the Warmth and Competence scales as the outcome vector and the survey version (youth versus adult) as the independent variable for a 2x1 design. Pillai's criterion was used for the omnibus F test, followed by separate between-subject analyses on the two outcome variables. As there were only two groups (youth vs adult), no post-hoc tests were conducted.

Predicting perceptions: logistic regression. Research Question 1b focused on what factors might predict membership in the perceptions clusters. Factors included demographic variables (gender, age, school, ethnicity), individual beliefs (political affiliation, general trust in scientists, interest in air quality, importance of air quality, and major as a proxy for science interest), and whether the participant saw the youth or adult version of the survey. To address this, multinomial logistic regression was conducted with cluster membership as the outcome variable and the various demographic, belief, and scenario variables as independent variables. Multinomial logistic regression allows regression analysis when the outcome variable is nominal with more than two categories

(Hosmer, Lemeshow, & Sturdivant, 2013). In the analysis, a reference category is compared to each of the other groups, and the impact of each predictor on the odds of being in the different groups is calculated. The calculations are based on the natural log of the odds (logit), which can be modelled as a linear function of the predictor variables, and the parameter values for each predictor that maximize the likelihood of the function accurately describing the data. A logit function is calculated for each comparison between the outcome groups. In this study, perceptions Group 1 (high warmth, high competence) was selected as the reference category and comparisons were made between Groups 1 and 2 (low warmth, high competence) and between Groups 1 and 3 (high warmth, low competence), leading to two logit functions:

$$logit_1 = log\frac{\Pr(Y = Group\ 2)}{\Pr(Y = Group\ 1)} = B_{10} + B_{11}x_1 + B_{12}x_2 + \cdots + B_{1p}x_p$$

$$logit_2 = log\frac{\Pr(Y = Group\ 3)}{\Pr(Y = Group\ 1)} = B_{20} + B_{21}x_1 + B_{22}x_2 + \cdots + B_{2p}x_p$$

where $logit_1$ models the natural log of the odds of being in Group 2 versus Group 1, $logit_2$ models the natural log of the odds of being in Group 3 versus Group 1, x_i indicates the value of predictor *i,* β_{1i} indicates the value of the parameter for predictor *i* in $logit_1$, and β_{2i} indicates the value of the parameter for predictor *i* in $logit_2$.

A sequential approach (Tabachnick & Fidell, 2007) involving two steps was conducted to examine the varied impacts of the demographic, belief, and scenario variables on cluster membership. First, univariate multinomial logistic regression analyses were conducted for each of the potential predictor variables (or set of dummy variables) to identify predictors that were theoretically or potentially statistically significant for inclusion in the multivariate model (Hosmer, et al., 2013). Next, the set of potentially important variables was examined through two multivariate multinomial logistic regression models, the first including all selected variables except for survey version (the "treatment"), and the second adding survey version to the model. This was done to examine the impact of survey version (in Model 2) on top of the impact of the personal variables (Model 1). The goodness-of-fit and parameter estimates were examined for Model 2. The analysis resulted in two regression equations predicting membership in Group 1 versus 2 and Group 1 versus 3 based on the predictor variables, and odds ratios for each variable in each comparison.

Examining responses from youth and adults: t-tests. Research Question 2a focused on the differences in "responses" to the science information when it was presented by youth or adults. The response variables include participants' expectations of the quality of the information (Information Quality) and their willingness to take action based on that information (Action). Independent sample t-tests were conducted on both scales to examine the differences between participants who saw the youth version of the survey and participants who saw the adult version. Independent sample t-tests were selected because the two outcome variables were continuous and relatively normally distributed, the independent variable contained only two groups (the two survey versions), the two groups were independent as each participant took only one version of the survey, and the observed correlation between the two outcome variables was not very high (.366, see Table 4.2). Additionally, while it may seem logical to think that individuals would be less likely to act on low-quality information, the action scale included several items that were not logically connected to participants' expectations of the quality of the information (e.g., "look for more information" or "talk to someone else" about air quality). As the theoretical relationship between the two outcome variables was unclear, it seemed better to examine them separately.

Predicting responses: linear regression. Research Question 2b focused on predicting difference in participants' expectations of the quality of the information and their willingness to take action based on that information based on multiple demographic, belief, and study variables. Separate multiple linear regression analyses (Pedhazur, 1997) were conducted to examine the factors that predicted each of these responses. In each, a sequential approach was taken to examine the impact of different sets of predictors on the responses. The first set contained demographic variables including gender identity, age, ethnicity, and the school the participant was enrolled in. These variables were included in this set as they were factual variables that were either beyond participants' control (e.g., age) or relatively stable (e.g., school). The second set contained variables that addressed participants' beliefs including political affiliation, major, trust in scientists, air quality importance, and air quality interest. While these variables may be relatively stable, they were based on participants' previous experiences and choices that shaped their interests and beliefs, and thus more malleable than the demographic variables. The third set contained variables specific to the current study, including survey version and perceptions group to predict expectations of information quality, and those two along with participants' expressed expectations of information quality to predict willingness to take action. Information quality was included as a predictor for action because it seemed logical that expectations of the quality of the information might influence participants' willingness to act on it, but unlikely that the reverse would be true. The initial model for each regression analysis entered demographics, followed by beliefs, followed by study variables. This was done to examine the impact of the malleable belief variables on top of the stable demographic variables, and then the impact of the study 'treatment' on top of the pre-existing personal variables. An iterative approach was then used to identify and remove variables that did not contribute to the model to obtain a meaningful and parsimonious model for each analysis. The assumptions of ordinary least squares regression were examined for the final model in each case (described in Chapter 4). The analyses resulted in regression equations predicting participants' expectations of information quality and their willingness to take action on the topic.

Qualitative Data Analysis

The qualitative data analysis primarily addressed Research Question 3, and aimed to understand the reasons driving the patterns identified in the quantitative analysis. The data were analyzed to identify potential factors that influenced participants' perceptions of and responses to the presenters and scenarios. The qualitative data included written responses from the open-ended question on the survey and recordings from the interviews. These data sources were analyzed separately.

Open-ended survey item. The open-ended question on the survey asked participants to explain why they would or would not have changed their answers if they had seen the alternate version of the survey. A total of 387 participants responded to this question. The responses were generally very short, from a few words to a few sentences, and compared relative amounts of one or several qualities of the different presenters. For example, typical responses included "adults have more experience," or "high school students have fewer resources."

The responses were coded to identify the major ideas expressed by each participant. Codes were based on words used by participants (i.e., 'experience', 'trust') or summaries of common ideas (i.e., 'intelligent', 'smart', 'better able to' were coded as 'intellectual ability'). The relative amounts of the qualities were recorded by having two versions of each code, one for 'more' and one for 'less' of the quality. Additionally, as participants mentioned either or both youth and adults in their responses, each response was coded in the direction that directly answered the question. For example, when the question asked if participants' answers would be different had they seen the scenario with the adult presenters, codes were applied to describe how the participants thought about the adults. Thus, as "adults have more experience" and "youth have less experience" both indicate they would have changed their answers because they felt adults have more experience than youth, both of these were coded as "more experience." If the question had instead asked about having youth presenters, both would have been coded as "less experience." This obscured a level of detail, namely whether participants were more likely to list certain qualities when talking about youth or adults, but facilitated comparison of the overall patterns between the youth and adult presenters. After coding, the qualities were tallied and examined for patterns in responses.

The vast majority of participants indicated they would have changed their answers had they seen the alternate survey. For these, the analysis focused on the qualities participants' described and the relative differences between the youth and adults. The analysis did not examine patterns within participants, such as whether certain qualities were more likely to be named together, as it seemed unlikely that the short-answer format could capture the requisite depth and nuance of participants' thoughts. A small number of participants indicated they would not change their responses. These responses were examined for common ideas that influenced participants' thoughts.

Interview data analysis. The interview data analysis aimed to understand and explain the patterns found in the quantitative data. This led to slightly different foci for different parts of the data. For the warmth, competence, and information quality scales, the analysis focused on understanding patterns in responses within and between the survey versions and perceptions groups. For the willingness to take action scale the survey version and perceptions group were not significant, and the analysis looked for patterns across participants that could explain the different predictors found in the quantitative analysis.

The 22 interviews were transcribed verbatim and coded using Atlas.ti qualitative data analysis software. An open and eclectic approach to coding was taken that included structural and provisional codes based on the scales (e.g., trust, action), and descriptive and in vivo codes based on participants' responses (Saldana, 2013). This was done to root the analysis in the theoretical and conceptual frameworks and to simultaneously reflect ideas that emerged from participants' responses. Codes were developed through an iterative process. First, an initial list was developed by reading through the interviews and recording ideas that were raised by participants. Next, the initial list was organized and condensed to combine ideas that were variations of common topics, and tested and refined by coding one interview from each subgroup. During this step, subcoding (Saldana, 2013) was used to connect and parse related ideas. Following that, a second rater helped to further refine the codes through co-coding and discussing several interviews. As the interviews were based on discussing different pieces of the survey, a large grain coding approach was used wherein codes were applied to the entire response about a set of survey items. For example, when the interview asked about participants' thoughts and reactions to the items in the Information Quality scale, the relevant codes were applied to the entire response to the initial question and all follow up prompts. This was done to facilitate looking for patterns in the ideas that came up for each of the major topics of the survey and comparing ideas across groups.

To assess the reliability of the application of the codes, the second rater independently coded six interviews (one from each subgroup; 27% of the data). The six interviews were randomly chosen from the interviews within each subgroup that had not been previously co-coded. Greater than 80% agreement was obtained for each of the six interviews, and any disagreements were resolved through discussion.

After coding, summaries of each interview were written that included the codes applied for each section of the interview and bullet points of the most salient ideas raised by each participant (Hatch, 2002). Next, the codes and summaries were put in to matrices (Miles et al., 2014) and examined for patterns within and between groups based on survey version and perceptions cluster. Responses were first analyzed for the warmth, competence, information quality, and action scale sections separately, followed by examination of the complete text.

For example, to understand the reasons driving participants' expectations of information quality, the section of the interviews specifically addressing their responses to that scale was examined first, followed by examination of the rest of the interviews to support or refute developing themes. When patterns began to emerge, the interview text was examined for quotes in support of or opposition to the potential themes, and the themes were refined accordingly. As a check for validity, the text was specifically searched for disconfirming evidence for each theme (Miles et al., 2014). As they stabilized, the themes were summarized and outlined with supporting quotes.

Summary

By drawing on research on perceptions and responses to science information from other contexts, this study aimed to use established means to examine a new question, namely the impact youth may have as sources of science information. This study utilized a mixed methods design to examine young adults' perceptions and responses to youth compared to adults as sources of science. The survey data was used to identify patterns in perceptions and responses across a large number of participants. The interview data was used to explore the reasons behind the patterns. The survey utilized a scenario to prompt participants' perceptions of the warmth and competence of the presenter, and their responses in terms of expectations of information quality and willingness to take action on the topic. The survey data was analyzed through several statistical techniques including cluster analysis, MANOVA, and logistic and multiple regression to look for pattern in and relationships between participants perceptions of the presenter, responses to the information, and individual factors. Using quantitative patterns as a framework, interview participants were recruited from each of the perception clusters, and a cognitive interview approach was used to examine participants' thoughts and motivations as they responded to the survey. This approach, using both quantitative and qualitative analyses, enabled examination of both patterns and the motivations behind them, and allowed for deeper exploration of the reasons for and impact of perceptions of youth as sources of science information.

CHAPTER 4: QUANTITATIVE RESULTS

Introduction

This chapter presents the results of the statistical analyses of the survey data. The quantitative data were used primarily to answer the first two research questions and their sub-questions:

1. What are young adults' perceptions of the warmth and competence of youth or adult scientists?
    a. Are perceptions of youth and adult scientists different?
    b. In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the importance of air quality, and the presenters' identities predict perceptions?
2. What are young adults' expectations of the information quality and willingness to take action related to the science information (hereafter called 'responses') provided by youth or adult scientists?
    a. Are these responses different when the information is presented by youth or adult scientists?
    b. In what ways do individual factors such as gender, ethnicity, school, political affiliation, age, trust in scientists, interest in or beliefs about the importance of air quality, perceptions of the warmth and competence of the presenters, and the presenters' identities predict these responses?

Research questions 1 and 2 were addressed through descriptive statistics of the warmth, competence, information quality, and willingness to take action scales.

Following the identification of clusters in the perceptions data and assignment of participants to clusters, MANOVA and t-tests were used to address question 1a and 2a, respectively, and multinomial logistic regression and multiple linear regression were used to address question 1b and 2b, respectively. This chapter first presents descriptive and correlation statistics, followed by the analysis used to generate perceptions clusters, and then proceeds to address question 1a, 1b, 2a, and 2b in order. For each section of the analysis the statistical steps and choices are described first, followed by the statistical outcomes and discussion of the results in relation to the research questions. The chapter concludes with a summary of the statistical findings and discussion of their meaning across the research questions.

Descriptive Statistics

The means and standard deviations for the scale variables can be seen in Table 4.1. Means are shown for both the total sample and the subgroups for participants who saw the youth and adult versions of the survey, to compare the major variable of interest. Examination of the scale histograms showed that the data on each scale was relatively normally distributed, though the data were typically centered on the higher halves of the scales. Although it is not possible to have extreme outliers on a Likert type scale, there were not individual outliers or large clumps of responses separated from the main distribution at the high or low ends of any scale. The air quality importance scale showed a strong ceiling effect, with the majority of participants (360 of 389) selecting either 4 or 5 on the scale. This is likely an accurate record of participants' attitudes, as air quality was selected specifically because it is easy to relate to and at a general level is not associated with strong partisan views, but the lack of spread may influence the analysis.

There additionally appeared to be a slight negative skew in the competence and trust in scientists scales, but the spread and distribution seemed sufficiently close to normal to not interfere with the analyses.

Overall, the data showed that there were differences in the mean values on several scales for participants who saw the youth version of the survey compared to those who saw the adult version. For example, the mean perceptions of competence were lower for youth (3.27) than for adults (4.11), while the mean perceptions of warmth were higher for youth (3.80) than adults (3.57). The difference in the competence scale was not surprising, as it was logical to expect that adult scientists might be seen as more competent than teenagers in the context of a science topic. This was similarly true for participants' expectations of the quality of the information where adult scientists were expected to have higher quality information (3.95) than the youth (3.19). Based on the Stereotype Content Model (SCM: Cuddy et al., 2007), the difference in perceptions of warmth suggests that participants saw the youth as more friendly (or less threatening) than the adults, and would perhaps be more willing to actively associate with or support the youth. Interestingly, the willingness to take action means were very similar for participants who saw the youth version (2.88) and adult version (2.90), suggesting that perhaps this variable was less directly related to the identity of the information source. Participants' trust in scientists, interest in and beliefs about the importance of air quality were likewise similar for those who saw the youth and adult versions of the survey, though trust in scientists and interest in air quality were both slightly higher for the youth version. The significance and potential meaning of these differences are discussed in later analyses.

Table 4.1: Scale Descriptive Statistics

Variable	Survey version	N	Mean (st dev)	Min	Max
Competence	All	399	3.68 (.84)	1.33	5.0
	Youth	*204*	*3.27 (.74)*	*1.33*	*5.0*
	Adult	*195*	*4.11 (.72)*	*1.67*	*5.0*
Warmth	All	397	3.69 (.62)	1.80	5.0
	Youth	*204*	*3.80 (.58)*	*1.8*	*5.0*
	Adult	*193*	*3.57 (.65)*	*1.8*	*5.0*
Information Quality	All	393	3.56 (.81)	1.25	5.0
	Youth	*202*	*3.19 (.76)*	*1.5*	*4.75*
	Adult	*191*	*3.95 (.66)*	*1.25*	*5.0*
Action	All	388	2.89 (.85)	1.0	5.0
	Youth	*199*	*2.88 (.85)*	*1.0*	*4.88*
	Adult	*189*	*2.90 (.86)*	*1.0*	*5.0*
Trust in scientists	All	389	4.12 (.61)	2.25	5.0
	Youth	*200*	*4.15 (.61)*	*2.5*	*5.0*
	Adult	*189*	*4.08 (.60)*	*2.25*	*5.0*
AQ interest	All	389	3.59 (1.01)	1.0	5.0
	Youth	*200*	*3.67 (1.04)*	*1.0*	*5.0*
	Adult	*189*	*3.51 (.97)*	*1.0*	*5.0*
AQ importance	All	389	4.44 (.74)	1.0	5.0
	Youth	*200*	*4.43 (.75)*	*1.0*	*5.0*
	Adult	*189*	*4.44 (.72)*	*1.0*	*5.0*

Correlation Matrix

The Pearson product correlations were calculated for the major scale variables. These correlations can be seen in Table 4.2.

Table 4.2: Correlation Matrix

Variable	1	2	3	4	5	6	7
1. Perceptions of Competence	--						
2. Perceptions of Warmth	.295**	--					
3. Information Quality	.614**	.243**	--				
4. Willingness to Take Action	.221**	.185**	.366**	--			
5. Trust in Scientists	.167**	.231**	.213**	.262**	--		
6. Air Quality Importance	.136**	.200**	.179**	.354**	.281**	--	
7. Air Quality Interest	.034	.179**	.105**	.466**	.234**	.551**	--

** Correlations are significant at the p < .001 level

Most of the variables showed significant positive correlations. For the most part these correlations were moderate, suggesting that the constructs were related but not so related that they were measuring the same thing. The highest correlation, between perceptions of competence and information quality, made logical sense in the context of this study, as participants who believed the presenters were highly competent would reasonably be more likely to think the information they presented was high quality. The higher correlations between interest in air quality and beliefs about the importance of air quality and willingness to take action also made logical sense, as participants who were interested in the topic would also reasonably be more likely to think information about it was important or be willing to act related to the topic. This was also true of the more moderate correlation between information quality and willingness to take action, as participants who believed the information was valuable, accurate, and complete would reasonably be more willing to act on that information. The somewhat lower correlations between perceptions of warmth and the other scales is interesting, and suggests that perhaps warmth is less directly related than competence to other responses to science information. This is explored further in later analyses. Finally, the lower correlations between trust in scientists and the other scales was expected, as this scale asked about scientists in general, rather than the scientists in the scenario who were the focus of the other scales.

Cluster Analysis

Analysis.

Cluster analysis (described in detail in Chapter 3) was conducted to identify participants with similar values in the perceptions data and assign participants to groups. Analysis using Ward's method suggested either a three (Figure 4.1) or four (Figure 4.2) cluster solution. Combining the cluster analysis with the underlying theory (Hair et al., 2013) suggested that three clusters provided a more theoretically meaningful division of the data. Although the data were more concentrated toward the high end of both scales, in the three cluster solution the divisions between clusters were relatively close to the midpoints of either the warmth or competence scales. This led to one cluster that was high on both scales (Group 1), one cluster that was high on the competence scale but lower on the warmth scale (Group 2), and one cluster that was lower on the competence scale but higher on the warmth scale (Group 3). The SCM (Cuddy et al., 2007) suggested that groups with these different combinations on the warmth and competence scales would elicit different emotional and behavioral outcomes. In the four cluster solution, there was more overlap among the clusters along the two scales, and thus among the emotional and behavioral outcomes expected by the theory. Consequently, the theory-based potential meaning of the clusters was less clear. Since cluster analysis is not a definitive technique on its own and should be interpreted in relation to theory, the three cluster solution (Figure 4.1) was selected.

Figure 4.1: Three Cluster Solution

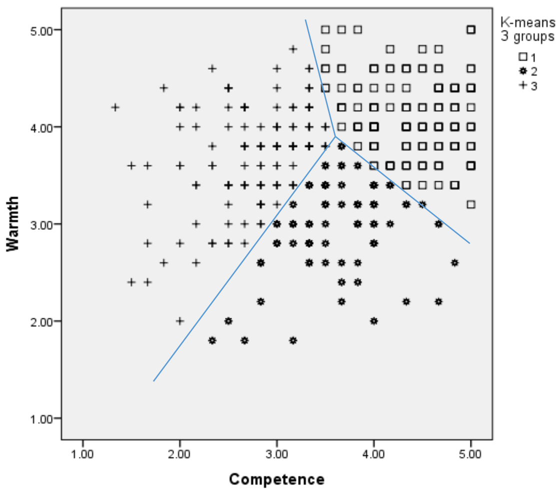
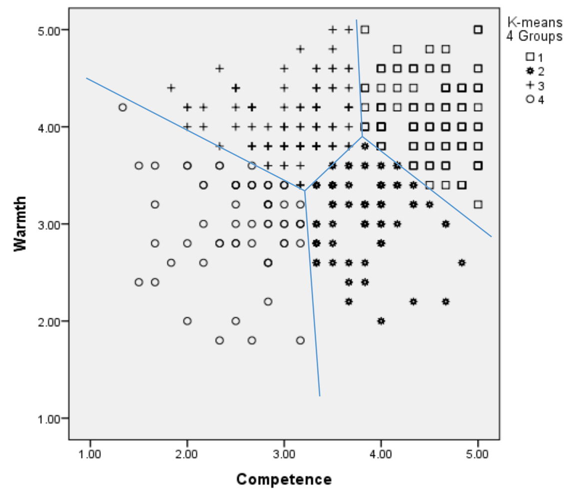


Figure 4.2: Four Cluster Solution



However, as cluster analysis identifies groupings in data but does not address the significance of those groupings, a follow up test was necessary to determine statistical significance. MANOVA was conducted using the warmth and competence scales as the outcome vector and cluster membership as the independent variable, for a 3x1 design.

MANOVA depends on several assumptions: 1) independence of observations, 2) normality, 3) linearity and multicollinearity among the dependent variables, 4) homogeneity of variance-covariance matrices, and 5) sensitivity to outliers. As participants took the survey independently and only once, the observations were independent of each other. Although it is difficult to assess multivariate normality, examination of the histograms of the dependent variables showed that the data were roughly normally distributed for the individual variables. Additionally, MANOVA is robust to modest violations of normality if there are more than 20 observations per cell (Tabachnick & Fidell, 2007), a minimum well exceeded with the current sample. The bivariate scatterplot of the warmth and competence scales (Figure 4.1) and the correlation matrix (Table 4.2) showed that the two dependent variables had an acceptably linear relationship, but not one that was so strong as to make the variables redundant. Since MANOVA is extremely sensitive to outliers, Tabachnick and Fidell (2007) recommended calculating Mahalanobis distance through regression analysis of the dependent variables to check for outliers. Regression of warmth on competence for each of the three clusters did not identify any outliers (with two variables and $\alpha = .001$, critical $\chi^2 = 13.816$; all values were below 8).

The homogeneity of variance-covariance assumption is tested in SPSS through Box's M test. In this case, Box's M was significant ($p < .001$), meaning that the variance-covariance matrices of the separate cells were not equal and the assumption was not met. With unequal sample sizes in the three cells, this meant that the alpha levels may be distorted. Tabachnick and Fidell (2007) state that if the larger variance occurs in the cells with the larger sample size the test becomes more conservative, whereas if the larger variance occurs in the smaller cells, the test becomes more liberal. In this case, the larger variances for both warmth and competence occurred in Group 3 (see Table 3.8), which had a sample size in the middle of the other two groups. The interpretation of this in terms of the impact on alpha levels was unclear. However, multiple sources (Rencher & Christensen, 2012; Tabachnick & Fidell, 2007) have recommended caution in interpreting the results of Box's M test, as the test is sensitive to both small deviations from normality and small deviations from homogeneity of variance with large samples, and suggested that a significant result should not rule out the use of MANOVA. Tabachnick and Fidell (2007) recommended using Pillai's criterion rather than the other measures in MANOVA when Box's M is significant with large and unequal samples.

Pillai's criterion showed that the omnibus F test was significant ($F(4, 788)=251.755$, $p < .001$, $\eta^2 = .561$), as were the follow up omnibus tests on the separate variables (Competence: $F(2,394)=430.62$, $p < .001$, $\eta^2 = .686$; Warmth: $F(2, 394)=175.60$, $p < .001$, $\eta^2 = .471$) (Table 4.3). Post-hoc analyses were conducted on both dependent variables to determine the nature of the group differences. Given the uncertainty of the alpha levels resulting from the violation of the assumption of homogeneity of variance-covariance, the Bonferroni procedure was selected for the post-hoc analyses. The Bonferroni procedure is the most conservative of the available post-hoc tests. Although it is sometimes seen as too conservative for between-subjects ANOVA designs like those used in the post-hoc analyses, this is typically only the case when there are more than three pairwise comparisons (Privitera, 2012). As the post-hoc analyses only include comparisons between three groups, the conservative Bonferroni procedure seemed a safe choice for a situation where the impact on the alpha levels was unclear. Additionally, as this analysis was intended to define a variable (group membership) that would be central to later analyses, a conservative choice seemed prudent.

The Bonferroni procedure showed that all pairwise comparisons were significant, and the three groups were different from each other on both the warmth and competence scales. Cohen (1988) suggested that in a one-way MANOVA a partial eta-squared value above 0.14 be considered a large effect, indicating the differences in both warmth (η^2 = 0.471) and competence (η^2 = 0.686) between the different clusters were substantial.

Table 4.3. MANOVA Results based on Cluster

Variable	Cluster	Mean	Standard Deviation	F	p	η^2
Omnibus	--	--	--	251.755	< 0.001	.561
Warmth	1[a]	4.09	0.40			
	2[b]	3.02	0.44	175.60	< 0.001	.471
	3[c]	3.70	0.53			
Competence	1[a]	4.39	0.44			
	2[b]	3.66	0.47	430.62	< 0.001	.686
	3[c]	2.76	0.84			

Note. N_{total}=397, N_1 = 166, N_2 = 104, N_3 = 127. Clusters with different superscripts are statistically significantly different ($p < .001$) according to Bonferroni post-hoc tests.

Discussion

This outcome indicates that the three groups represent separate combinations of warmth and competence perceptions. The combinations and associated characteristics are summarized in Table 4.4. Specifically, Group 1 had the highest means on both warmth (4.09) and competence (4.39). Based on the SCM (Cuddy et al., 2007) high warmth and high competence perceptions suggest feelings of admiration for people like the presenters, and lead to both active and passive facilitation. This suggests that participants in this group would expect people like the presenters to have good or beneficial intentions, be willing to help if they actively needed it, and willing to trust them to go about their business without interfering when they did not need help. In terms of science information, this further suggests that participants in this group may be more willing to trust the presenters, accept or believe the information, and perhaps act on the information if asked to do so. Group 2 had relatively high competence (3.66) but moderate warmth (3.02). In the SCM this corresponds to passive facilitation but neither active facilitation nor active harm. This suggests that participants in this group may trust the people like the presenters to do their work and let them do it without interfering as long as it did not actively impact the participant, but would be hesitant to help if asked and just as likely to help (facilitate) or attack (harm) if active impact occurred. In terms of science information, this could perhaps manifest as general respect for and acceptance of scientists when the information was not personally relevant, but varied reactions when the information directly impacted the participant, perhaps guided by whether the information confirmed or conflicted with participants' own beliefs or agendas.

Group 3 had relatively high warmth (3.70) but lower competence (2.76). In the SMC this corresponds to active facilitation but passive harm. This suggest that participants in this group would be willing to help people like the presenters but may do so in a way that is not requested or may be dismissive of their opinions and needs (similar to the over-helping of elderly or disabled individuals that ignores what the individuals actually want), or may passively neglect the presenters by ignoring their information or needs when it is not convenient for the participant. In terms of science information, this could perhaps indicate a general approval of the science project and willingness to be supportive, but only on their own terms and when it is convenient for them. Interestingly, roughly a third of the participants in Group 1 (55 of 166) and Group 2 (36 of 104) saw the youth version of the survey, while nearly 90% of the participants in Group 3 (113 of 127) saw the youth version. This implies that the majority of participants who saw the adult version either trusted and supported (Group 1) or passively trusted (Group 2) the adult scientists, while the perceptions of the youth scientists were more mixed. The behavioral consequences are, of course, speculative, and the potential implications of the differences in perceptions are explored further in subsequent analyses.

Table 4.4: Perceptions Group Characteristics

Group	Participants	Mean warmth	Mean competence	SCM meaning[1]
1	Total = 166 *Youth = 55* *Adult = 111*	4.09	4.39	Active and passive facilitation: *Helping and agreeing*
2	Total = 104 *Youth = 36* *Adult = 68*	3.02	3.66	Passive facilitation: *Passive support until agendas conflict*
3	Total = 127 *Youth = 113* *Adult = 14*	3.70	2.76	Active facilitation, passive harm: *Over-helping and neglect/dismiss*

[1]: Stereotype Content Model, Cuddy et al., 2007

Examining Perceptions of Youth and Adults: MANOVA

Analysis

To address Research Question 1a, a MANOVA was conducted to examine the differences in perceptions of youth or adult scientists. The warmth and competence scales were used as the outcome vector with survey version (youth versus adult) as the independent variable for a 2x1 design. As with the MANOVA examining the different clusters, the data met the assumptions of independence of observations, normality, and linearity. In this case Box's M test was nonsignificant ($p = .09$) indicating the data met the assumption of homogeneity of variance-covariance matrices. Calculating Mahalanobis distance through regression did not identify any outliers (with two variables and $\alpha = .001$, critical $\chi^2 = 13.816$; all values were below 12). Pillai's criterion showed that the omnibus F test was significant ($F(2,394)=113.40$, $p < .001$, $\eta^2 = .365$) (Table

4.5). Between-subjects analyses of the separate variables showed that the groups were significantly different on both the warmth ($F(1,395)=13.453$, $p < .001$, $\eta^2 = .033$) and competence ($F(1,395)=129.75$, $p < .001$, $\eta^2 = .247$) scales. As there were only two groups, post-hoc tests were not conducted.

Table 4.5: MANOVA Results for Youth vs Adults

Variable	Group[1]	Mean	Standard Deviation	F	p	η^2
Omnibus	--	--	--	113.40	<0.001	.365
Warmth	Youth	3.80	0.58	12.453	< 0.001	.033
	Adult	3.57	0.65			
Competence	Youth	3.27	0.74	129.75	< 0.001	.247
	Adult	4.11	0.72			

[1]: $N_{youth} = 204$, $N_{adult} = 193$.

Discussion

This outcome indicated that perceptions of youth and adult scientists were significantly different. Youth were perceived as warmer but less competent than adult scientists, with a small effect for warmth ($\eta^2 = 0.033$) and large effect for competence ($\eta^2 = 0.247$) (Cohen, 1988). Means for both groups were above the midline of both scales, suggesting, according to the SCM (Cuddy et al., 2007), that reactions would tend toward facilitation rather than harm, though the degree of active or passive facilitation may differ. Specifically, according to the model, warmer perceptions of youth may trigger more active facilitation of youth than adults, but lower perceptions of competence may trigger lower passive facilitation of youth than adults. In terms of science information, this could perhaps mean that participants would be more willing to support the youth and their projects, but only when helping aligned with the participants' own goals or agendas. However, the comparison of youth to adults overall does not account for the potential differences in reactions between different combinations of perceptions suggested by the

SCM. Examining the differences between perceptions groups, as well as between presenters, in the following statistical and qualitative analyses provides a more nuanced understanding of participants' reactions.

Predicting Perceptions: Multinomial Logistic Regression

Analysis

To address Research Question 1b, multinomial logistic regression was conducted to examine the impact of different predictors on participants' perceptions of the youth or adult scientists. As described in the methods section, perceptions group membership was used as the outcome variable with gender, age, school, ethnicity, political affiliation, major, trust in scientists, air quality interest, air quality importance, and survey version considered as possible predictors. Perceptions Group 1 was selected as the reference category, resulting in logit equations and associated odds ratios comparing the impact of various predictors on membership in Group 1 (high warmth, high competence) versus Group 2 (moderate warmth, high competence), and Group 1 versus Group 3 (high warmth, low competence). Listwise deletion of participants with missing values on one or more variables left a total of 381 participants included in the analysis. Of these, 160 were in perceptions Group 1, 99 in Group 2, and 122 in Group 3. Evaluation of the adequacy of expected frequencies for the categorical variables revealed expected frequencies greater than 5 for all two-way comparisons, indicating adequate power for the goodness-of-fit tests (Tabachnick & Fidell, 2007).

The analysis was conducted through several steps. First, univariate multinomial logistic regression analyses were conducted for each predictor variable. Following Hosmer and colleagues (2007), a liberal alpha of 0.25 was used to identify variables that could potentially be significant in the multivariate model. The results of the univariate analyses are shown in Table 4.6. Both statistical ($p < 0.25$) and theoretical significance were considered in selecting variables for the multivariate model. The univariate analyses indicated that participants' major, trust in scientists, interest and importance of air quality, and survey version were potentially statistically significant and should be included in the multivariate model. Additionally, although they were not statistically significant, age and political affiliation were deemed to be theoretically important and were likewise included. Political affiliation was selected because it is theoretically associated with responses to science topics that can be politically charged (e.g., climate change, stem cell research, green energy) and has been found to be significant in previous studies (e.g., Brewer & Ley, 2013; Feldman et al., 2015; Hart & Nisbet, 2012; Nisbet, 2005). Although the partisan lines surrounding air quality are less clear than for other topics, a non-significant outcome in the multivariate model would still be interesting, and would speak to and inform related work in science communication. Age was selected because of the centrality of age to the topic under study. While certainly not the only factor, it is logical to think that perceptions of youth might change as individuals aged and became further removed from being youth themselves. Consequently, age seemed to be an important variable to include in the model, whether or not it was statistically significant with the current sample.

School, gender, and ethnicity were not included in the multivariate model. These variables were not statistically significant in the univariate models, and not as theoretically important for the current study. School was initially included to determine whether there were differences in perceptions between the students from the two participating schools. The lack of significance in the univariate model ($p = 0.47$) indicated that this was not the case. As there was not a strong theoretical reason that participants' enrollment in the community or private college should influence their perceptions of youth or adult scientists, this variable was not included in the multivariate model. Gender and ethnicity are commonly significant variables in education research, but not as frequently included in science communication studies. In this study, the univariate analyses showed that neither gender ($p = 0.364$) nor any of the ethnicity dummy variables ($p = 0.276$ to 0.715; overall model $p = 0.577$) were significant. As with many science communication studies, the current study was shaped by the particular topic and scenario context. It is certainly possible that for other topics or contexts these variables would be important. For example, other work has discussed fundamental differences in Western and many Native American views of nature and science (Medin, 2013), and for a topic that was culturally or geographically important to a Native American community, ethnicity might be an important variable. Similarly, for a topic that contains an inherent gender component (e.g., science related to women's health topics), gender could be an important variable to include to understand perceptions of communicators or content related to the topic. However, there was not a strong theoretical reason to think that either gender or ethnicity was inherently related to perceptions related to air quality (as it was presented in the survey scenario), and the lack of statistical significance in the univariate models suggested that these variables were not important for the current topic. For ethnicity specifically, this may be due in part to the unequal distribution of participants among response categories, with 67.2% of participants identifying as White. It is possible that a more evenly diverse sample would show a significant effect, but this would need to be examined in future work. Consequently, these variables were not included in the multivariate model, though future studies would be advised to consider these variables in light of the particular study topic and context.

Table 4.6: Results of Univariate Multinomial Logistic Regression Analyses

Variable	-2LL	Chi-square[1]	df	p
Gender	23.73	2.02	2	0.364
Age	133.59	1.57	2	0.457
School	22.88	1.51	2	0.469
Political Affiliation[2]	43.01	4.40	8	0.819
Republican	45.28	2.22	2	0.329
Democrat	44.57	1.52	2	0.468
Other	44.52	1.46	2	0.481
No answer	43.20	0.14	2	0.930
Ethnicity[2]	50.61	6.63	8	0.577
African American	53.18	2.57	2	0.276
Hispanic	51.28	0.67	2	0.715
Asian American	52.52	1.92	2	0.384
Other	52.55	1.94	2	0.379
Trust in scientists*	100.50	10.59	2	0.005
Major*	24.85	3.14	2	0.208
Air Quality Interest*	50.18	3.04	2	0.218
Air Quality Importance*	43.69	5.87	2	0.053
Survey version*	137.57	116.89	2	<.001

* These variables were significant at the $p < .25$ level.
[1] Chi-square statistic is the difference in the -2LL for models with this variable included or omitted.
[2] These values are for the overall model containing the relevant dummy variables

Following selection of potential predictors, a sequential approach (Tabachnick & Fidell, 2007) was used. This involved examining two models, the first including only the personal variables identified through the univariate analyses, and the second adding which version of the survey participants' saw to the model. This was done in order to examine the impact the survey version (the "treatment") had on participants' perceptions on top of the impact of personal variables. Specifically, Model 1 included age, political affiliation (as dummy variables), major, trust in scientists, air quality interest, and air quality importance. Analysis of this model showed that the model was not significantly different than the intercept-only model (-2LL = 766.604; χ^2 (18, N = 381) = 27.0, p = .079; Nagelkerke R^2 = .077). The Nagelkerke R^2 provides a logistic regression version of the R^2 from linear regression, and indicates the improvement in predicting the observed results obtained by adding the predictors to the intercept-only model, with values closer to 1 signifying a better model fit. The low Nagelkerke R^2 value for Model 1 indicates that the combined personal variables did not substantially improve the model and were not sufficient to adequately predict perception group membership. This model correctly classified 45.8% of participants overall. Model 2 included all of the variables in Model 1, as well as which version of the survey participants' were shown. The omnibus test showed that this model was significant (-2LL = 671.005; χ^2 (20, N = 381) = 142.818, $p < .001$) and explained 35% of the variance in group membership (Nagelkerke R^2 = .351). Comparison of the difference in log-likelihood values for Model 1 (-2LL = 766.605) and Model 2 (-2LL = 671.005) showed a significant improvement in the model when survey version was added (χ^2 (2) = 95.599, $p < .0001$). Model 2 correctly classified 59.4% of participants overall, with 68% correct in Group 1, 19.0% in Group 2, and 80.3% in Group 3.

Before examining parameters calculated by the model, the fit of the model to the data was assessed. Assessing model fit is more complicated for multinomial models than for binary models, and at the time of writing appropriate tests were not available in many software packages (Hosmer et al., 2007). Following Hosmer and colleagues (2007) and Begg and Gray (1984), the assessment was done by examining the goodness-of-fit statistics in two separate binary logistic regression analyses, one comparing Groups 1 to 2, and one comparing Groups 1 to 3. In both analyses, the Hosmer & Lemeshow test was not significant (Groups 1 to 2 χ^2 (8, N = 262) = 7.71, p = 0.463; Groups 1 to 3 χ^2 (8, N = 284) = 8.31, p = 0.404), indicating that the models fit the data.

The likelihood ratio tests for Model 2 indicated that survey version ($p < .001$) and trust in scientists (p = .001) were significant predictors in the overall model. The parameter estimates (Table 4.7) for the separate comparisons in the model (Group 1 to 2; Group 1 to 3) showed that trust in scientists was a significant predictor in both comparisons, while survey version was only significant in comparing Group 1 to 3. Age, political affiliation, major, and interest in or importance of air quality were not significant predictors of group membership. Trust in scientists was the only variable that significantly predicted membership in Group 2 compared to Group 1. The output showed that in Logit 1 the β coefficient (the change in the logit associated with a one unit change in x) was -0.66 and the odds ratio was 0.52 (p = .005). This is a negative correlation, and means that as trust in scientists increased, the odds of being in Group 2 compared to Group 1 decreased. Specifically, the output showed that for a one unit increase in trust in scientists, the odds of being in Group 2 decreased .52 fold, or 48% (Exp(β)-1*100). For predicting membership in Group 3 compared to Group 1, both trust in scientists and survey version were significant. For trust in scientists, the output showed that $\beta = -0.87$ and the odds ratio was 0.42. This is again a negative correlation, and indicated that as trust in scientists increased the odds of being in Group 3 compared to Group 1 decreased. Specifically, the output showed that for a one unit increase in trust in scientists, the odds of being in Group 3 decreased 0.42 fold, or 58%. For survey version, the output showed that $\beta = 2.97$ and the odds ratio was 19.53. This is a positive correlation, and indicated that the odds of being in Group 3 compared to Group 1 was greater for participants who saw the youth version of the survey (survey version = 1) compared to participants who saw the adult version of the survey. Specifically, seeing the youth version of the survey was associated with a 19.53 fold, or 1853%, increase in the odds of being in Group 3 compared to Group 1.

Table 4.7: Multinomial Logistic Regression Model

	Variable	β Coeff.	St. Error	Wald	*p*	Odds Ratio [Exp(β)]	95% Confidence Interval Exp(β) Lower	Upper
Logit 1 (Group 2 vs 1)	Intercept	3.14	1.19	6.96	0.008			
	Age	-0.01	0.02	0.36	0.547	0.99	0.95	1.03
	Air Quality Importance	-0.12	0.23	0.27	0.604	0.89	0.57	1.39
	Air Quality Interest	-0.12	0.17	0.53	0.466	0.89	0.64	1.23
	Major (science)	-0.11	0.27	0.17	0.684	0.90	0.53	1.52
	Political Affiliation							
	Republican	0.62	0.39	2.47	0.116	1.86	0.86	4.02
	Democrat	0.57	0.33	3.08	0.079	1.77	0.94	3.34
	Other	0.59	0.51	1.34	0.247	1.80	0.67	4.89
	No answer	-0.13	0.55	0.06	0.812	0.88	0.30	2.58
	Survey Version (youth)	0.24	0.28	0.71	0.401	1.27	0.73	2.21
	Trust in Scientists*	-0.66	0.24	7.74	0.005	0.52	0.32	0.82

Table 4.7 (continued): Multinomial Logistic Regression Model

	Variable	**β Coeff.**	**St. Error**	**Wald**	***p***	**Odds Ratio [Exp(β)]**	**95% Confidence Interval Exp(β) Lower**	**Upper**
Logit 2 (Group 3 vs 1)	Intercept	2.51	1.30	3.73	0.053			
	Age	-0.03	0.02	1.87	0.171	0.97	0.93	1.01
	Air Quality Importance	-0.15	0.26	0.33	0.569	0.87	0.53	1.43
	Air Quality Interest	0.10	0.19	0.29	0.588	1.11	0.77	1.59
	Major (science)	-0.57	0.30	3.73	0.053	0.56	0.32	1.01
	Political Affiliation							
	Republican	0.38	0.44	0.74	0.390	1.46	0.62	3.48
	Democrat	0.35	0.35	1.05	0.305	1.42	0.73	2.80
	Other	-0.20	0.63	0.10	0.750	0.82	0.24	2.83
	No answer	-0.12	0.55	0.04	0.834	0.89	0.30	2.63
	Survey Version (youth)*	2.97	0.35	72.72	<0.001	19.53	9.86	38.67
	Trust in Scientists*	-0.87	0.26	11.44	0.001	0.42	0.25	0.69

* These variables are significant at the $p < 0.01$ level

Discussion

Overall the collected variables did an acceptable, but not excellent, job of predicting group membership, correctly classifying roughly 60% of participants. Correct classification was high for Group 3 (80.3%) and moderate for Group 1 (68%), but fairly low for Group 2 (19.0%). This suggests that additional variables not collected for the current study influenced membership in Group 2. Group 2 was characterized by moderate warmth (3.02) and moderate to high (3.66) competence perceptions. It had the lowest mean warmth score of the three groups, raising the possibility that membership in this group could be based on factors related to perceptions of warmth. This, and other possible explanations, are explored in the qualitative portion of the study.

The significance of trust in scientists as a predictor in both comparisons indicated that greater trust in scientists was associated with being in Group 1 (high warmth, high competence). This is logical, as participants in Group 1 perceived the communicators to have both high warmth and competence, a combination which the SCM suggested is associated with admiration, respect, and both passive and active facilitation (Cuddy et al., 2007). This suggests participants would be willing to help if asked or support the communicators and let them go about their business if all was well. In terms of science communication, this suggests that individuals with high trust in scientists may be more likely to perceive the communicators (youth or adult) as both warm and competent, and consequently may be more willing to actively and passively support the communicators' goals. It is interesting that this was also true in predicting membership between Groups 1 and 2, where survey version was not a significant predictor, as that indicated that participants with high trust in scientists in general were more likely to perceive the communicators as high warmth and high competence, regardless of whether the communicators were youth or adults. Speculation suggests that this could be related to either a general trust in science (or the process of science) and thus willingness to support things related to science, or to a general willingness to trust, regardless of the source. Potential explanations for this are explored in the qualitative portion of the study.

It is clear from the group compositions and analysis that participants were more likely to perceive adults as having high competence than youth. Seeing the youth version of the survey was a strong predictor of being in Group 3 (high warmth, low competence) and only a small minority (14 of 193 total, or 7%) of participants who saw the adult version of the survey were in Group 3. However, despite the major increase in the odds of being in Group 3 for participants who saw the youth version of the survey, not quite half of participants who saw the youth version (91 of 204 total, or 45%) were in Groups 1 or 2 (roughly a third of each group). The current variables do not provide insight into why these participants perceived the youth to be competent while the participants in Group 3 did not. This difference is explored in more depth through the qualitative portion of the study.

Examining Responses from Youth and Adults: T-Tests

Analysis

To address Research Question 2a, independent sample t-tests were conducted to examine the differences in responses on the action and information quality scales between participants who saw the youth version of the survey and those who saw the adult version. The analyses showed that participants who saw the youth versus the adult versions of the survey were significantly different on the information quality scale ($p < 0.001$), but not on the action scale ($p = 0.816$) (Table 4.8).

Table 4.8: T-tests Comparing Responses to Youth vs Adults

Variable	Group	N	Mean	t	p
Action	Adult	189	2.90	0.23	0.816
	Youth	199	2.88		
Information Quality	Adult	191	3.95	10.66	<0.001
	Youth	202	3.19		

Discussion

The similarity in means on the action scale suggests that participants' willingness to take action about the topic was not directly related to whether they heard the information from youth or adults. Examination of the information quality means showed that participants who saw the adult survey had higher expectation of the quality of information (3.95) than participants who saw the youth survey (3.19). This scale focused on how valuable, complete, accurate, and credible participants expected the information to be. The difference in means implies that participants had higher expectations of the ability of the adults to conduct high quality investigations or produce and share high quality information related to air quality than they did of the youth. In terms of science communication, this indicates that participants had higher expectations of science information produced by adults, but that the source of information did not influence how likely they were to take action about the topic. Potential reasons for the different expectations, as well as factors that influenced participants' willingness to take action, are explored in the qualitative portion of the study.

Predicting Responses: Linear Regression

To address Research Question 2b, two linear regression analyses were conducted examining factors that predicted participants' expectations of the quality of the information shared by the presenters, and their willingness to take action based on that information. The analyses are described separately below.

Information Quality

Analysis. To examine factors that predicted participants' expectation of the quality of the information (information quality), a sequential and iterative approach to linear regression was used in which information quality was regressed on blocks of variables. In iterative models, the blocks were examined and variables that did not significantly contribute to the model were removed (see Table 4.9).

Table 4.9: Information Quality Regression Models

Model	Predictors	Adjusted R^2	R^2 Change	R^2 Change sig
Model 1				
	Demographic: Gender, Age, Ethnicity (as dummy variables), School	0.005	0.024	0.253
	Belief: Political Affiliation (as dummy variables), Major, Trust in Scientists*, Air Quality Interest, Air Quality Importance	0.063	0.076	<0.001
	Study: Perceptions group* (as dummy variables), Survey Version*	0.419	0.347	<0.001
Model 2				
	Belief: Political Affiliation (as dummy variables), Major, Trust in Scientists*, Air Quality Interest, Air Quality Importance	0.062	0.082	<0.001
	Study: Perceptions group* (as dummy variables), Survey Version*	0.408	0.343	<0.001
Model 3				
	Belief: Political Affiliation (as dummy variables), Trust in Scientists*	0.056	0.068	<0.001
	Study: Perceptions group* (as dummy variables), Survey Version*	0.401	0.345	<0.001
Model 4				
	Belief: Political Affiliation (as dummy variables), Trust in Scientists*	0.056	0.068	<0.001
	Study: Perceptions group* (as dummy variables), Survey Version*	0.401	0.345	<0.001
	Interaction: Trust in Scientists x Survey Version	0.401	0.002	0.219

* These variables were significant at the .05 level

Specifically, in Model 1 demographic variables including gender, age, ethnicity, and school were entered as the first block, belief variables including political affiliation, major, trust in scientists, air quality interest, and air quality importance were entered as the second block, and study variables including perceptions group and survey version were entered as the third block. The analysis showed that none of the variables in the demographic block were significant, and the block did not significantly improve R^2 (R^2 change = 0.024, p = 0.253). Removing the demographic variables individually or as a block did not significantly change R^2, indicating that these variables did not contribute to the model. The demographic variables were removed from the analysis.

In Model 2, both the belief and study variables blocks significantly increased R^2. Examining the individual variables in the belief block showed that trust in scientists and one of the political affiliation dummy variables (No Answer) were significant ($p < .05$), while major, air quality interest, and air quality importance were not. Removing major, air quality interest, and air quality importance individually or as a group did not significantly change R^2 for the model (R^2 change to remove as a group = -0.008, p = 0.149), indicating that these variables did not significantly contribute to predicting information quality. As political affiliation contained multiple dummy variables, Dunnett's test was used to assess the significance of these variables. Dunnett's test is a method of controlling familywise error when multiple comparisons are made to one reference group by adjusting the critical t value for the comparisons (Dunnett, 1964). In this case, four categories (Republican, Democrat, Other, No Answer) were compared to Unaffiliated. With five groups, the critical t value for Dunnett's test with $\alpha = 0.05$ and $n > 120$ is 2.51. The t value for the β coefficient for the No Answer political affiliation dummy variable in Model 2 (t=2.280) was lower than the critical value required by Dunnett's test. This indicates that although the significance for No Answer was reported by SPSS as 0.023, this category was in fact not significantly different from the reference category on the outcome variable, and should not be considered significant at the $\alpha = 0.05$ level. However, removing the four dummy variables for political affiliation resulted in a significant change in R^2 (R^2 change = -0.017, p = 0.025, adjusted R^2 change = -0.011). This could be due to the fact that adding predictors always leads to increases in R^2, and consequently removing the four dummy variables caused a significant change despite the non-significance of the predictors, or to the inflated significance of one of the dummy variables reported by SPSS. Regardless, the theoretical importance of political affiliation in other work in science communication (Brewer & Ley, 2013; Feldman et al., 2015; Hart & Nisbet, 2012; Nisbet, 2005) combined with change in R^2, suggested retaining political affiliation for the subsequent model.

In Model 3, both the remaining belief variables (political affiliation and trust in scientists) and the study variables blocks significantly increased R^2. Examining the variables individually showed that trust in scientists, survey version, and perceptions group were all significant ($p < .001$, see Table 4.10). Similar to Model 2, the No Answer category of political affiliation was listed as significant in the output (p = 0.022) , but was not significant at the 0.05 level when the critical t-value was adjusted through Dunnett's test (t-critical (n=60, J=5) = 2.51). However, removing political affiliation led to a significant change in R^2 (R^2 change = -0.02, p = 0.13, adjusted R^2 change = -0.014). Given the change in R^2 and theoretical importance of political affiliation, this variable was retained in the model.

Following the examination of main effects, theoretically meaningful interactions were considered. Among the variables in Model 3, it seemed possible that there could be an interaction between trust in scientists and survey version. Specifically, it seemed possible that there could be a different relationship between trust in scientists and information quality among participants who saw the different versions of the survey. As the trust in scientists scale asked about adult scientists in general, it seemed reasonable that there would be a more direct correlation between trust in scientists and trust in the presenters among participants who saw the adult version of the survey, potentially influencing their expectations of the information presented, while the relationship between general trust in scientists and trust in the presenters was less clear for participants who saw the youth version. However, testing this interaction (Model 4) showed that the interaction was not significant (R^2 change = 0.002, p = 0.219). This indicated that the relationship between trust in scientists and expectations of information quality was similar for both survey groups. This resulted in a final model (Model 3) that included trust in scientists, survey version, perceptions group, and political affiliation as predictors of information quality. Model 3 explained 40.1% of the variance in information quality overall (Adjusted R^2 = 0.401), with the majority of the explained variance accounted for by the study variables (R^2 change = 0.345).

Table 4.10: Information Quality Model 3 (N=388)

	Unstandardized Coefficients					**Collinearity Statistics**	
Predictor	***b***	**Std. Error**	**Std. β**	**t**	**Sig.**	**Tolerance**	**VIF**
(Constant)	3.20	0.23		13.75	<0.001		
Republican	-0.17	0.09	-0.08	-1.81	.072	.816	1.226
Democrat	-0.10	0.08	-0.06	-1.33	.184	.769	1.300
Politics other	-0.11	0.13	-0.03	-0.83	.409	.897	1.114
Politics No Answer	0.29	0.13	0.10	2.30	.022	.897	1.115
Trust in Scientists	0.25	0.05	0.19	4.59	<0.001	.933	1.072
Survey Version (youth)	-0.54	0.08	-0.34	-7.30	<0.001	.720	1.390
Perceptions Group 2	-0.48	0.08	-0.26	-5.95	<0.001	.803	1.245
Perceptions Group 3	-0.66	0.09	-0.39	-7.68	<0.001	.614	1.628

Assumptions. Before interpreting the coefficients, the assumptions of ordinary least squares (OLS) analysis (Pedhazur, 1997) were examined for the final model. The first assumption is that x is a fixed variable and the values could be replicated with a new sample. This is often not true in social science research where personal or latent variables that cannot be directly manipulated are used and it is not possible to exactly replicate the values from the initial study design. This was the case for the current study, where several of the study variables focused on beliefs that individually, and particularly as a group, would be difficult to replicate exactly. However, OLS is reasonably robust to violations of this assumption, so a non-fixed x is not a serious problem for the analysis.

The second assumption is that x is measured without error. This, again, is often not true in social science research, where scales are used to imperfectly measure latent traits which themselves may shift over time. In multiple regression, measurement errors in either (or both) the dependent and independent variables can result in an underestimate of R^2 and either under or overestimation of the regression coefficients. However, barring the creation of instruments that can measure latent traits without error, there is not a straightforward solution to this problem, and linear regression is regularly used despite errors in measurement (Pedhazur, 1997).

The third assumption is that the relationship between y and each x is linear. Scatterplots of the four continuous predictors (age, trust in scientists, air quality importance, air quality interest) were used to examine the linearity of the relationship between information quality and each predictor. The plots showed that the relationships were roughly linear with slight positive trends, though the correlations were not very strong (R^2 values all below 0.05). Age, air quality importance, and trust in scientists were all grouped toward the high end of the predictor scales, but the plots did not suggest that the relationships violated the assumption of linearity. Scatterplots were also created for the categorical variables. These plots did not indicate any major problems with the data. However, as dichotomous variables appear linear regardless of the relationship and the relationship for multi-category nominal variables depends on the order in which the categories were entered, the plots did not provide insight on the relationship between the categorical variables and dependent variable.

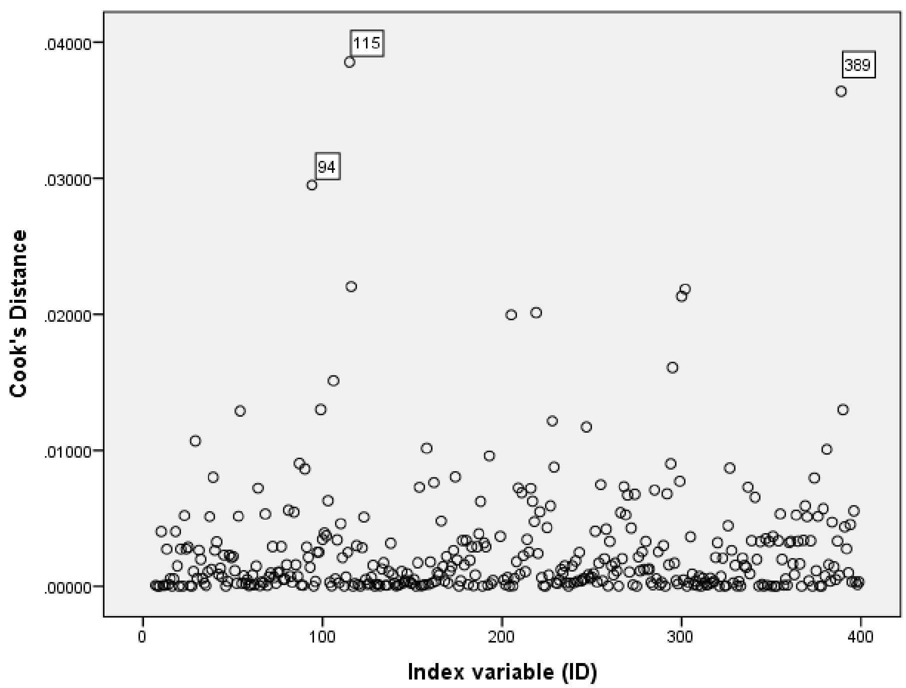
Next, the analysis assumes that the residuals are independent or uncorrelated. This can be assessed through the Durbin-Watson statistic, which examines whether there is correlation among the residuals. The Durbin-Watson statistic for Model 3 was 1.954. The critical value for $\alpha = .05$, k (number of predictors plus intercept) = 9, and 379 (~380) degrees of freedom is d = 1.875 (dUpper). The observed d was greater than the critical value, indicating there was no auto-correlation in the data.

The final assumption is that the data are homoscedastic, or the error variance is normal and constant. The histogram of the SRESID for Model 3 showed the studentized residuals to be roughly normally distributed and the P-P plot of the studentized residuals showed the points close to the expected line. Additionally, the plot of the SRESID against the unstandardized predicted values of Y did not appear to have a clear pattern. Together this suggested that the error variance was normal and constant and the assumption of homoscedasticity was met.

Although they are not assumptions of the analysis, outliers and collinearity among predictor variables can also pose problems for linear regression. Collinearity was assessed by examining the tolerance and variance inflation factor (VIF) across the models. In all models, both tolerance and VIF for each variable were close to 1, indicating there was limited collinearity between variables. The tolerance and VIF for Model 3 can be seen in Table 4.10. To identify potentially influential points, plots of Cook's D and SDFBETA were made for two of the predictor variables (trust in scientists and survey version). Plots could not be created for the two multi-vector categorical variables (political affiliation and perceptions group) because the SDFBETA values were based on the separate vectors, not the variable as a whole.

Cook's D describes the difference in the predicted score with and without that point in the analysis, and is used to identify points that may be influential due to their value on one or both of the predictor and outcome variables. SDFBETA indicates the standardized change in the regression coefficient when a point is removed. Rather than a particular cut off value, Pedhazur (1997) suggested that potentially influential points should be identified by looking for points with Cook's D and SDFBETA values that are a fair amount larger than other values in the data set, and decisions to remove these points should be based on examining the data, diagnostic values, and impact of removing the points. The plot of Cook's D (Figure 4.3) showed three points that were higher than the others (ID# 94, 115, 389), but none of the points were substantially higher than the rest, and they appeared to be the high end of a normal spread of data rather than potential outliers. Similarly, the two SDFBETA plots both contained points above and below the 95% confidence lines, but they were not far from the majority of the data points and fairly evenly distributed above and below. These again appeared to be part of the 5% of data points that are expected to be outside the 95% confidence intervals in a normal spread of data rather than potential outliers. Only one point on either SDFBETA plot appeared outside the range of the rest of the data, ID# 115 on the plot for survey version. This point was also high on the Cook's D plot. Examining the data did not provide a clear reason for this point to be an outlier. As survey version was a dichotomous categorical variable, point 115 could not be an outlier on that variable. Additionally, while that participant had a low score on information quality (the dependent variable), the score was not outside the range of data or even the lowest among participants who were shown the same version of the survey. Given the lack of substantial distance in the Cook's D values and apparent normality of this point from examining the data, this point was retained in the analysis. No other points were considered for removal.

Figure 4.3: Information Quality Model 3 Cook's D Plot



As the examination of the assumptions and potential outliers did not reveal any problems with the data, Model 3 was used as the final model for this analysis. This resulted in the following regression equation (see Table 4.10):

Information Quality = 3.20 + 0.25(Trust in Scientists) - 0.54(Survey Version) - 0.48(Perceptions Group 2) - 0.66(Perceptions Group 3) - 0.17(Republican) - 0.10(Democrat) - 0.11(Other) + 0.29(No Answer) + e

Discussion. The regression coefficients indicated that an increase in trust in scientists in general led to an increase in expectations of the quality of the information shared by the presenters, but seeing the youth version of the survey or being in perceptions Groups 2 or 3 led to a decrease in expectations of information quality. Specifically, an increase of one on the trust in scientists scale corresponds to an increase of 0.25 on the information quality scale, whereas seeing the youth version of the survey led to a decrease of 0.54, being in perceptions Group 2 (moderate warmth, high competence) led to a decrease of 0.48 compared to Group 1 (high warmth, high competence), and being in Group 3 (high warmth, low competence) led to a decrease of 0.66 compared to Group 1. Additionally, the political affiliation variables were included in the model as being theoretically, though not individually statistically, significant. However, the final model only explained 40.1% (Adjusted $R^2 = .401$) of the variance in expectations of information quality. This indicates that additional variables that were not collected as part of the current study influenced participants' expectations of the information quality. The qualitative portion of this study explores potential additional variables that could be included in future work.

The information quality scale asked about participants' expectations of how valuable, accurate, credible, and complete the information shared by the presenters would be. The positive association between trust in scientists and information quality makes intuitive sense, as it is reasonable to think participants who had greater trust in scientists in general would also have higher expectations regarding the information they produce and share. The decrease in expectations associated with seeing the youth version of the survey further suggests that participants expected information produced or presented by the youth to be less valuable, accurate, credible, or complete than information produced by adult scientists. The non-significance of the interaction between trust in scientists and survey version indicates that while participants overall had higher expectations of the adult scientists, higher trust in scientists increased expectations of the information quality similarly among participants who saw both versions of the survey. This indicates that individuals who trusted scientists and the information they produce in general were also more likely to trust youth when they shared science information, and that general trust in scientists is an important factor in individuals' initial expectations of science information that might be shared. This is in line with previous research, which has repeatedly found that trust in the source is an important factor in forming opinions about information and topics (Brossard & Nisbet, 2007; Nisbet & Scheufele, 2009; Wynne, 1992) and individuals regularly make decisions about complex topics by determining whether they trust the source, not the specific information (Bromme & Goldman, 2014). In terms of youth as sources of science information, this could suggest that participants who had higher trust in scientists either viewed the youth as being capable, credible scientists (though less so than adult scientists), or that the fact that the youth were sharing science information was more important than the fact that they were teenagers. Potential reasons for this are examined in the qualitative section of the study.

The results also showed that participants who were in perceptions Group 1 had higher expectations for the information than participants in either perceptions Group 2 (*b*

= -0.48) or Group 3 (*b* = -0.66). This indicates that participants who viewed the presenters (youth or adult) as having high warmth and high competence had higher expectations for the information they would share than participants who viewed them as having lower warmth or competence. This fits with the reactions predicted by the SCM (Cuddy et al., 2007), which holds that groups in the high/high quadrant elicit active and passive facilitation, and feelings of admiration. People expect individuals in these groups to competently do good things, and it logically follows that they would also expect them to produce and present high quality information.

Conversely, participants in perceptions Group 2 viewed the presenters as competent but had ambivalent feelings about their warmth, a combination the SCM (Cuddy et al., 2007) suggests elicits passive facilitation but neither active facilitation nor harm. This could indicate that although participants in that group generally viewed the presenters as competent, their expectations of the information the presenters shared were influenced by factors other than the presenters' competence. For example, previous work has found that individuals' trust in specific sources of information is not static, but can be influenced by the perceived intention of the source (Lang & Hallman, 2005; Rabinovich et al., 2012), perceived alignment with one's own beliefs (Gunther & Schmitt, 2004), or perceived influence of the information source (Gunther & Liebhart, 2006).

Participants in perceptions Group 3 viewed the presenters as having high warmth but lower competence. This could indicate that participants in that group thought the presenters may have good intentions, but not have the expertise or knowledge necessary to produce or present high quality information. SCM (Cuddy et al., 2007) suggests this combination elicits active facilitation but passive harm, which may be manifest as pity or concurrent over-helping and neglect. A possible outcome of this perception is that participants may have supported the presenters' efforts, but felt they were not capable of carrying out their intentions on their own and would need additional help to produce high quality information. Factors that may have influenced the expectations of information quality for participants in different perceptions groups are examined in the qualitative part of the study.

Finally, the political affiliation variables were theoretically important, but not individually statistically significant. The lack of significance is interesting, as previous work has found that partisan affiliation influenced perceptions of identical information and responses to that information (Brewer & Ley, 2013; Feldman et al., 2015; Gunther & Leibhart, 2006; Gunther & Schmitt, 2004; Hart & Nisbet, 2012; Nisbet, 2005). It is possible that the non-significance in the current study is due in part to the uncertainty in the degree of affiliation among participants (casual or die-hard Republican?), a factor which was considered in other work (e.g., Feldman et al., 2015; Gunther & Schmitt, 2004). This may be exacerbated by the age range of the current sample, as younger adults tend to be less politically active overall than older age groups (File, 2013). However, the dissimilarity of the current outcome to previous research warrants further exploration of political affiliation as a factor influencing responses to science communication.

Willingness to Take Action

Analysis. Similar to the analysis of information quality, a sequential and iterative approach to linear regression was used to examine factors that predicted participants' willingness to take action based on the information about air quality (action). In iterative models, blocks of variables including demographic, belief, and study factors, followed by potential interactions, were examined and variables that did not significantly contribute to the model were removed (see Table 4.11).

Table 4.11: Action Regression Models

Model	**Predictors**	**Adjusted R^2**	**R^2 Change**	**R^2 Change sig**
Model 1				
	Demographic: Gender, Age, Ethnicity (as dummy variables), School*	0.035	0.053	0.005
	Belief: Political Affiliation (as dummy variables), Major*, Trust in Scientists*, Air Quality Interest*, Air Quality Importance	0.268	0.244	<0.001
	Study: Perceptions group (as dummy variables), Survey Version*, Information Quality*	0.351	0.087	<0.001
Model 2				
	Demographic: School*	0.032	0.035	<0.001
	Belief: Political Affiliation (as dummy variables), Major*, Trust in Scientists*, Air Quality Interest*, Air Quality Importance	0.265	0.247	<0.001
	Study: Perceptions group (as dummy variables), Survey Version*, Information Quality*	0.352	0.092	<0.001
Model 3				
	Demographic: School*	0.032	0.035	<0.001
	Belief: Major*, Trust in Scientists*, Air Quality Interest*	0.260	0.233	<0.001
	Study: Perceptions group (as dummy variables), Survey Version*, Information Quality*	0.353	0.099	<0.001
Model 4				
	Demographic: School*	0.032	0.035	<0.001
	Belief: Major*, Trust in Scientists*, Air Quality Interest*	0.260	0.233	<0.001
	Study: Survey Version*, Information Quality*	0.350	0.093	<0.001

Table 4.11 (continued): Action Regression Models

Model	Predictors	Adjusted R^2	R^2 Change	R^2 Change sig
Model 5a-d				
	Demographic: School*	0.032	0.035	<0.001
	Belief: Major*, Trust in Scientists*, Air Quality Interest*	0.260	0.233	<0.001
	Study: Survey Version*, Information Quality*	0.350	0.093	<0.001
	5a- Interaction: Major x Survey Version*	0.356	0.007	0.042
	5b- Interaction: Trust in Scientists x Survey Version	0.349	0.001	0.478
	5c- Interaction: School x Survey Version	0.351	0.003	0.212
	5d- Interaction: School x Major	0.350	0.001	0.353

* These variables were significant at the .05 level

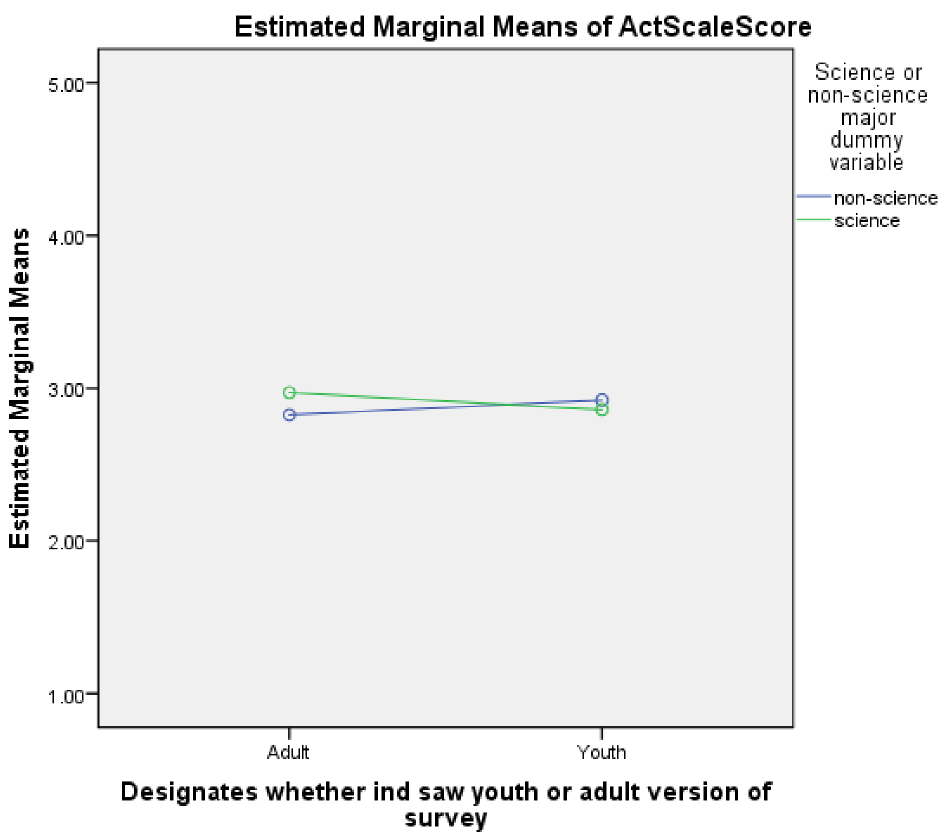
Specifically, in Model 1 demographic variables including gender, age, ethnicity, and school were entered as the first block, belief variables including political affiliation, major, trust in scientists, air quality interest, and air quality importance were entered as the second block, and study variables including perceptions group, survey version, and information quality were entered as the third block. The analysis showed that all three blocks significantly contributed to the model. To refine the model, variables within each block were examined to identify non-significant factors. Demographic variables were examined first, and the analysis indicated that only school was a significant predictor of willingness to take action. Removing gender, age, and ethnicity individually or as a group did not significantly change R^2, indicating that these variables did not contribute to explaining variance in willingness to take action. These three variables were removed from the model.

In Model 2, which included only school in the demographic block, all three blocks again significantly improved R^2 (R^2 change $p < .05$ for each). The analysis indicated that political affiliation and air quality importance were not significant predictors ($p > .05$ for air quality importance and all political affiliation dummy variables), while major, trust in scientists, and air quality interest did significantly predict willingness to take action ($p < .05$). Removing air quality interest and political affiliation separately or together did not significantly change R^2, indicating that these variables did not contribute to the model and should be removed.

In Model 3, the reduced demographics and belief blocks were entered, followed by the complete study block. The analysis showed that among the study variables, survey version and information quality were significant predictors ($p < .05$) but perceptions group was not ($p > .05$ for each dummy variable). Removing the perceptions group dummy variables did not significantly change R^2, indicating that this variable did not significantly contribute to the model. Model 4 included only the variables that had been found to be significant. This included school, major, trust in scientists, air quality interest, survey version, and information quality. The analysis indicated that the overall model explained 35% of the variance in willingness to take action (Adjusted $R^2 = 0.350$).

Finally, potentially theoretically meaningful interactions between the 'treatment' variable (survey version) and the pre-existing personal variables (school, major, trust in scientists, air quality interest) were examined (Models 5a-d). This was done to see if the survey version participants were shown altered the relationship between the personal variables and participants' willingness to take action. Interactions were entered individually following the main effect variables. The analysis indicated that only Major x Survey Version significantly improved the model (R^2 change = 0.007, $p = 0.042$). Although the change was small, this indicated that accounting for the interaction between major and survey version increased the ability of the model to explain participants' willingness to take action. Examination of the willingness to take action mean values for science and non-science majors who saw each version of the survey revealed a cross-over interaction, with willingness to take action decreasing for science majors who saw the youth version (2.86) compared to the adult version (2.97) but increasing for non-science majors who saw the youth version (2.92; Adult version = 2.82) (Figure 4.4).

Figure 4.4: Major x Survey Version Interaction



This resulted in a final model (Model 5a) that included school, major, trust in scientists, air quality interest, survey version, information quality, and the Major x Survey Version interaction. Model 5a explained 35.6% of the variance overall (Adjusted R^2 =

0.356), with the majority of the explained variance accounted for by the belief variables (R^2 change = 0.233). The coefficients for Model 5a are shown in Table 4.12.

Table 4.12: Willingness to Take Action Model 5a

	Unstandardized Coefficients					Collinearity Statistics	
Predictor	***b***	**Std. Error**	**Std. β**	**t**	**Sig.**	**Tolerance**	**VIF**
(Constant)	-0.51	0.29		-1.73	0.084		
School (CC)[1]	0.27	0.09	0.14	3.10	0.002	0.795	1.258
Major (science)[1]	-0.03	0.11	-0.02	-0.26	0.798	0.450	2.224
Trust in Scientists	0.17	0.06	0.12	2.75	0.006	0.861	1.161
Air Quality Interest	0.33	0.04	0.39	8.85	<0.001	0.891	1.123
Survey Version (youth)[1]	0.35	0.11	0.20	3.13	0.002	0.404	2.477
Information Quality	0.37	0.05	0.35	7.22	<0.001	0.709	1.410
Major x Survey Version	-0.29	0.14	-0.15	-2.04	0.042	0.308	3.250

1: Category in parentheses set as 1

Assumptions. Before interpreting the coefficients, the assumptions of ordinary least squares regression were checked for Model 5a. As with the linear regression for information quality, the predictor variables in this analysis cannot be assumed to be fixed and directly replicable with a new sample. Additionally, as the variables include scales measuring latent traits, they cannot be said to be measured without error. However, OLS is reasonably robust to violations of these assumptions. Scatterplots of the continuous predictors (age, trust in scientists, air quality importance, air quality interest, and information quality) indicated that each of these variables had a roughly linear relationship with action, with slight positive trends. Age and air quality importance were grouped toward the high end of the predictor scales, but the plots did not suggest that the relationships violated the assumption of linearity.

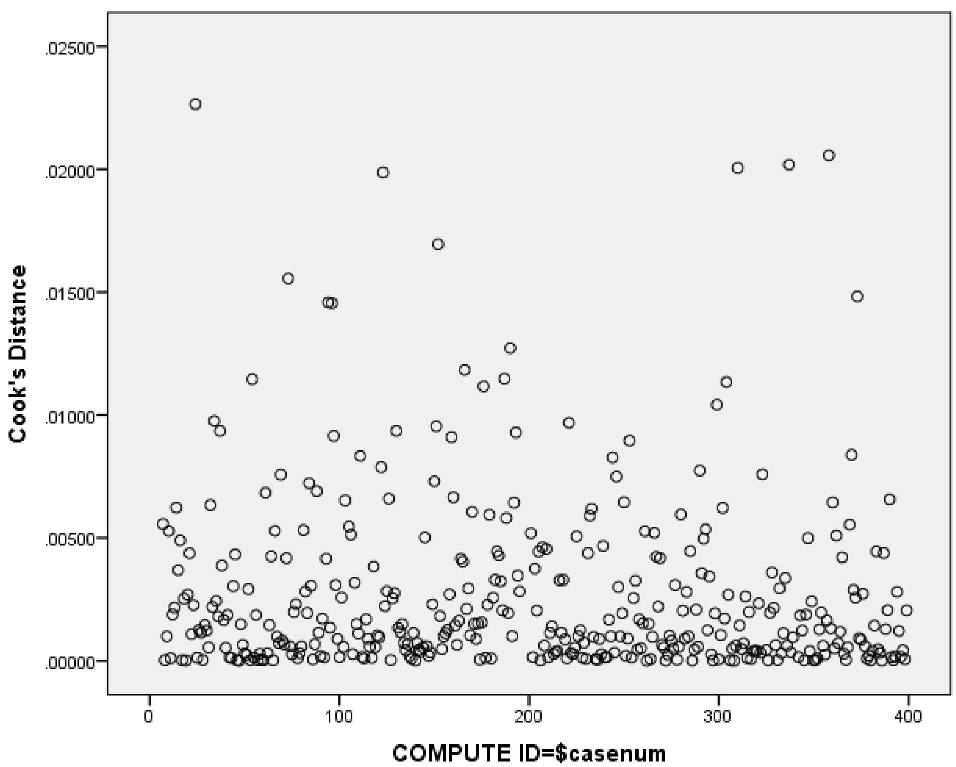
The Durbin-Watson statistic for Model 5a was 2.116. A value greater than 2 indicates potential negative autocorrelation in the data. To test for negative correlation, the observed value is subtracted from 4 (the highest possible value) and compared to critical values. This yielded an observed value of 1.884 (4-2.116). The critical values for $\alpha = .05$, k (number of predictors plus intercept) = 8, and 377 (~380) degrees of freedom are dLower= 1.794 and dUpper = 1.869. The observed d was greater than the upper bound, indicating there was no autocorrelation in the data.

The histogram of the SRESID for Model 5a showed the studentized residuals to be roughly normally distributed, the P-P plot of the studentized residuals showed the points close to the expected line, and the plot of the SRESID against the unstandardized predicted values of Y did not appear to have a clear pattern, indicating that the error variance was normal and constant and the assumption of homoscedasticity was met.

The tolerance and VIF for all variables were close to 1 in all models without interaction terms. In Model 5a, tolerance values were low (<0.5) and VIF slightly higher (>2.0) for major, survey version, and the interaction term including those two variables. This was expected, as the interaction term should be correlated with its component variables, and does not interfere with the analysis. Tolerance and VIF for all other variables were close to 1. Additionally, the collinearity diagnostics table for Model 5a showed that major, survey version, and their interaction loaded strongly on one dimension, while each other predictor loaded strongly on single (but different) dimensions. Together this indicated that there was limited collinearity between the variables. Tolerance and VIF for Model 5a can be seen in Table 4.12.

Examination of Cook's D and SDFBETA scatterplots did not identify any points that would be considered outliers. For Cook's D (Figure 4.5), there was a spread of data moving up from the major clump, but no points that were substantially higher than the others. The SDFBETA plots similarly showed points spreading above and below the 95% confidence interval lines, but no points that were substantially farther away from the mean than the others. Additionally, there were no individual points that appeared as high or low across multiple of the Cook's D and SDFBETA plots. Consequently, no points were removed from the analysis.

Figure 4.5: Cook's D for Action Model 5a



As the examination of the assumptions and potential outliers did not reveal any problems with the data, Model 5a was used as the final model for this analysis. This resulted in the following regression equation (see Table 4.12):

Action = -0.51 + 0.27(School) – 0.03(Major) + 0.17(Trust in Scientists) + 0.33(Air Quality Interest) + 0.35(Survey Version) + 0.37(Information Quality) – 0.29(Major x Survey Version) + e

Discussion. The regression coefficients for the final model indicated that greater trust in scientists, interest in air quality, and expectation of the information quality, as well as being enrolled at the community college, led to an increase in willingness to take action, and that science and non-science majors responded differently to the different versions of the survey. Specifically, an increase of one on the trust in scientists, air quality interest, or information quality scales led to increases of 0.17, 0.33, and 0.37, respectively, in willingness to take action. Being told the presenters were youth resulted in a decrease in willingness to take action among science majors, but an increase among non-science majors. The final model explained 35.6% of the variance in willingness to take action overall (Adjusted $R^2 = 0.356$). This indicates that additional variables not collected for the current study may contribute to participants' willingness to take action, and identifying them could produce a model with more explanatory power. Potential variables to include in future work are explored in the qualitative portion of the study.

The increase in willingness to take action associated with trust in scientists, interest in air quality, and expectations of the information quality make logical sense, as it is reasonable to think participants would be more likely to act on information if they believed it was high quality, generally trusted scientists when they shared information, and were interested in the topic. This aligns with previous work that found that perceptions of presented information and the presenters' motivations influenced willingness to take action (Hwang et al., 2008; Rabinovich et al., 2012), and that personal interest is a major motivation for engaging with science topics (Dietz, 2013; Falk et al., 2007; Liu & Falk, 2014). It is interesting to note that trust in scientists did not interact with survey version, indicating that a greater trust in scientists in general led to a greater willingness to take action based on the presented information, regardless of whether that information was shared by youth or adults. This may suggest that trust in scientists is linked to general trust in science, and thus a trust in the information generated by science regardless of who specifically generated it. This is explored further through the qualitative portion of the study.

The significant impact of school indicated that students enrolled at the community college were more likely to take action than students enrolled at the private college. A possible reason for this could be based on the fact that the private college had a national reputation and draw and thus students came from a much wider and more geographically distant area than students at the community college, who came from a relatively small area of the surrounding towns. Previous work has found that individuals are more interested and engage more when the topics are personally relevant to them (Falk et al., 2007; Patchen et al., 2014). It is perhaps possible that students at the private college did not identify as strongly with the local area or did not see the local air quality described in the scenario as relevant to them, and were consequently less willing to get involved. This is explored further in the qualitative section of the study.

The difference between science and non-science majors in willingness to take action after seeing different versions of the survey is interesting, and points to youth's potential contributions to the STEM learning ecosystem. The finding that science majors were less likely to take action based on the youth's presentation than the adults was disappointing but perhaps not surprising. It is possible that science majors have greater belief in the authority of science, or a deeper understanding of the complexities involved in science that would make them less willing to trust and act on information collected and presented by youth, who typically do not have extensive training and resources. However, the increase in willingness to take action among non-science majors who saw the youth version of the survey suggests youth might be an avenue for reaching and engaging individuals who did not choose to pursue study in science. This could perhaps be a way to reach a broader and more diverse audience than the science elite, a major challenge and goal for both informal science education and science communication (Feinstein & Meshoulam, 2014; Nisbet & Scheufele, 2009). The quantitative analyses do not provide insight into the reasons for this difference, and it is explored further in the qualitative portion of the study.

Summary of Quantitative Findings

The findings from the quantitative data analyses indicated that participants had different perceptions of the adult and youth scientists, different expectations of the information they would present, and different degrees of willingness to take action based on that information. Specifically, the data showed the following results:

- For research question 1 and 1a, perceptions of the warmth and competence of the presenters and differences in perceptions of youth and adults:

    - Perceptions of the warmth and competence of the presenters were centered on the moderate to high end of each scale.
    - Youth were perceived as warmer but less competent than adults overall.
- For research question 1b, the factors that predicted perceptions:
    - Different combinations of warmth and competence perceptions were predicted by participants' general trust in scientists and by whether they were told the presenters were youth or adults.
- For research question 2 and 2a, expectations of the quality of and willingness to take action based on the information shared by the youth or adults:
    - Expectations of information quality and willingness to take action were centered on the moderate to higher end of each scale.
    - Expectations of information quality were higher for adult presenters than youth presenters.
    - Willingness to take action was not significantly different for the youth or adult presenters.
- For research question 2b, the factors that predicted both responses:
    - Expectation of the information quality was predicted by trust in scientists, youth or adult presenter, and perceptions of the presenter.
    - Willingness to take action was predicted by school, trust in scientists, interest in air quality, expectations of information quality, and an interaction between major and youth or adult presenter.

The quantitative findings are generally internally consistent and in line with theory and previous research. Expectations of higher quality information from adults logically follows higher perceptions of competence for adults. The significance of trust in scientists in all three regression models indicates this is an important variable in perceptions and responses to science topics. The fact that this variable was significant but did not significantly interact with survey version is interesting as it indicates that trust in scientists influenced participants' responses regardless of whether the information was presented by youth or adults. This could perhaps suggest that this variable addressed participants trust in science in general (and associated processes and methods) rather than their trust in the human scientists.

The differences among science and non-science majors in willingness to take action after seeing the different survey versions is especially interesting, as it hints at the potential of youth as a science information source for a broad and hard to reach non-science-elite audience. Drawing on the SCM (Cuddy et al., 2007) to understand perceptions and reactions, this difference combined with the overall perceptions of youth as warmer but less competent further suggests there may be interesting differences in the relative importance of warmth and competence perceptions among science and non-science participants.

The quantitative results do not, of course, offer explanations for the observed patterns. The following chapter examines the qualitative data to understand and explain participants' thoughts and reasoning that contributed to the quantitative patterns.

CHAPTER 5: QUALITATIVE RESULTS

Introduction

The goal of the qualitative analysis was to understand and explain the patterns that emerged in the quantitative data. This analysis addressed Research Question 3:

> *What are the reasons driving young adults' perceptions of the warmth and competence of youth or adult scientists, and their willingness to take action based on and expectations of the quality of the information the youths or adults present?*

This was examined through two data sources: responses to an open-ended question on the survey and extended interviews. A major feature of the quantitative analysis was the identification of three groups among participants that had different perceptions of the presenters. Group membership was found to be a significant predictor of participants' expectations of the quality of the information the presenters would share. To understand these groups and the influence they had on information quality, interview sampling was structured to select participants from each perceptions group for each version of the survey, resulting in six 'subgroups.' Cognitive interviews were conducted in which participants were asked to talk through the survey and describe the thoughts that had influenced their responses to each of the scales. The analysis looked for similarities and differences in responses within and between the subgroups.

In general, there were many more commonalities in responses between the open-ended survey question, perceptions, and information quality sections than with the willingness to take action section. Responses to the open ended survey question indicated participants thought about a core set of similar ideas when thinking about the presenters. These included qualities specifically related to science, such as methods and training, and more subjective or personal qualities, such as credibility, honesty, and trust. In the perceptions and information quality sections several themes were identified, with similarities and differences delineated by the survey version, perceptions groups, or both. Some of these focused on specific external factors, such as assumptions about the funding for the research, that impacted participants' responses. Others appeared to be underlying beliefs held by participants, such as whom and when to trust, that were repeatedly offered as explanations for their opinions but often not themselves explained. Across the themes a larger pattern emerged in the way participants explained their responses for the perceptions and information quality scales. In Group 1 (high warmth, high competence), participants' responses were imbued with a sense of trust in science, society, and the "goodness" of people. In Group 2 (moderate warmth, high competence), a pervasive sense of skepticism and doubt appeared to drive their thoughts. For Group 3 (high warmth, low competence), their assumptions and expectations for the presenters seemed to be based on their own experiences doing science. These characteristics are summarized in Table 5.1. For ease of reading the table is presented here, but will be repeated and described in detail later in the chapter. Finally, in the action section several patterns in responses were identified that focused primarily on the participants' thoughts about specific actions, rather than about the presenters or presentation.

This chapter begins by examining responses to the open-ended survey question. Although the conclusions that could be drawn from this set of data were limited by the format and length of the responses, the responses do provide an overview of participants' thoughts about the presenters. Participants' ideas are then examined in much greater depth through interview responses about their warmth and competence perceptions, followed by descriptions of the group characteristics. The chapter then examines participants' interview responses about their expectations of the information quality and willingness to take action on the topic.

Table 5.1: Group Characteristics

	Adult presenters (193)	**Youth presenters** (204)
Group 1 (166)	**Trust and belief** N: S=111, I = 3 High Warmth: *good intentions* High Competence: *high experience*	**Trust and belief** N: S=55, I = 4 High Warmth: *good intentions* High Competence: *high ability*
Group 2 (104)	**Skepticism** N: S=68, I = 4 Low Warmth: *bad intentions, ulterior motives* High Competence: *high experience*	**Science skepticism** N: S = 36, I = 3 Mixed Warmth: *good intentions, cold scientists* Mixed Competence: *insufficient experience, but smart scientists*
Group 3 (127)	**Mixed** N: S = 14, I = 2 See discussion	**Personal experience** N: S = 113, I = 6 High Warmth: *personal good intentions* Low Competence: *personal low ability/experience*

Open-Ended Survey Question

An open-ended question on the survey asked participants if, and why, they would have changed their responses had they seen the alternate version of the scenario. Of the 387 participants who answered this question, 349 (90%) said they would have responded differently. Most responses were very short, ranging from a few words to a few sentences. The major ideas repeated by multiple participants included primarily positive qualities (listed below), such as ability or experience, that the alternate presenters would have to varying degrees. The only 'negative' quality that was mentioned was how likely the presenters would be to do 'bad' things, such as have ulterior motives, alter their data, or be otherwise nefarious in their work.

The vast majority of participants indicated they would have changed their responses because they felt the adults would have more of one (or several) of the positive qualities (e.g. more ability) than the youth. Among the 349 who would have responded differently, only one participant felt the adults would have 'less' of any of the positive qualities. The most commonly mentioned reason was experience, with 134 participants stating that the adults would have more experience than the youth. This was followed by comments on the credibility (84 participants), education or training (79), expertise (61), or knowledge (75) of the presenters, and somewhat less frequently their abilities (53), methods (44), motivations (30), data (44), resources (44), or trustworthiness (44). A typical example, from a participant in Group 1A, was, "Scientists have more experience and knowledge in the area than high school students would." While the majority of participants agreed they would have answered differently for the alternate scenario, the number and combination of qualities they mentioned to explain their opinions varied greatly.

Only one quality, how likely participants would be to do bad things, was describes as both higher and lower for adults. Eight participants felt the youth would be more likely to be nefarious, while 12 felt this would be more of a concern with adults. For seven participants, their views were clear, favoring one presenter over the other. For example, one participant in Group 2A trusted youth more, stating "high school students seem to be more honest than scientists." A participant in Group 2Y felt the opposite,

stating, “in general, teenagers are perceived as immature and not always completely honest. That's just how it is even though it doesn't apply to every teenager.”
The other 13 participants appeared to balance positive and negative thoughts, favoring either the adults or the youth. For example, a participant in Group 1Y said:

> Each group has their strengths and weaknesses. The adults may be more experienced and knowledgeable than the students, but I feel like they are also more likely to have some ulterior political or economic motive that causes them to have a specific viewpoint.

Although the number of participants who mentioned this on the survey was small, it indicates their opinions were influenced by qualities about the presenters that were not directly related to science. In thinking about the other qualities participants mentioned, it seems likely that assumptions about personal factors would have more influence on the subjective qualities such as trustworthiness and credibility. The variation in their responses suggests the influence may be complex.

Thirty-eight participants indicated they would not change their answers if they had seen the alternate scenario. A few common ideas stood out among their responses. Four of the participants simply stated that the presenters’ age would not influence their responses, without providing any additional information. As one said, “age of the persons would not make a difference on my answers”. Most of the remaining participants focused on either the presenters or the science involved in the project. The participants that focused on the presenters typically explained that they felt high school youth could be just as good as or better than adult scientists. These comments frequently mentioned the presenters’ intentions. For example, one participant in Group 1A said, “scientists even high school student or adult they both will have same intention so my answer would be same.” A second in Group 1Y said, “if anything I would think the high school students would be conducting the experiment with the utmost integrity and they would be less likely to be swayed by outside influences such as money, politics, etc.” The participants that focused on the science most commonly mentioned the equipment and methods used in the study. For example, one participant in Group 3Y said, “depends entirely on how complete the design of the experiment is. Who presents facts the best is up to them.” A few participants focused instead on a general belief about science that was unrelated to the specifics of the project. As one participant in Group 2Y said, “science is something that people will question whether a teen or adult is conducting the research.”

Overall, it appeared that participants considered a core set of ideas about both the science and the people involved in the project when forming their opinions. The majority felt that adult scientists would have ‘more’ of the positive qualities than youth scientists, and consequently would have answered differently had they seen the alternate scenario. However, the relative importance of the personal and science-related qualities, and the manner in which they influenced their responses, varied across participants. Although the short-answer format limited the analyses and conclusions that could be drawn from these data, as it seems likely participants’ views were more nuanced and complex than the few words they typed in the survey, this indicates participants’ reactions and responses to the science encounter described in the scenario were influenced by multiple, and sometimes competing, ideas.

Perceptions of Warmth and Competence

In the Stereotype Content Model (Cuddy et al., 2007) the combination of warmth and competence perceptions are used to predict emotional and behavioral outcomes. Participants' perceptions of the warmth and competence of the presenters were measured through two separate scales on the survey. The survey data showed that perceptions of warmth and competence of the presenters was centered over the higher ends of both scales, with youth perceived as warmer but less competent than adults. Three clusters were identified in the perceptions data, separating participants with different combinations of warmth and competence perceptions. The quantitative analysis showed that participants' general trust in scientist and whether they saw the youth or adult version of the survey predicted which group they would be in. The qualitative analysis aimed to understand the reasons that influenced participants' perceptions. What was it about the adults or youth, or participants' trust in scientists, that led participants to have different perceptions? As a reminder, to measure warmth the items asked how friendly, well-intentioned, trustworthy, good-natured, and sincere participants thought people like the presenters would be. The items for competence included competent, confident, capable, efficient, skillful, and intelligent. As the two are connected, the reasons participants' gave as influencing their responses for the two scales are discussed together.

The analysis of participants' discussion of the factors that influenced their perceptions identified themes both within and between the perceptions/survey version groupings. Two major ideas were present across all participants, though expressed somewhat differently among members of different groups. First, assumptions about the presenters' experience with and associated ability to do science was a major factor in participants' perceptions of competence. Second, the presenters' intentions—good, bad, or uncertain—was a major driver of participants' perceptions of warmth. There were additionally several ideas that were primarily expressed by participants in only one of the perceptions groups. These included participants' own experience doing science, a pervasive sense of trust or skepticism regarding science and society, and the impact of the television news context. The combination of the cross-group and group-specific themes led to unique sets of ideas expressed by participants in each of the groups, and suggest overarching characteristics driving their responses.

The analysis below is organized by theme. While there are several ways to subdivide this data, organizing by theme allows for a more coherent examination of each theme, and direct comparison of the different ways themes were discussed by members of different subgroups. The two major themes, science experience and ability and presenters' intentions, are analyzed first, followed by the group specific themes. These include trust and the news context for Group 1, skepticism and self-interest for Group 2, and personal experience for Group 3. Finally, the over-arching group characteristics are discussed.

Science Experience and Ability

Presenters' science or academic experience and associated science abilities were major factors that influenced their perceptions of competence. The majority of participants commented on the degrees, training, or years of experience they assumed the presenters had (or did not have), and their assumptions about the presenters' intellectual ability to do the work involved in researching air quality. These ideas were expressed differently about youth and adult presenters.

Among participants who saw the adult version of the survey, experience and ability were often linked and cited as a reason for thinking the presenters were competent. For example, in describing how society thinks about people like the adult scientists, G2A2 (Group 2, Adult survey, participant #2; see Table 3.6) said:

> When they think scientists they think extremely intelligent, extremely mathematic, extremely skillful in what they do, they've done it for years, they probably have a doctorate at some point in their life so they probably know what they're talking about, as viewed by society. And I think that goes across most people.

G2A2 indicated that he assumed the adult scientists in the scenario had enough of the right experience, through an advanced degree and years of work, to be extremely capable of doing the research. G2A2 went on to highlight the all-encompassing nature of this assumption by suggesting it was universally true of scientists, saying, "no one thinks of a scientist as not intelligent, not skilled in their craft." Several participants stated that the fact that the scenario said the scientists were from a "research institution" indicated that they must have extensive experience with science and high ability. Although the scenario gave no information about the "institution", participants referred to this as evidence of the presenters' abilities and, therefore, as the reason they believed the presenters to be competent. As G3A1 (Group 3, Adult survey, participant #1; see Table 3.6) said, "I just thought that because they were two scientists from the institution ok so they know exactly what they're doing." Similarly, G3A2 equated "local research institution" with a well-respected institution in his community, and said working there meant the presenters "know their stuff". Nearly all participants who saw the adult version of the survey mentioned the presenters' experience with and ability to do science as evidence of their competence. The uniformly positive nature of these comments highlights the strength of this association.

In contrast, the comments were more mixed among participants who saw the youth version of the survey. Participants in Groups 2 (moderate warmth, high competence) and 3 (high warmth, low competence) primarily assumed the youth would not have sufficient experience to be seen as competent. When participants in Group 2 discussed this, they related it to academic experience. For them, the ability to do the work required for scientific research was developed through years of training and experience, which the youth would not have. As G2Y2 said, "I feel like we generally expect teenagers to go on and do an undergraduate degree, and maybe even go beyond that. We expect them to need that level of education before they can really be considered a solid intellectual." G2Y1 also felt the youth would not have the "years of expertise" needed to be competent researchers. Participants in Group 3 spoke more generally about experience and were less likely to specifically refer to academic training. Instead, these participants were largely influenced by their own experiences (this theme is described later) and typically mentioned feelings about their own competence when explaining their perceptions of the youth. As G3Y2 said:

> High school you're so young, and I'm like in college so I was just in high school so I know yes I was smart but I did not nearly have a lot of knowledge as a professional did or even as I do now so just because you're so young and lack of experience and therefore older people I think they feel the same way because of

> years of living and their own experience they see what is really, like a high schooler know. So that's why they might not really take them as seriously.

However, although these participants focused on the youth's lack of experience, they also qualified their negative views with positive counterpoints. G2Y3 indicated that the association with science mitigated the youth's lack of experience: "society generally thinks anyone, any scientist is pretty intelligent, like the way people view news, scientific news, they seem to just automatically assume that everything is correct because it's like science, it must be like right or wrong." G3Y2 thought that the youth did have the abilities to make positive contributions, despite not having the experience to be taken seriously:

> Definitely there are teenagers who are very innovative and some of the best ideas come from young people so that's why I put a little bit more, but still, high schoolers, so that's why I didn't do any moderate or extreme.

Several participants balanced negative assumptions about academic experience with positive thoughts about the youth's hands-on experience. G3Y3 said:

> I figured they must have some baseline knowledge of what's going on so I put somewhat for a lot of them because like I don't think they have the ability to speak on these topics as like a PhD would have, but like I don't think they would be not at all or slightly competent, confident, or capable, just because like they put in the work and they presumably the data they collected with the monitors would be accurate and it would just be their, how well they could interpret the information.

G2Y2 similarly thought that because the youth had been studying the topic they must have "some level of knowledge" even though they would not have the same understanding as someone with a higher degree. For all of these participants, the youth's experience with science warranted low perceptions of competence, but some aspect of their abilities or other experience led them to slightly raise their scores.

For others, ability and experience were not as directly linked. All four participants in Group 1 (high warmth, high competence) focused on ability over experience. For these participants, the fact that the youth were involved in a project like the one described in the scenario and sharing it on the news meant that they must be highly intelligent and competent. As G1Y3 said:

> When two high school students are motivated enough to do a research project people are going to view them as very ahead of their time or very just like the forefront geniuses of the next generation, so if they see someone like this they might be like, the next, I don't really know any current scientists, they'll be the next Einstein or the next newton, so they're going to be very, I think people like, my opinion is that people would think favorably upon them

Another participant, G1Y1, suggested the youth might be more adept than adults because of their age

> So if people are watching high school students they're like, wow these high school students must be really smart because they're getting interviewed about science. And then also just with new developments and stuff I think they would be more in the know than adults and people above them, so that's how I viewed that.

Interestingly, these comments parallel the reasons given by participants in other groups for increasing their competence perceptions. Both G1Y3 and G2Y2 (above) indicated that working on a science topic increased their perceptions of the youth's competence. G1Y1 and G3Y2 (above) both suggested the youth may be more forward-thinking, through innovations or new developments, than adults. Only one participant in this group suggested that experience might influence perceptions. G1Y2 stated that an adult scientists who had years of experience might be viewed as "more authoritative", but that did not mean to him that youth would be any less capable.

Overall, it was clear from the data that perceptions of competence were influenced by assumptions about the presenters' experience and abilities. For adult presenters, assumptions of extensive experience and intelligence led participants to believe they were highly competent. For youth, while a few participants felt the youth's abilities meant they were highly competent, the majority stated they did not have the experience to be seen that way. However, rather than completely dismissing the youth, participants felt that hands-on experience, working on a science topic, or an ability specific to the youth increased the youth's competence.

Intentions - Good, Bad, Questioning

A second major theme was the influence that participants' assumptions about the presenters' intentions in doing the research had on their perceptions. In general, participants who assumed the presenters' intentions were good described that as a reason for high warmth perceptions, while those who questioned their intentions or believed they may have had some "ulterior motive" mentioned intentions as a reason for lower warmth perceptions. Nearly all participants commented that the presenters' intentions influenced their opinions about the project and their perceptions of presenters' warmth, but the assumptions they made were different for the youth and adult scientists, and among participants in different perceptions groups.

For adults, participants in Group 1 (high warmth, high competence) associated the topic with good intentions, assuming that scientists who were researching air quality would do so for the purpose of helping the environment and society. For example, G1A1 explained why she selected high ratings for the warmth items:

> I put extremely because if people are taking the time to collect all this data about the Earth and especially if it's leading to bad things that lead to further change, good change, then that means they want to make a difference in the world and well intentioned is good.

G1A3 echoed this, saying, “if they're presenting news about air quality they want to kinda help people so I said yeah they have good intentions to kinda make sure everyone's aware of what they're breathing.” The participants in Group 1 viewed air quality and the environment as a good cause, and believed scientists who would spend their time working on this topic would be well-intentioned people aiming to make a positive difference in the world.

In contrast, participants in Group 2 (moderate warmth, high competence) were skeptical of the presenters’ intentions. Although participants gave different reasons for their skepticism, they had in common a sense that the presenters’ intentions might not be entirely good. Several participants were concerned that the presenters might be “biased” and misrepresent their data to support their own opinions. As G2A1 said:

> And then trustworthy, good natured and sincere, I thought that those ones could also be, like as society as a whole, people might not take that as much at face value because you know trustworthy and sincere they're trying to convince you of their opinion so there's always the half that you're not hearing.

For G2A2, the history of questionable research done by other scientists influenced his perceptions of the scientists in the scenario. He were concerned that these scientists would also do research in a way that "put people at risk." G2A3 had concerns about the trustworthiness of scientists. Although she felt environmental research was generally well-intentioned, the controversy surrounding other environmental topics led her to doubt whether the scientists would tell the truth. This could be alleviated, she suggested by knowing "a reason why they're coming to speak, I know it said that they're researching air quality but maybe... why they want to do that." For all of these participants, doubts about the presenters' intentions led to lower perceptions of warmth.

Interestingly, perceptions of the youth presenters were more uniform, with participants from all three groups assuming the youth would have good intentions. For all, this seemed to be based on the idea that teenagers who were willing to work hard on a project were "good people." As G1Y3 said:

> Overall people would think that their personalities would be good and honest people and compassionate because they're willing to research a project that impacts the air quality of the world, which a lot of people are concerned about, so having those students there they'd be like ok yeah they're good people.

G2Y2 similarly suggested that the youth would have good intentions, because that is what youth who are passionate enough about a project to work on it do:

> I did think that society does tend to expect teenagers to be well intentioned. I think that we, you know when we hear about young people getting really involved in something and working passionately toward something, it gets everyone excited, you know we're pleased to see that they're showing some passion. And we would expect that their intentions are good, that they really do want to make a difference about it, because young people often do.

Four people went farther to say that the youth would not have bad intentions. They believed youth would be unlikely to be biased or have the ulterior motives that concerned other participants about the adult scientists. As G3Y2 said:

> I think as a high schooler you're not really trying to do anything bad. Like if anything at that age you're trying to succeed and you're trying to find something new and cool and so I don't really think they'd have any reason to have bad intentions. And society probably views them as like innocent anyways so, as young and like innocent kids, so they wouldn't really see anything bad about that.

Several participants repeated the idea that the youth and innocence of the high school scientists precluded any bad intentions. As G1Y2 stated, the youth could not have bad intentions because "what they're doing they're not doing for profit or anything like that cause they're just a couple of teenagers." He later went on to say "it's not like they're going to try to pull out the rug on anyone, they don't have any ulterior motives." G3Y1 was not concerned about youth being motivated by financial conflicts of interest because they would not have had the financial know-how to do so. G1Y1 suggested the youth's innocence made them more trustworthy than adults:

> I would almost trust a younger person talking about it more that hasn't had the experience and all the influences of people trying to fight them on their opinions cause I feel like they're seeing it from a very like, clear, almost like, unbiased way than other people would.

The positive thoughts about the youth's intentions is particularly striking when compared to participants' views about the intentions of scientists in general. When asked if they would have had the same positive views of adults' intentions, several participants said no. As G3Y2 said, "adults can be more scheming and can have ulterior motives and other intentions." G1Y2 explained:

> I think people sometimes get a little skeptical about that, they think that there's some sort of ulterior motive, which I think is pretty common, you can see something like climate science denial, and stuff like that, that's a pretty common trend.

In the section of the interview addressing general trust in scientists, the majority of participants' expressed doubt about scientists' intentions. Although many of these participants expressed a belief or hope that in general most scientists would be trustworthy, they were quick to qualify their trust with hesitations. The most common concern focused on the desire or need for funding undermining the integrity of scientists' research. As G3Y2 stated, "everything's about profit nowadays so you never really know if the scientist is actually pursuing something for the good of society or if it's an ulterior motive." Others focused on slightly different aspects of similar ideas. G2Y2 said, "there's a lot of bias in science toward getting published, or getting funds." G2A1 said, "if they were hired by somebody to do this research their opinion could obviously be swayed." G1Y1 said, "I think that some scientists are influenced by political opinion or funding or things like that." G2Y4 summed up a common sentiment: "I want to believe that they know what they're doing and they're doing what they're doing for the best interest of society but I don't know, there are always those few exceptions and it changes stuff." Despite dominating comments about scientists in general, these concerns were either not mentioned or expressly rejected when discussing the youth. Participants uniformly felt that youth would have good intentions, and in fact could not have bad intentions, and consequently viewed them as warm. A potential implication of this sentiment was expressed by a participant who initially saw the adult presenters, G2A4, who stated: "it's easy to dismiss scientists because they might have a bias, it's harder to dismiss high school students."

Overall, the data indicate that participants' perceptions of the warmth of the presenters' were influenced by their assumptions about the presenters' intentions. Further, they show that participants generally assumed that youth would have good intentions while doing the project, and would primarily be aiming to help society or the environment. In contrast, many participants were concerned that adults may be influenced by funding, politics, or other ulterior motives, and did not assume their intentions would be entirely good.

Trust in the News Context

A theme related to the context of being on the news emerged, primarily from participants in Group 1 (high warmth, high competence). For all seven participants in Group 1, the fact that the presenters were sharing their information on the news lent credibility to the project and increased participants' willingness to trust them. This, in turn, increased their perceptions of competence. For participants who saw the youth survey, the reasons for this were clear. As G1Y4 said:

> I just assumed that they had done a lot of intricate research already, and because of their appearing on a news station that the information that they were giving to the public was deemed accurate by multiple people before it got to air, so I think that's why I chose on the more positive side of competent and capable because multiple people had thought that this information was worth spreading to the public.

G1Y2 thought similarly, saying if they were on the news he assumed “that they've been kinda screened, and it's not that they're just making things up as they go along, anything like that.” The importance of “screening” by the news station was reinforced by participants’ comments about trusting the youth less if they encountered them in a social setting. As G1Y4 said:

> That way it could have just been them, or it could have been friends telling information or while, I guess when I think of information in the media I assume it has to go through multiple people to get there so not only the students, but someone above the students, the editor, the producer, things like that.

Participants who saw the adult survey similarly indicated that the news context increased their trust in the presenters, but did not provide specific reasons as to why.

As G1A2 said, “if two people are speaking on the news, that like gives them kind of a sense of, connotes trust, it kinda legitimizes them.” G1A3’s response offered the most reasoning from the adult group, which she explained as “gut instinct”:

> I think I just trust them for being on the television. Usually when I hear something on the news at night I trust it, usually gut instinct, but I'd just assume they know what they're talking about, they're not just making stuff up.

Both sets of participants felt that the news context increased their sense of trust, and therefore their perceptions of competence. For participants who saw the youth survey, this was based on assumptions about the vetting that occurs before something is shown on the news, and thus on the assumed validation of the youth's work. Participants who saw the adult survey were not as explicit in their reasoning, other than to say they trusted the news.

Unwilling to Believe

In contrast to the trust expressed by participants in Group 1, several participants doubted whether people would believe what scientists had to say. This doubt was expressed most strongly and consistently by participants in Group 2 (moderate warmth, high competence) who saw the adult version of the survey. Their comments suggested two components: a lack of trust in scientists and a sense that people would only believe scientists if the scientists' information agreed with their previous opinions. All four participants in this group stated that they did not think society would trust the scientists. For G2A3, this was related to evidence and uncertainty in the project:

> Trustworthy, slightly, because I don't know, there's just a lot of back and forth on this topic so a lot of people don't trust everything they hear unless it's cited by a lot of evidence which is not there so that's why I was like oh, slightly.

G2A1 likewise mentioned evidence, suggesting that society would trust scientists more than politicians or activists who would express "purely personal opinion", but said this was not enough to overcome concerns about scientists' "biases and where are they coming from and what information are they trying to present you." She stated, "so I think scientists get a little more credibility but in general people would still be slightly skeptical just because that's how most people are." The sense that people are inherently skeptical was similarly expressed by the other two participants. For them, trusting scientists was based on a central belief about science, not on any action the scientists may take or evidence they may present. As G2A2 said, "people are either like 100% agree with the science, won't listen to any logic that doesn't' back it or they're like no there's no reason ever to believe it even if there are facts and statistics behind it." Additionally, all four participants in this group suggested that whether or not someone "believed" science depended in part on whether the scientific information supported their opinions or interests. G2A4 articulated this:

> I've always gotten the impression that we, when we think of scientists we think of them as important people, people we can trust, but then when we hear information from them that we dislike, as a society we often dismiss them as having some sort of bias or trying to promote a specific cause that is in their best interest rather than our best interest. So I said that in most cases, confident, competent, capable, intelligent, skillful, they're moderately... society views them as moderately competent, confident, etc. I would say that's only because it's not extremely because they may not like the information they hear so they dismiss the integrity of what they hear.

For these participants, the unwillingness to believe scientists influenced their perceptions of both warmth and competence. This appeared to be based on their thoughts about both scientists and people. To them, scientists were probably biased, and people were inherently skeptical and unwilling to be convinced by data they did not like. These thoughts resulted in lower perceptions of the warmth and competence of the presenters.

Personal Experience

For many participants who saw the youth survey the scenario brought up memories of their own experiences doing science in high school. Although participants in all perceptions groups referred to their own experience, the occasional comments from participants in Groups 1 and 2 were mostly minor and not directly connected to their responses, whereas for participants in Group 3 (high warmth, low competence) personal experiences seemed to be the major factor influencing their perceptions of the presenters. G3Y6 stated this explicitly:

> I know as a high school student, like as a previous high school student, what I was allowed to do and what I was given, is where my answers came from. It didn't come from the actual fact of you know what they did or what they, I want to say I almost stereotyped them a little bit, but you know, it only came from experience.

Although other participants were less direct about the influence, they all made explicit connections between themselves and their perceptions of the youth. These comments focused variously on the experience, ability, effort, or resources related to science research, but had in common doubts about the competence of high school students. For example, G3Y1 referred to the legitimacy of her own research methods as a high school student as evidence of the presumed competence of the youth scientists:

> Overall, especially including the competence, I was thinking of the degree of legitimacy of my research when I did a project like that. How often did I cross-

> check or did I write something and then try to figure out how to prove it and go backwards. So I guess that's sort of what I was thinking about in the like competent, efficient, skillful, intelligent.

G3Y6 mentioned her own feelings of confidence, saying “I didn't think they would be confident because, like I said again from experience I wasn't very confident in high school and I don't think I knew that many people that were.” G3Y4 reflected on his abilities with a similar project. He said, “I had no idea what I was doing when I was presenting my own poster presentation” and went on to say:

> so I'm not saying that high school students in general are just unintelligent, but in my personal experience in that specific field that we were working with, I just wasn't well informed in what I was doing really, so that's why I said not at all.”

G3Y5 doubted their interest and willingness to work hard on the project:

> Just thinking about myself in high school, I don't think, like I think if it was me it was something I would have done just to get it done and I wouldn't have, I would have not been really passionate about it.

Several participants additionally referred to their own experience when assessing the warmth of the presenters. In contrast to the competence perceptions, this association primarily resulted in higher warmth perceptions. G3Y4 expressed a common sentiment, “well I can only speak for my high school, but at my high school we were all pretty outgoing, pretty friendly, that's why I gave it an extreme rating.”

The extensive focus on themselves set these participants apart from the participants who saw the youth survey from Groups 1 and 2. For Group 3, their expectations of the youth were directly related to their memories of doing science in high school. They saw themselves in the presenters and based their responses on their perceptions of themselves. This resulted in lower perceptions of competence for all six, and mostly higher perceptions of warmth.

Overarching Influences

Across the themes, different subgroups appeared to have different over-arching sentiments that influenced many of their responses. Examining responses by subgroup, rather than by theme, offered a different and illuminating perspective on the reasons driving participants' perceptions. In the following paragraphs, short quotes or ideas followed by participant numbers in parenthesis refer to quotes that were discussed above. The major characteristics of each group are summarized in Table 5.1 (repeated below). The summaries are meant to be read as a loose structure. That is, they capture the major ideas expressed by members of each group or the group where a specific idea was most commonly expressed, not as a definitive description of each individual participant. The characteristics are discussed in detail below.

Table 5.1 (repeated): Group Characteristics

	Adult presenters (193)	**Youth presenters** (204)
Group 1 (166)	**Trust and belief** N: S=111, I = 3 High Warmth: *good intentions* High Competence: *high experience*	**Trust and belief** N: S=55, I = 4 High Warmth: *good intentions* High Competence: *high ability*
Group 2 (104)	**Skepticism** N: S=68, I = 4 Low Warmth: *bad intentions, ulterior motives* High Competence: *high experience*	**Science skepticism** N: S = 36, I = 3 Mixed Warmth: *good intentions, cold scientists* Mixed Competence: *insufficient experience, but smart scientists*
Group 3 (127)	**Mixed** N: S = 14, I = 2 See discussion	**Personal experience** N: S = 113, I = 6 High Warmth: *personal good intentions* Low Competence: *personal low ability/experience*

Participants in Group 1 (high warmth, high competence), for both the youth and adult surveys, seemed guided by a pervasive sense of trust. These participants believed that the presenters' had the necessary experience and abilities for the research project, and that they would be "good and honest people" (G1Y3) who were researching air quality to "make a difference in the world" (G1A1) and "help people" (G1A3). They further believed that the information from the project would be valid and "worth spreading to the public" (G1Y4) because it was shared on television news. While the participants who saw the youth survey repeated the idea that the pre-television screening process was the reason the news context increased their perceptions, neither group questioned whether the news would provide accurate or truthful information. Instead, they trusted information from the news out of "gut instinct" (G1A3). Taken together, this suggests that these participants were willing to believe in both the warmth and competence of the people associated with the project, trusting that they were good people doing good work for good reasons. This seems to support and explain the high ratings participants in Group 1 gave for both warmth and competence perceptions on the survey.

This differs from the participants in Group 2 (moderate warmth, high competence), and particularly those in Group 2 who saw the adult survey, who appeared to be driven by a persistent feeling of skepticism. Although participants in Group 2 felt the adults would have sufficient experience to do the research well, they did not trust their intentions. They were concerned the adult scientists would be biased and only share data that supported their opinion (G2A1, G2A3), conduct risky research (G2A2), generally be untrustworthy. They further doubted whether society would believe the scientists, suggesting people would be "skeptical" (G2A1) and "dismiss" (G2A4) the scientists when they did not like the findings. This sentiment was nicely summed up by G2A2, who said, "I trust science, I just you know I don't want to trust science too much." This sense of doubt, of both science and people, pervaded their comments and influenced their perceptions of both warmth and competence. This again matches the survey responses for Group 2, showing high perceptions of competence but lower perceptions of warmth.

The comments among participants in Group 2 who saw the youth survey were less clear, and did not align as well with their survey responses. Despite higher perceptions of competence on the survey, the participants in this group felt the youth would not have the academic experience to be competent and not fully understand the topic even though they had been working on it (G2Y1, G2Y2). Additionally, despite lower perceptions of warmth on the survey, participants claimed to expect youth to be passionate about the project, have good intentions, and want to make a difference in the world (G2Y2), feelings that suggest higher perceptions of warmth. For competence, a possible explanation for this discrepancy was raised in G2Y3's comment that "any scientist is pretty intelligent". This suggests, perhaps, that for this participant the fact that the project was about science was more influential for their perceptions than who was presenting it. Searching for an explanation of the discrepancy in warmth perceptions among the interview responses offered some support for this supposition. In explaining their warmth perceptions, G2Y3 said:

> In general I associate science with, maybe because our classes are curved and everything, more like analytical minds that are a little bit colder, but because they're high school students I didn't know if maybe they had other interests and, maybe they weren't quite that cold and analytical but something in-between like somewhat and not at all.

In this, G2Y3 again referenced science and scientists more generally before modifying her thoughts to be more specifically about the youth. G2Y1 likewise referenced generic 'scientists' when explaining his perceptions of the youth's warmth, saying, "I guess scientists you would think, they wouldn't necessarily be the most extremely on being the charismatic." This suggests that participants in this group may have based their responses more on their perceptions of scientist as intelligent but cold, and then adjusted slightly to reflect the impact of the youth. However, this idea was not probed during the interviews, and the evidence supporting it is not extensive. Additional research would be required to further examine this possibility.

For participants in Group 3 (high warmth, low competence) who saw the youth survey, their own experience was the most salient reason for their perceptions of both warmth and competence. All six participants in this group felt that they had not been competent researchers when they were in high school, and, therefore, neither were the youth in the scenario. They additionally felt that they and their classmates had been good and friendly people (G3Y4), and would not have had bad intentions (G3Y1, G3Y2), and, therefore, the presenters would be the same. This is consistent with the perceptions of high warmth and lower competence expressed on the survey. The absence of self-referencing comments among participants who saw the adult survey suggests that participants were able to relate to the youth scientists in a way they were not able to do with the adults. This makes sense, as everyone in the sample had been a high school student but none were adult research scientists. However, it raises the possibility that adults in a broader audience might also be able to relate to youth where they cannot relate to adult scientists. It is interesting that all six participants felt that they had not been competent when doing science as high school students. This raises a question of whether any of the participants had experiences where they felt competent doing science and how that might have influenced their perceptions, as it did not come up during the interviews.

The comments from participants in Group 3 who saw the adult survey were the least consistent and did not align with the survey results. This was by far the smallest subgroup, containing only 14 individuals among the survey participants, with only two ultimately agreeing to be interviewed. This was also the least intuitively logical combination of perceptions—while high warmth but low competence seems reasonable for youth presenters, this combination of perceptions for adult scientists contradicts research on public opinion and common stereotypes (Fiske & Dupree, 2014) related to scientists. The interview data did not provide much insight into the reasons behind these participants' perceptions. Other than feeling that the adult scientists would have sufficient experience to be competent, the two participants in this group had little in common. G3A1 appeared conflicted about the scientists' warmth. She suggested the presenters would be warm, because "they wouldn't put someone on the news that couldn't [be friendly when talking about science]", but also not trustworthy because "it's hard to trust someone you don't know." G3A2 also expressed conflicting views about scientists' warmth, but they directly contradicted G3A1's thoughts. G3A2 suggested the scientists would appear arrogant and cold when discussing science, because they "dumb it down for the general population" but also warm, because "obviously they have to be trustworthy to get funding". While this could suggest these participants believed in the presenters' competence but were uncertain about their warmth, this also conflicts with the survey results for this group which indicated high warmth but low competence. It is possible that a larger sample or different interview questions could illuminate these perceptions, but the current data do not provide explanations for these conflicts.

Summary

In summary, participants' perceptions of the warmth and competence of the presenters were influenced primarily by their assumptions about the presenters' intentions and their experience and abilities related to science, respectively. Broadly, participants felt the adults would have sufficient experience to be competent but had mixed feelings about their warmth, whereas they felt the youth would be warm and well-intentioned, but with mixed thoughts about their competence. However, the basis for their assumptions appeared to be guided by different factors for participants in different subgroups. Participants in Group 1 trusted the presenters and their project, influenced in part by the context of being on the news. Participants in Group 2 assumed the adult scientists would have the right experience to be competent, but were skeptical of the presenters' intentions and the way people would respond. Perceptions of the youth scientists among members of this group were less clear, and perhaps focused more on the fact that the project was about science than that it was presented by youth. For Group 3, perceptions of the youth were driven by participants' own experiences, where they felt they had had good intentions but limited abilities doing science when they were in high school.

Information Quality

To measure participants' expectations of the quality of the information the presenters would share, the survey asked how valuable, complete, accurate, and credible participants' felt the information would be. As a reminder, the survey data indicated that youth or adult presenter, perceptions of the presenter, and trust in scientists predicted participants' expectations of the information quality, with adult presenter, higher trust, and perceptions Group 1 associated with higher expectations of the information. Participants' explanations for their expectations of the information quality had many similarities to their responses about their perceptions. Across the subgroups, assumptions about the presenters' science experience and associated ability to correctly conduct the study and interpret findings, as well as the presenters' intentions, were the major drivers of expectations. Once again, participants' assumptions and associated reactions were different among the different subgroups, and were typically aligned to the over-arching perspectives identified in the perceptions data. In this section, the primary responses – intentions and experience/ability—are examined for each subgroup, followed by examination of a cross-group theme regarding having a professional mentor for the youth. This organization allowed for clearer connections to the perceptions data and comparisons among groups.

Experience and Intentions

Participants in Group 1 (high warmth, high competence) who saw the adult survey again expressed an underlying trust in the scientists. All the participants in this group said they assumed the adult scientists would do good work on a good cause, and produce high quality information. Often, this trust seemed to be based more on intentions than experience. As G1A2 (see Table 3.6) said, “the majority of the time, as I said before, I would value it and take it as truth and believe them because they have this air of reputable-ness about them.” G1A2 went on to explain this was, in part, due to the fact that they were working on a good cause: “given the nature of the topic it lends me to trust them. Seeing how it was something that kinda was going to benefit people or it didn't seem to have any negative repercussions.” G1A1 focused on the presenters’ effort and background as reasons for trusting their information, saying, “if they're taking the time to do all that research, they're probably doing it well. Or they're probably like of that background and just want to, are well intended, intentioned.” G1A3 stated her generally sense of trust would be reinforced by the news context, saying, “I would generally trust them, and then depending on how their other data was I guess I would put that in extremely because I would trust them if they're on television.” Although they focused on different aspects, these participants felt that people who were ‘of a science background’ would be reputable, trustworthy, and well-intentioned, and, therefore, would produce high quality information.

Conversely, participants in Group 2 (moderate warmth, high competence) expressed some hesitation over the quality of the adult scientists' information. These participants' comments echoed the sentiment expressed by G2A2 (above) of trusting science, but not too much. The reasons they gave for their hesitation included both the presenters' abilities and intentions. For G2A1, adult scientists' experience suggested they would have high quality information, but she were concerned about the scientists' opinions influencing their presentation:

> I would mostly trust what a scientists was telling me with the forethought that they were, you know if I knew that they were who they said they were and they were credible then I think that I would definitely trust the information that they were giving me at the base level minus the opinions, but the physical, the quality of the information being given I think would be very high.

G2A2 felt that the scientists would have done extensive work but was not convinced they would have done it all correctly because "everybody makes mistakes". This, he said, lowered his expectations of the information quality:

> I'm sure they've done thousands of tests, figured it out, got a pretty good idea of it, but I'm not gonna just say, you know I'm not going to lean all the way there's always going to be just a little bit of doubt.

G2A4 felt the data was probably good because it was "a very objective measurement", but was hesitant about two scientists being able to do the required work on their own. He expressed needing to know more to evaluate the information, saying, "I mean two scientists could have very complete information but without knowing specifics I would not immediately assume it's complete." These comments have in common a sense of doubt about the scientists and project. Compared to Group 1, where participants unreservedly trusted the scientists to produce high quality information, these participants' hedged their trust with hesitations that lowered their expectations of the information quality.

Similar to the perceptions data, the two participants in Group 3 (high warmth, low competence) who saw the adult survey again had conflicting views. In this case, the two participants seemed to have more in common with the other groups than with each other. G3A1's responses seemed consistent with those of participants in Group 1, focusing on the news context as the reason for trusting the scientists and the quality of their information. She said, "all of them were extremely because they're on the news presenting the information so I concluded that the study was done or that they had come up with something that was significant to share." In contrast, G3A2 fit better with Group 2, expressing doubt over both the information and the presenters' intentions in sharing it:

> Science is not, it's never a really concrete thing, so I don't know whether I can fully believe them or not, in a sense. And especially, what was I about to say, I mean like I don't know, they could have skewed it if they really wanted to to like draw a reaction.

As with the perceptions data, the current data do not provide a clear or consistent explanation for the reasons driving participants in this subgroup.

Across the groups, participants were more hesitant about the quality of the information the youth presenters would share. This was again expressed differently, and with different motivations, among the subgroups. Participants in Group 1 felt the youth would produce the best information they could within limitations that were primarily external to the youth. As G1Y1 said, “if they're talking about it and presenting it that it's you know believable and it's as complete as it could be from someone in that level of knowledge.” For G1Y3, the youth’s motivation and interest in the project meant that the information would be “overall good quality” but limited by the information available to the youth:

> Sometimes what high schools teach to students isn't quite up to date or it's misconstrued or it's not the best, it's not taught the correct way in a sense, so that's why I said somewhat valuable, because maybe what they're teachers are saying isn't, like they're not really going in to enough detail into what they're thinking about

G1Y2 felt the information the youth presented would be correct, but limited by the resources and equipment available to high school students:

> I definitely don't think it would be wrong in any capacity but just thinking about kind of the range of the presentation in terms of how much technology is needed to assess, what the students actually have access to, to conduct that kind of stuff

They thought these limitations meant the information would be a good start, but not a definitive analysis, saying, “I would kind of see a segment like this as being a great jumping off point for doing further research but not necessarily the full case closed analysis of what's going on.” Overall, these participants were somewhat less positive in their expectations of the youth’s information than they were in their perceptions of the youth. They again felt that they youth would have good intentions and would do the best work they could. However, they thought there would be external factors such as equipment or instruction that would set limits on what the youth could achieve.

Participants in Group 2 focused more on internal factors that would limit the quality of the youth's information. This included both ability and intentions. G2Y2 focused on the presenters' ability to do the work required for the project, saying, "I don't necessarily have as much confidence in their understanding of the scientific method or in the groundwork that they're basing it on." She thought this might influence their ability to both conduct and interpret the research, saying, "they might not necessarily understand the full implications of what they're doing and so they might not have pursued it to the extent that someone with specific goals might have." Contrary to their stated perceptions that youth always have good intentions, several participants became hesitant and skeptical about the youth's intentions and honesty when thinking about the information they would produce. G2Y1 said, "not knowing how, what their intentions are and what their objective is makes it, not sure how complete and accurate it will be." G2Y3 described her hesitation more explicitly:

> There are some people who would just make up numbers and add them in to their papers, so I didn't know if maybe the high school students would do that as well to skew the data, like to support their opinion or something, try to increase like global, awareness of global warming or belief in global warming. I didn't know if maybe the high school students were maybe doing that.

These concerns about the youth's integrity and abilities led the participants to have lower expectations for the quality of the information the youth would share.

For Group 3, personal experience was again a major factor in participants' expectations. All six participants in this group felt that the youth's information would be inaccurate or incomplete. For some, this was based entirely on their own experience. As G3Y4 stated, "I know when I conducted an experiment in high school I would completely screw up the procedure and whatnot and the data would be extremely skewed." G3Y5 said, "Just because I think, like thinking back to some projects that I've done, my information wasn't always accurate." G3Y1 stated that since she, as a college student, still felt it was difficult to research, interpret, and present the information needed for a science project the youth would certainly not be able to do it well. In addition to referencing their own experiences, half of the participants specifically connected their expectations that the information would be incomplete to the youth's lack of experience. G3Y2 explained:

> I guess at that age you really, when you conduct studies you probably don't think of every single little factor of variable that goes in to it whereas someone more experienced would have more experience and know the logistics of how to conduct a study.

G3Y3 echoed this, stressing that her concern was that the youth might miss important information: "not that their data is necessarily wrong, but there might be things that they missed or confounding variables that someone with more experience might be able to catch." Because of this, G3Y3 thought, "there would have to be more research done before a statement of true scientific worth could be made." These participants were primarily concerned with the youth's experience and ability to do the research well. They felt the data they had produced as high school students was not high quality, and, therefore, the presenters' information would also be inaccurate or incomplete. The absence of any comments about the youth's intentions suggests this was not a concern for Group 3, and participants felt mistakes or omissions were due to honest inexperience. This aligns with the reasons driving their perceptions.

Professional Mentor

Across the groups, participants who saw the youth survey mentioned that having a "professional" or "mentor" associated with the project would increase their expectations of the information. This idea was not part of the interview protocol, but was independently raised by half of the participants who saw the youth survey as a way to increase their expectations. As G2Y3 said:

> I think if it had like a research mentor somewhere in the study and somehow, like a sentence saying they had a really good relationship with the mentor and the mentor really checked up on their work I guess. Then I think I would trust it more.

Participants did not have strong opinions about who would be considered a "professional", suggesting variously that a science teacher, science professor, or someone working in the field on air quality issues would be acceptable. For most, the important part of the association was having the professional "check up" on the youth's work. As G3Y3 said, "If there was some kind of professional guiding them and, or even a professional backing them saying like no these values are valuable this is a really good finding, I think it would push everything to the right [higher]." G3Y4 described how he wanted the professional to be involved:

> If he reviewed the procedure in which they collected the data, insured that he, like, very methodically went through the data and made sure that everything was accurate, so I guess his own findings. Or maybe if he replicated the experiment himself, collected his own data, and compared the two to see how off they were. Cause I think that's even more important, if you see that high school students collected their own data and it was very similar to a professional grade experiment, then you could say maybe these high school students know what they're talking about and doing.

For all, this seemed to be related to concerns about the youth's understanding of and ability to use appropriate methods. Having a professional, who presumably had more extensive experience and training, involved in the project alleviated these concerns. G1Y4 explained, "I think a lot of people put credibility in people who have completed multiple years of schooling." G3Y4 said, "I guess having a professional source backing their data would definitely increase the credibility, the value, the accuracy, the completeness, so I would move my answers up in that case."

Across participants, having a professional mentor working with the youth or checking up on their findings would increase participants' expectations of the methods used and consequently the quality of the information the youth would produce. The similarities among the participants' comments, and unsolicited nature of the idea, lend strength to this theme.

Summary

Participants' assumptions about the presenters' intentions and their science experience and ability were the major factors influencing expectations of the quality of the information they would share. The assumptions participants' made about these things varied across the subgroups, and had many similarities to the thoughts that influenced their perceptions of the presenters' warmth and competence. In thinking about the patterns in the quantitative data, it seemed that participants' assumptions about the experience and abilities of youth versus adult scientists was the major factor that led to the difference in expectations for the different presenters. The assumptions participants made, and how they reacted to them, seemed guided by their trust in science and scientists.

Overall, participants felt that the adult scientists would have the experience and abilities to produce high quality information. Participants in Group 1 believed the presenters would have good intentions with the project and would, therefore, share high quality information on the news. Participants in Group 2 were concerned about the presenters' opinions, methods, or errors influencing their work, and while they said they generally trusted the scientists work, these concerns lowered their expectations. Participants were typically more hesitant about the quality of the youth's information. In Group 1, participants remained positive about the youth's abilities but felt they would be limited by factors, such as resources, that were beyond the youth's control. They felt the youth's information would be as good as it could be given their limitations, but would not be complete or definitive. In Group 2, despite stating that they expected youth to be warm and well intentioned, when they thought about the data the youth produced participants were concerned about both their abilities and intentions. They felt that the youth would not perform or interpret the research correctly, or would alter their data to support their positions, and consequently the data would be low quality. For Group 3, participants' concerns about their own abilities to conduct scientific research as high school students led them to expect the youth's information to be low quality as well. Across the groups, participants felt that having a professional mentor to guide and review the project would alleviate their concerns about the youth's abilities and methods, and increase their expectations of the information they could produce.

Willingness to Take Action

In contrast to their perceptions and expectations of information quality, participants' willingness to take action did not seem as closely connected to the presenters or presentation. In the survey, participants were asked how willing they would be to take specific actions after seeing the presentation on the news. These included how likely they would be to sign a petition, attend a public forum, post a comment on social media, meet with an elected official, do volunteer work, look for more information, talk to someone else, or donate money related to air quality after seeing the presentation on the news. As a reminder, the quantitative data showed that attending the community college, higher trust in scientists, higher interest in air quality, and higher expectations of the information quality were associated with higher willingness to take action. Additionally, the data showed that science majors were more willing to take action if they saw the adult survey but non-science majors were more willing if they saw the youth survey.

The interview data indicated several factors that influenced participants' willingness to take action, including effort, habits or personal preference, how strongly participants' felt about the topic, the potential impact of different actions, participants' knowledge of the topic, and how motivated or convinced they were by the presentation. Unlike the previous topics, these themes appeared across perceptions groups and were mostly not influenced by the different presenters. Rather, they seemed to be internal to the participants and their previous experience. These themes are described below.

Effort

Fifteen of the interview participants commented that they would be more willing to do actions that required less effort. This included the time, inconvenience, or difficulty related to an action. For example, most of the fifteen participants said they would be willing to do activities like sign a petition, look up information online, or post on social media because they were easy. As G1A1 (see Table 3.6) said, “sign a petition is very easy to do, it's just signing your name.” G2Y3 outlined just how much effort she were willing to put in to a petition, saying, “if I could access that petition easily, like if you have to log on and create an account on a website I might not do that as readily.” Nine participants stated they would be unlikely to do actions such as attending a public forum or meeting with an elected official that required extra effort. As G1A2 said, “I picked somewhat instead of moderately because, just trying to be truthful, that would involve more effort for me. I would have to physically go there.” G3Y2 likewise would not, because “that would require to go out of my way and set up a meeting and do that.” G3A1 would not “just mostly out of the convenience.” G3Y4 explained:

> Nowadays it's very hard to get people to dedicate a lot of their time to doing anything active. Like volunteer work, let alone meeting with an elected official or attending a public forum because people nowadays value their time very highly, so I don't think it would be as easy to get them to actively look for solutions to

this problem. But I guess the ones about social media or donating money, or looking for more information or signing a petition, all these things take like maybe an hour of your day, I could see people rallying around.

Overall, when participants commented on the effort involved in different activities, they typically mentioned that activities that could be done quickly, either online or without any intentional effort by the participants, were easy actions that they would be likely to do. Participants were less willing to put in the effort to do the more time-intensive in-person activities. There were, however, several reasons (described below) that would motivate them to do so.

Habits and Personal Preference

Fourteen participants mentioned their willingness to take specific actions was influenced by whether they would typically do that type of action, not by the topic or presenters. This included being both more and less willing to take different actions. For example, several participants stated they would do different actions because they like to do them. G1Y4 said, “attend a public forum, I really like getting involved in my community especially at [my college] I really like going to events and participating in scientific things that affect my community.” G2A3 said, “do some volunteer work related to the air quality project, yeah I would because I personally do a lot of volunteer work now so just another thing for another good cause. “ G3Y1 said, “I feel like I always see people coming around with things to sign and I always sign them.” Others expressed the opposite sentiment. G2A2 said, “personally for me if a petition comes up about anything I've never signed one, I don't really see the benefit of getting so many signatures on a piece of paper.” G2Y2 said, “in terms of attending a public forum, making a comment on social media, or meeting an elected official, that's more just me as a person, I have no interest in doing any of those things. G3Y3 said, "the social media one I just don't really like posting stuff on social media so I think that's just what led me to answer that question." There was not an apparent pattern in which actions were more likely to be influenced by participants' habits, with different participants expressing positive or negative preferences for different combinations of actions.

Interest and Importance

Seventeen participants indicated that their willingness to take action would be influenced by how strongly they felt about the topic. Personal interest and broader importance were cited as reasons the participants would be more willing to take action. However, personal interest appeared to be more influential than feeling that air quality was an important topic. Participants frequently commented that air quality was obviously important, but they were not interested enough in the topic to pursue it. As G2A1 said:

> Air quality is definitely something that is very important, but it's not necessarily an area specifically in which I'm very passionate, so I think I would definitely take into consideration the information that was being given, and I would value that information, but, whereas it's not something that I'm personally invested in. Like I definitely view as important but not something that is particularly stimulating to me that I probably wouldn't do as much.

This sentiment was repeated by most of the participants who discussed their interest in the topic. G3Y5 explained what would make her more willing to engage in action:

> There's just other things I'm interested in in the community that I think I would like to see happen and change but you know like I said if there was a clear reason

why or you know if there was some crisis, like a global crisis then I might be a little more [willing]

Barring a "crisis", however, for most participants, personal interest in the topic played a larger role in motivating them to take action than believing the topic was important for their community.

Potential Impact

Ten participants indicated that their beliefs about the impact an activity might have influenced their willingness to do it. As G2A4 said, "generally things that are easier to do, but also might have a significant impact are things that I would favor. So particularly anything that might help change the view of the public." Participants had different ideas about which actions would have the most impact, often expressing conflicting views about specific actions. For example, G1Y4 thought meeting elected officials was a good option because "they have a lot of power over the policies in the neighborhood." G1Y1 was less optimistic about this, stating, "I guess with the elected official I wouldn't even know who to meet with to discuss this and like I think I would also be skeptical that they would do anything about it." G1A2 explained that he would be more likely to do volunteer work than the other options because "at least there would be some kind of measurable change." G2A4, however, said, "I would be less likely to do volunteer work or attend a public forum because I'm not sure they would have as much of an impact and they would take a lot of time." G3Y5 said she would post a comment on social media because "people post a lot on social media in general but that's a good way to share things with people and to spread news around," whereas G3Y6 felt differently, "post a comment on social media, no, because I know that people don't really pay attention to it if it's educational, so it wouldn't really make a difference." Although their thoughts about the activities differed, it was clear across participants that they would be more willing to do actions that they felt could have a larger impact.

Knowledge about Air Quality

Eight participants indicated that a sense of limited knowledge about the topic would influence their actions. This was typically mentioned in regards to two types of action. First, participants mentioned that feeling like they did not know or understand enough about the topic would prompt them to search for more information. Several participants felt they would not know enough about the topic to assess the presenters' data, and would want to know more before taking action to "double check" their work. As G1A2 said, "probably a small amount of me wants to double check what they're saying and follow up and part of me would want to dig a little bit further, especially if I was going to take action." Others had a different view, and felt that the fact that a topic they did not know much about was being discussed on the news should push them to learn more. As G3Y4 said:

> If this issue is being brought up by high school students you know that there is some I guess underlying message there that there is some kind of issue there on a grander scale. So the fact that they're so interested in this and you have no knowledge of that whatsoever I guess sparks a red flag and should encourage more adults to look for more information about the issue.

Although these ideas—wanting to learn more to "double check" the presenters' work or to alleviate a "red flag" about being uniformed—suggest different feelings about the presentation, they both indicate that feeling like they did not know enough about the topic after seeing the presentation on the news would prompt the participants to independently learn more. Interestingly, both ideas were mentioned for both the adult and youth presenters, suggesting the feeling was internal to the participant, not based on the presenter.

Second, participants felt they did not have sufficient knowledge about the topic to take actions that were seen as more public commitments. G3A1 expressed a common sentiment:

> Meet with an elected official kind of is the same as the public forum. It's almost like too much for me because I don't know enough, like I feel like I don't know enough to meet with an elected official to discuss air quality.

Two participants explained why they felt the same way. G1A1 said, “just from listening to a lecture I would have to do more research to meet with someone and be official, you can't screw up talking to someone that high up.” G2A1 said, “I wouldn't feel knowledgeable enough on the information to either fully defend my opinion or defend against somebody else who offered a different one.” Together, these comments suggest that participants would not feel confident enough in their understanding of the topic after seeing a short news story to take extensive action, but simply seeing the story might encourage them to learn more.

Convinced and Motivated

Thirteen participants mentioned that they would or would not be motivated or convinced to take action after seeing the presentation. For some, this reflected a general feeling that they would not be motivated to act just from seeing a short segment on the news. As G1Y2 said:

> I mean just thinking about it realistically I think I wanted to mark highly but you know, I've seen a million segments about how terrible everything is and I just obviously I'm not, can't get invested in all of them so just picturing another three or four minute segment probably would not, unfortunately would probably not make me go out and do things.

Four participants focused specifically on the youth, indicating they would not be convinced by the youth's presentation. For G3Y4, this was based on thoughts about himself as a teenager:

> I don't, me as a high school student I don't think I could rally my community to sign a petition about anything I was advocating for just because I'm... less than half of their age in most of the cases and I have no credibility to my name as a high school student.

The others felt that they would not be convinced by the youth alone. G1Y3 suggested she would be more motivated if the youth appeared on a "big CNN type thing instead of the local news station", as that would indicate they had something really important to share. G3Y3 stated that the youth would lead her to "think more about what's going on" but she would not be willing to act without checking with a professor or other air quality professional to verify they youth's work. G2Y3 also felt she would be more willing to act if the youth's data was externally validated:

> If they had someone backing up their, someone who had a lot of research experience and was published backing up their results. Or if another group of high school students had done the same study a couple years ago then I might be more likely to do all these things.

The responses were not all negative, however, and two participants indicated the youth's presentation would motivate them to act. In contrast to the previous participants, G2Y2 felt she would be motivated to act because, "I think I would be compelled by their data, and that would probably mean that I would if they approached me." For G3Y1, seeing the presentation would encourage her to take actions to support the youth. She said, "especially to affirm if students were creating such a grassroots movement and passionate about making an impact on the community I would want to show my support there."

The majority of comments about being motivated or convinced came from participants who had seen the youth presenters. This could suggest that participants who saw the youth survey were more aware of whether they would be motivated to act specifically by the presentation from the youth, while participants in the adult group focused more on their general willingness to do different actions. However, there was not a strong pattern in whether and why participants would be convinced by the youth. The major idea participants had in common was simply that their willingness to take action would be influenced by how convincing they found the information, with three participants repeating the notion from previous sections that external or professional verification would increase their opinion of the youth's work.

Summary

Participants' willingness to take action appeared to depend more on their thoughts about the topic and specific actions, rather than the presenters or presentation. Of the six themes that influenced participants' actions, three of them were based on the actions themselves. Participants were more likely to do actions that required less effort, matched their habits or typical actions, and that they felt had a larger potential impact, though the specific actions that met these criteria varied across participants. A fourth, how strongly participants' felt about the topic, was based more on the participants than the scenario. Participants stated that they felt air quality was important, but they would be more willing to take action if they were personally interested in the topic. This aligns with, though perhaps does not add to, the finding in the quantitative data that interest in air quality predicted willingness to take action. It did not appear from the interviews that seeing the presentation would influence participants' interest.

The action participants attributed most directly to seeing the presentation was seeking out more information on the topic. Although participants felt they would not have enough information from watching the presentation to take action, they also indicated the presentation could encourage them to independently learn more about the topic to either fill perceived gaps in their own knowledge or to "check up" on the presenters' work. Participants did indicate that the presentation could convince them to act if the information was very compelling or if the presenters said the topic was critically important. However, many of these comments suggested the youth's information would not be enough on its own to motivate them. Similar to their expectations of the information quality, participants proposed that having external validation of the youth's information, either through a more reputable news station or professional mentor, would increase the likelihood that they would be motivated to act by the data. This touches on two of the quantitative findings, that expectations of the information quality and trust in scientists predicted willingness to take action. From the interviews, it appeared that participants focused on trust in the data or science, rather than trust in the individuals doing the work. Participants implied that their trust in the scientists would influence their actions by stating they would be more willing to act if the data was validated by a more reputable agent. They did not, however, mention the presenters' intentions or motivations, and did not explicitly state that trusting or believing the presenters would influence their actions, all of which were major components of their responses to the other scales. This is a much narrow version of trust than participants discussed in their responses to the other scales.

The interview data did not offer insight into the other patterns identified in the quantitative data. Despite targeted recruiting, only three individuals from the community college responded to the request for interviews. These three did not have responses in common with each other and different from the private college participants that would explain the differences in willingness to take action between the two schools on the survey. This is similarly true for the interaction between major and survey version, where there were not obvious patterns in the science or non-science major responses that could explain the interaction. It is possible more targeted sampling or interview questions could further illuminate this finding.

Summary

The interview data indicated that participants' responses were based on multiple factors about both the participants and their assumptions about the presenters. Perceptions of warmth and competence were influenced by their assumptions of the presenters' intentions and science-related experience and abilities. These assumptions were, in turn, influenced by whether they saw the youth or adult survey, and their overarching beliefs about science and the people who do it. Overall, participants felt the adults would have sufficient experience but had mixed feelings about their intentions, while they felt the youth would have good intentions but were mixed about their experience and abilities. Participants in the different perceptions groups raised different ideas and spoke in different ways about their responses, and the combination of survey version and overarching beliefs led to different responses. For adult scientists, responses were largely influenced by participants' trust in science and scientists.

In Group 1 (high warmth, high competence), participants expressed a great deal of trust in science and the people who do it, leading them to think the scientists would be doing good work on a good cause in order to benefit society. Their sense of trust was strengthened by their assumption that being on the news meant the presentation must be accurate and valuable. Participants in Group 2 (moderate warmth, high competence) were more skeptical, and were concerned that scientists would have ulterior motives or outside influences and alter their results. This led them to think the adult scientists would have the experience to do the science well but might not be honest, and consequently, would not be trusted by society. The two participants in Group 3 (high warmth, low competence) had conflicting ideas about the adult scientists, and the interview data did not clearly explain their motivations. For the youth scientists, participants again were influenced by their sense of trust or doubt, with an additional category of individuals whose own experience dominated their thoughts. In Group 1, trust prevailed, again influenced by the news context, with participants having similar ideas about the youth and adults. In Group 2 participants seemed torn between the age and topic, with their comments about scientists in general as cold but competent less in line with their survey responses than their comments about well-intentioned but inexperienced youth. In Group

3, participants seemed driven by their own experiences, and based their responses about the youth scientists on their feelings of their own warmth and competence while doing science in high school.

Expectations of the information quality appeared to be closely linked to perceptions of warmth and competence. For this scale, experience and intentions were again the major factors that drove participants' responses. For adult scientists, participants' general expectations of high quality information were modified by their level of trust. Group 1 repeated that the adults would be trustworthy and produce high quality information, while Group 2 was concerned the adults' bad intentions would sully their data. For youth scientists, participants' previous positive thoughts about the youth's intentions seemed to be diminished by hesitations about their abilities and experience. In Group 1 participants repeated their trust of the youth, but thought their ability to produce high quality data would be limited by factors outside of the youth's control. For Group 2, concerns about the youth's motivations reduced their expectations of the information. For Group 3, hesitation about the quality of the data they produced as high school students lowered their expectations of the youth. For both perceptions and information quality, participants in all three groups indicated their responses would be more positive if an adult professional mentor guided the youth or reviewed their data.

Participants' responses about their willingness to take action based on the news presentation were not as tightly linked to the other topics. Responses indicated that participants' willingness to do different actions was based on their thoughts about the actions more than the presentation. Participants were willing to do actions that took less effort, were habitual, or had a higher potential impact, though they had different ideas about which actions those would be. In line with the survey findings, participants did indicate that they would be more likely to take action if they were interested in the topic or if they found the data to be very compelling. Unfortunately the interview data did not provide insight into the differences between the two schools or the interaction between participants' major and whether they saw the youth or adult presenters. However, the major focus of participants' responses seemed to be their thoughts about the actions themselves rather than reacting to a presentation they saw on the news.

CHAPTER 6: CONCLUSIONS

Introduction

The purpose of this dissertation was to begin to examine how youth might be seen and received as sources of science information. This was based on the premise that youth can impact their communities' thoughts and actions related to science, and indeed may contribute in a way that is different than more typical science information sources. Education projects that encourage youth to engage in science beyond their classrooms make the implicit assumption that youth can, and should, have an impact when they interact with public audiences around science topics (e.g., Calabrese Barton, 2003; Schusler & Krasny, 2008). Research on informal science learning has indicated that such interactions are part of an ecosystem of encounters that shape adults' relationship with science, and indeed may be an important part of how adults come to know about new science topics (Falk et al., 2012; National Research Council, 2009, 2014). However, research on how public audiences respond to science information has highlighted the importance of the source in shaping individuals' reactions (Brewer & Ley, 2013; Lang & Hallman, 2005). Youth are different than the more typical sources of science information, and the specific impact they may have on individuals' relationships with science is not well understood.

This question takes on greater significance when one considers the importance of lifelong learning about science topics. Science is central to many personally, socially, and politically relevant topics (National Research Council, 2011; Roth & Barton, 2004). Making informed decisions related to these topics requires some understanding of, or willingness to engage in thinking and learning about, the pertinent science (Feinstein, 2010; Jenkins, 1999). However, the rapid rate of change in science fields combined with the small percentage of individuals' lives spent in formal science education indicates that individuals cannot possibly learn all the science that will be relevant to their lives through formal schooling (Falk & Dierking, 2010). Thus, lifelong science learning is critical for full participation in informed decision making related to science topics (Feinstein, 2010; Jenkins, 1999).

Unfortunately, research into lifelong science learning has found that it does not occur equally for everyone. Research in informal science education and science communication has found that common methods are most effective at reaching individuals who are already interested in a given topic (Falk et al., 2007; Heath, 2007; Miller, 2001). Not all individuals, however, are inherently interested in the topics that may impact their lives. This leads to gaps in who has knowledge about important topics and, subsequently, who participates in decision-making regarding science topics with social or political implications (Scheufele & Brossard, 2008). The gaps are exacerbated by outreach methods that are most influential with and accessible to the already interested and informed 'science-elite' (Feinstein & Meshoulam, 2014; Nisbet & Scheufele, 2009). This problem has led to calls in both science education and science communication to find ways to engage broader, more diverse, public audiences in thinking and learning about science topics (Feinstein & Meshoulam, 2014; Mejlgaard & Stares, 2010; Miller, 2001; Nisbet & Scheufele, 2009; Stilgoe, Lock, & Wilsdon, 2014).

Research has indicated that short, informal interactions, such as those that might happen when youth share information about a science project they have undertaken, can influence individuals' thoughts about a topic and in fact are an important means through which individuals encounter different science topics (National Research Council, 2009). However, research in science communication has found that the source of information influences individuals' responses to and opinions about the information (Brewer & Ley, 2013; Davis & Russ, 2015; Lang & Hallman, 2005; Schultz, Utz, & Goritz, 2011). Youth are different in many ways from the more typical professional, institutional, or media sources of science information. How might having youth as science information sources influence responses to the information they share? How might interactions with youth influence lifelong science learning? Despite research and practice encouraging youth to engage with their communities about science topics, there is very little research on the impact this may have on members of the community and their relationships with science. This project aimed to begin to fill that gap.

To that end, the goals of this dissertation were fourfold: to understand participants' thoughts about youth as sources of science information; to understand their expectations for the information youth scientists might produce and share; to understand if and how youth might prompt participants' to take action related to the shared science; and to understand how each of those responses compared to how participants' might respond to adult scientists. In this chapter the major findings from the study are first discussed in relation to the current study and previous research. Limitations of the study are then addressed, followed by implications for research and practice in science communication and science education.

Conclusions

The research questions for this study asked about participants' warmth and competence perceptions, expectations of information quality, and willingness to take action related to youth or adult scientists. The data indicated several responses to these questions, some of which cut across multiple research questions. Consequently, this section is structured in terms five major findings for the field:

- Participants reacted in multiple ways to the same scenario.
- Participants described intertwined thoughts about trust in scientists and assumptions about the presenters' intentions with an overall assumption that youth would have good intentions while adults might not.
- Many participants stated their personal experience doing science in high school had a major influence, which reinforced the assumptions that youth would have good intentions but lower abilities to do high quality work.
- Participants did not appear to separate their expectations of the information from the people who would be sharing it.
- Willingness to take action was more related to aspects of the action and individual than the presenter or information.

Participants reacted in multiple ways to the same scenario

Study participants did not view youth or adults in uniform ways as sources of science information. Rather, the survey data identified three major clusters of warmth/competence perceptions. Through the interviews, participants stated that their perceptions of the presenters and expectations of the information they would share were based on combinations of their assumptions about the presenters' experience/abilities in science and intentions with the project, their trust in science generally, and their personal experience. Participants in different perceptions clusters, and who saw the different presenters, expressed different combinations of ideas that motivated their opinions (outlined in Table 5.1). This is in line with previous work that has suggested any "public audience" is made of multiple different audiences (McCallie et al., 2009; Nisbet & Scheufele, 2009), and has found that responses to science communication are influenced by various personal, social, and communication factors (Davis & Russ, 2015; Jasanoff, 2014; Miller, 2001).

This finding is interesting for several reasons. First, it suggests that although the sample used in this study was not particularly diverse and was drawn from a relatively narrow demographic of individuals enrolled in undergraduate coursework at two institutions, it was in fact made of multiple "publics" in terms of responses to science. Second, the "publics" were motivated both by different factors of the communication and by different reactions to the same factors. As Entman (1993) and Davis and Russ (2015) described, aspects of the communicator, the receiver (audience), the culture, and the message have been found to influence responses to a particular communication. In this study, participants focused on different aspects to explain their responses. Central ideas raised in the interviews included the presenters' (communicator) experience, abilities, and intentions, the participants' (receiver) personal experience and beliefs about or trust in science, and the surrounding culture of funding, politics, or pressures outside the bounds of the specific scenario that participants said influenced their thoughts. Participants also mentioned aspects of the message—the news context and particular topic—though these were somewhat less salient, perhaps because the scenario did not include an actual message. Different participants focused on different combinations of these in explaining their opinions, and additionally had different reactions to the same pieces (e.g., some assumed good intentions, some assumed bad). This reinforces previous findings about multiple publics, and highlights the complexity of responses to science communication events. It additionally supports the point made by Fiske (2013b) that communicators must attend to both warmth and competence to effectively communicate science.

Third, the depth and nuance of responses to the relatively short scenario that were described by participants in the interviews points to the importance of heuristics in opinion formation (Bromme & Goldman, 2014). Bromme and Goldman (2014) suggested that individuals have a *bounded understanding of science* based on their pre-existing knowledge about and experience with a topic. Individuals use this existing understanding to form opinions about new situations or related topics based on what they already know, rather than on a complete and detailed understanding of the new information. In this study, it appeared that individuals drew on their *bounded understanding* of scientists, youth, and science research. Participants formed their opinions about the presenters in the scenario based on extensive assumptions about the presenters' experience, abilities, intentions, the presentation context, beliefs about science, and participants' personal experiences. Other than stating that the presenters would appear on the local news station, these ideas were not described or hinted at in the scenario. Rather, participants used their pre-existing knowledge of and experience with scientists, youth, or science research to form opinions about the specific presenters and project in the scenario. The same scenario raised different, but repeating, assumptions among different participants, indicating that the heuristics triggered by this communication were different based on individuals' different pre-existing knowledge and experience. Three heuristics—participants' trust in scientists, assumptions about scientists' intentions, and participants' personal experience doing science—appeared particularly influential in forming opinions about the youth scientists. These three are discussed in the following sections.

Finally, the alignment between the groupings identified by the warmth and competence survey responses and the way participants in the different groups explained their ideas in the interviews suggests that the combination of warmth and competence perceptions outlined in the SCM (Cuddy et al., 2007) could be a useful means for understanding different responses to science communicators. Looking at the clusters of participants formed by the combined scales offered a better understanding of participants' thoughts than looking at differences in warmth and competence perceptions separately would have. This is reinforced by the similarities between participants' explanations of their perceptions and their expectations of the information quality. The ideas captured about the presenters by the combined warmth and competence scales in the SCM also informed how participants thought about the science they would share. As the SCM suggested (Cuddy et al., 2007), the combination, not the individual scales, were important.

Participants described intertwined thoughts about trust in scientists and assumptions about the presenters' intentions, with an overall assumption that youth would have good intentions while adults might not.

For many participants there was an interplay between trust and assumptions about the presenters' intentions. In the survey data, participants' trust in scientists predicted their warmth and competence perceptions, as well as their expectations of information quality (discussed below). The interviews offered a more detailed and nuanced understanding of this relationship. In the interviews, participants in Group 1 generally expressed high levels of trust in scientists while participants in Group 2 described lower levels of trust, and concerns about the influence ulterior motives might have on the scientists or science. For the adults, assumptions about the scientists' intentions aligned closely to participants' trust, with Group 1 assuming good intentions and Group 2 expressing doubt. In contrast, participants in all three groups expected youth to have good intentions, regardless of their level of trust in scientists in general, and some went so far as to say youth could not have bad intentions. The expectations of good intentions additionally appeared in participants' expectations of the information the youth would produce, with a general sense that youth would do the best work they could despite internal (Group 2 and 3) or external (Group 1) limitations.

Both aspects of this finding, that beliefs about the presenters' intentions were associated with trust in scientists and that youth would have good intentions while adults might not, were similar to findings from related research in science communication. First, previous work has found connections between expectations of the scientists' intentions and trust in the scientists and their work. Lang and Hallman (2005) found different levels of trust in organizations that intended to evaluate, regulate, or sell ideas related to topics. Rabinovich and colleagues (2012) found that expectations about the scientists' intentions directly influenced participants' trust in the scientists, and participants had greater trust when they believed the scientists intended to inform, rather than persuade, the public about their topic. In both studies, higher levels of trust were associated with expectations of more neutral intentions (evaluate or inform, rather than persuade or sell). This sentiment is repeated in the current study in that participants in Group 1 expressed general trust in the scientists and their intentions, while participants in Group 2 felt the scientists' desire to support a specific agenda would negatively impact their science. Although the current study cannot make directional or causal claims about intentions and trust, the findings support the connection between perceptions of scientists' intentions and trust in scientists.

Second, the finding that youth would be seen as warmer than adult scientists and with uniformly good intentions aligns with the limited previous work that examined youth as science information sources. In their studies of the hostile media effect, Gunther and Schmitt (2004) found that participants viewed a text as relatively neutral when they were told it was written by a student but biased against their opinion when told it was written by a professional journalist. A second study (Gunther & Liebhart, 2006) found higher perceptions of bias associated with both the professional source (journalist vs student author) and professional context (news story vs course essay). Although examining youth as science information sources was not the purpose of the studies, these outcomes suggest that participants viewed youth as less biased, or less likely to share biased information, than the professional journalists. This is similar to the ideas expressed in the current study, particularly by participants in Group 2, who felt that adult scientists might be biased and influenced by ulterior motives, but youth scientists would not.

The bias associated with the news context in Gunther and Liebhart's (2006) study, however, conflicted with the finding in this study that the news context was associated with increased trust and expectations of information quality among participants in Group 1. Gunther and Liebhart suggested the increased perceptions of bias may have been due to the increased reach of the text in the news context, with participants more sensitive to potential bias when they felt more people might read it. In the current study, participants stated the vetting and external approval required to appear on the news would increase their views of the credibility of the youth's information. Although somewhat contradictory, these studies also examined the communication event in different ways (expected vs actual message), and do not offer a definitive understanding of the interplay between context and source. Future work could examine how different contexts might influence audience members' thoughts about youth scientists and the information they share.

The combination of these findings—that assumed intentions are associated with trust, and that youth would have good intentions where adults might not—raises the possibility that youth might be viewed as more trustworthy than adults. This is particularly interesting since, as Bromme and Goldman (2014) described, in contexts such as science topics where the information is very complex individuals often form opinions about topics by deciding who, not what, to trust. The potential of this outcome seemed most apparent in the current data among participants in Group 2 who saw the youth presenters. These participants expressed distrust of scientists generally, stating that adult scientists might be influenced by non-science motives. They did not, however, have the same concern about the youth and expected the youth to have good intentions.

Given the importance of trust in the source to secondary reactions to science information (e.g., actions and opinions; Hwang et al., 2008; Schultz et al., 2011; Rabinovich et al., 2012), this suggests that youth might be an effective medium through which to reach individuals who have lower trust in scientists or science generally, an audience that is hard to reach with current typical communication methods (Nisbet & Scheufele, 2009).

Many participants stated their personal experience doing science in high school had a major influence, which reinforced the assumptions that youth would have good intentions but lower abilities to do high quality work.

More than half (113 of 204) of participants who saw the youth presenters selected warmth and competence responses on the survey that put them in perceptions Group 3 (high warmth, lower competence). In the interviews, this group's responses were dominated by their own experiences doing science as high school students. This idea was not raised by participants who saw the adult survey, despite random administration of the survey versions meaning there should have been just as many people in the adult group who had experience doing science in high school. This indicates that seeing the youth presenters triggered different thoughts, a heuristic based on personal experience, to guide opinion formation that was not triggered by seeing the adult presenters. Although the heuristic of personal experience unfortunately seemed to bring up feelings of remembered incompetence or doubt in their own abilities, this finding also indicates that participants saw themselves in, and were able to identify with, the youth in a way that they did not or could not with the adults. This may be due to the fact that the sample was composed of undergraduates who had completed high school, but did not contain professional scientists. It would be interesting to explore the corresponding responses of adult scientists in future work.

In typical uses of the SCM, where participants are asked to rate the warmth and competence of 'others' generally, 'other' groups that the participant is part of (in-groups) are often perceived to be both highly warm and competent (Fiske et al., 2002)—both willing and able to 'do good' toward the participant. The different structure of the current study, asking about perceptions of others in the specific context of doing science, led to an interesting in-group in which participants viewed themselves, and therefore these 'others', as warm but not competent. The emotional and behavioral responses to this combination of pity, over-helping, and neglect suggested by the SCM (Cuddy et al., 2007) are certainly not an ideal response to science communication. However, the identification with the youth presenters also raises the possibility that youth might be a more approachable or relatable information source than adult scientists, and could perhaps provide an avenue for engaging with a topic for people who cannot engage with adult scientists. Further, the comments from participants in Group 3 seemed somewhat more positive than those emotional outcomes would suggest, and it would be interesting to examine potential outcomes in more depth. For example, future studies could dig more deeply into which aspects of youth scientists and their work participants felt comfortable with, which were cause for concern, and how those compared to the same participants' thoughts about adult scientists.

An interesting tangential aspect of this finding is that personal experience was almost exclusively associated with feelings of incompetence in doing science. Were there participants in the sample who had better experiences doing science as high school students? If so, how did their experiences influence their perceptions of the youth, and why were they not more prominent in their explanations? It would be interesting to probe this more intentionally in future work by asking explicitly about participants' experiences doing science, how typical they felt their experiences were for youth science projects, and how those experiences might related to their other responses.

Participants did not appear to separate their expectations of the information from the people who would be sharing it.

Across the groups, participants' indicated that their expectation of the quality of the information the presenters would share were based on the same ideas as their perceptions of the presenters. For Groups 1 and 2, this was primarily related to their assumptions about the presenters' experience, abilities, and intentions. For Group 3, personal experience was again the most salient idea. Reactions seemed dominated by thoughts about the presenters and individual participants (the communicator and audience, as well as cultural aspects surrounding science (Davis & Russ, 2015)), rather than the potential information (the message), despite more text in the scenario being devoted to descriptions of the information that would be shared. Although this was certainly impacted by asking first about participants' perceptions of the presenters, and by not presenting actual information about air quality, it is interesting that participants did not appear to separate their expectations of the information from the people who would be sharing it. The fact that so many of the comments were about the presenters rather than about wanting to know specifics of the methods used or data collected suggests the presenters played a role in shaping participants' thoughts about the information. This again suggests that participants were deciding who, not what, to trust (Bromme & Goldman, 2014), and is similar to the work done by Schultz and colleagues (2011) that found that responses to an identical communication about a science topic (the message) were influenced by the medium (the means through which the message was shared). In this study, it seemed the "medium" was the messenger, with the youth and adult presenters triggering different expectations of the information. Additionally, the connections between trust, intentions, and expectations of the information reinforce the importance of trust in public responses to science (Bauer et al., 2007).

It is interesting that, as with warmth and competence perceptions, the same messenger (adult or youth) did not trigger the same expectations from all the participants who saw each survey version. This suggests a more complicated reaction that that found by Schultz and colleagues (2011), with an interaction between the messenger and recipient shaping responses. This is similar to work done by Brewer and Ley (2013) that found multiple personal factors led to different levels of trust in the same organizations. These findings imply that understanding audiences' views of the individuals sharing science information could inform an understanding of their thoughts about the information shared. The extensive overlap in participants' thoughts about warmth and competence perceptions and expectations of information quality suggests that the SCM (Cuddy et al., 2007) could be a useful way to understand what individuals might think about the information a given communicator might share.

Overall, however, despite their assumptions of good intentions, participants' expectations of the information produced by youth were lower than the expectations of adults' information. Participants described this as being due to limitations present for the youth but not for the adults such as resources (Group 1), or ability (Groups 2 and 3). However, assumptions about the youth's intentions again played a role, with all three groups suggesting that youth would try their best to do good work, despite having various limitations. The difference between youth and adults is again seen mostly clearly in participants drawn from survey Group 2 (high competence, lower warmth), where participants in the adult group suggested the scientists would be capable but might alter their data to support an ulterior motive, whereas lower expectations for youth data was based on innocent inability, not bias or nefarious behavior. This again suggests that individuals similar to participants in Group 2, who had less positive thoughts about scientists in general, might be more willing to trust the intentions of youth doing science and thus less likely to dismiss the science as biased. This could, perhaps, offer a means of engaging individuals who have pre-existing lack of trust in more typical scientists in learning about science topics.

Willingness to take action was more related to aspects of the action and individual than the presenter or information.

In contrast to perceptions and expectations of information quality, the identity of the presenters was not a major aspect of participants' willingness to take action. The survey data indicated that greater trust in scientists, interest in air quality, and expectation of the information quality, as well as being enrolled at the community college, were associated with greater willingness to take action. The difference associated with the different presenters was limited to the interaction between survey version and major, wherein the quantitative data indicated that non-science majors were more willing to act when they saw the youth presenters, but science majors were more willing after seeing the adult presenters. This is interesting as it suggests that youth might be a means for engaging individuals who are less inherently interested in science, an audience that is typically hard to reach (Crettaz von Roten, 2011; Feinstein & Meshoulam, 2014; Nisbet & Scheufele, 2009). However, the interaction in the quantitative data was small and the difference was not apparent in the interview responses. Further work would be needed to understand the interaction.

Of most interest for the current study was the finding that the different presenters alone, or different perceptions of the presenters, were not associated with differences in willingness to take action. This is clearly different than the findings for the perceptions and information quality, in which there was a relationship. Although the BIAS map extension of the SCM (Cuddy et al., 2007) connects behavioral outcomes with the emotional perception responses, differences in potential actions among participants in different perceptions groups were not found in the current study. This was repeated in the interviews, where although participants indicated several factors that would influence their willingness to take particular actions, the presenter or presentation were not major influences and there were again no apparent patterns in responses associated with different perceptions subgroups. Rather, participants indicated their willingness to take particular actions was related to aspects of the actions and their individual preferences.

The fact that the scenario did not inspire participants to take immediate or extensive action is not entirely surprising, as the short, abstract, nature of the scenario and fundamentally deficit- based interaction have not been found to be particularly effective at motivating audiences across topics and presenters (Holliman & Jensen, 2009; Miller, 2001; Nisbet & Scheufele, 2009). What is interesting is the fact that there were no major differences in responses to youth and adult presenters. In other words, the youth were not immediately dismissed as science information sources. This contradicts the feelings youth expressed in previous research that they would not be taken seriously as science information sources or able to effect change because they were “just kids” (Vailaitis, 2002, p. 257; also Bencze et al., 2015). This implies that youth could have an impact on their communities’ science engagement, or at least as much of an impact as adults could have through a short news segment. It is, of course, possible that the specific scenario and abstract context used in this study were simply not sufficient to inspire action regardless of the source, and it would be interesting to examine this further with an actual presentation or topic with real-life relevance to participants.

Limitations

There are several limitations to the findings from this study. First, the sample was drawn from a limited demographic of students currently enrolled in undergraduate courses at two institutions. The fact that one of these institutions was a private, selective, and expensive school further limited the sample. Although recruiting from the community college expanded the age range and (slightly) increased the ethnic diversity of the sample, the sample remained primarily white and in their early 20s, and was not representative of a meaningful broader population. However, as science communication research rightly holds, any public audience is in fact multiple audiences delineated by multiple personal, social, and cultural factors (Baram-Tsabari & Osborne, 2015; Jasanoff, 201). The differences in responses identified in this study suggest that this sample was no different, and while homogeneous in some dimensions was diverse in others that offered interesting insights into the research questions. Still, the findings from this study should be understood to apply to this particular sample, not to adult audiences generally.

Second, the abstract nature of the scenario likely influenced participants' reactions. Structuring the scenario as an anticipated rather than actual presentation was done to draw on participants' first impressions and pre-existing ideas, and helped to isolate participants' ideas about the youth or adults. However, reactions to any communication or sharing of information are certainly influenced by the style, content, and event of the presentation, and real-life interactions would have many more dimensions of influence. This study explored participants' perceptions and assumptions about the presenters, but the findings do not represent how participants might respond to the multiple factors at play in an actual presentation.

Third, the study is limited by the instruments that were used. While the survey scales and interview structure were effective at drawing out participants' thoughts about perceptions, information quality, and actions, participants only responded to the questions that were asked. It is certainly possible that additional factors not investigated in the current study influenced participants' responses. This seemed particularly evident in the data's ability to explain differences in participants' perceptions, trust in scientists, and assumptions about the presenters. For example, while it was clear from the data that participants in Group 1 trusted the presenters and participants in Group 2 were concerned about bias and ulterior motives, the data did not address why the participants had these different beliefs. Further work would be needed to understand what led one participant to trust the presenters and believe they would have good intentions, but another to have the opposite beliefs.

Implications

The findings from this study have implications for both science education and science communication. Research and practice in both fields should consider the impact youth may have on their communities' science engagement. The findings from this study suggest that, at the very least, the youth's age did not appear to summarily disqualify them as a source of science information. At best, the findings raise the possibility that youth might be seen as more trustworthy than adult scientists, and may represent an avenue for engaging individuals who, for various reasons, have lower general trust in science. Encouraging youth to engage with their communities around science topics is certainly not a new idea (e.g., Calabrese Barton, 2003; Schusler & Krasny, 2008). However, the lack of follow through in research to understand the impact on community audiences, and the positioning of youth in the literature as recipients of, not contributors to, learning in their STEM learning ecosystems (e.g., National Research Council, 2009), suggest that youth's contributions are not taken as seriously as they could be. The importance of trust to public responses to science (Bauer et al., 2007), the association between intentions and trust (Rabinovich et al., 2012), and the positive expectations of youth's intentions found in this study suggest potentially positive interactions that deserve further attention.

Educators should certainly continue to encourage youth to engage in science beyond the classroom. Previous work has outlined the benefits this approach can have for youth (e.g., Calabrese Barton, 2003; Schusler & Krasny, 2008), and the findings from this study suggest youth's engagement could have positive benefits for the community as well. In designing programs, educators could consider connecting with a professional scientist or organization to support or review the youth's work. Although participants expected youth to have good intentions with the project, participants in all three perceptions groups suggested an affiliation with some form of professional would increase their expectations for the quality of the information the youth would produce. Such an affiliation, or other external review of the youth's data, could also be beneficial for the youth through making personal connections with science mentors and encouraging robust research methods. While the particular research methods the youth used was less prominent than thoughts about resources and abilities in participants' expectations of the youth's information, poor methods and low quality data appeared to be a common theme in participants' own experiences doing science. Facilitating experiences where youth feel they are conducting high quality science research would be beneficial for the youth, and might prepare them to have higher expectations of youth projects in the future.

Furthermore, knowing that adults can have concerns about the quality of the information could also impact how youth present the information. Utilizing robust methods and then explicitly sharing the methods used could help to alleviate concerns about ability and resources, and could increase others' trust in the evidence. Educators could help facilitate this by highlighting the importance of communicating in convincing others' of one's conclusions, and encouraging and supporting clear communication practices from the youth. This would, of course, be subject to many of the same challenges that professional science communicators face in terms of accuracy, clarity, and brevity. However, including instruction on these skills during youth projects could both increase future scientists' abilities to communicate and future public audience members' understanding of and ability to think critically about science communications.

Positioning youth as potential sources of science information could be an area that would benefit from more explicit collaboration between educators and communicators. Integrating youth programming with communication research could encourage and facilitate youth engagement with the community and explore the impact on the community audience. Given the compelling democratic and social justice reasons for engaging broad audiences with science (Feinstein, 2010; Jenkins, 1999; Tate, 2013), along with the political climate toward science at the time of writing (e.g., Reardon, Tollefson, Witze, & Ross, 2017), any avenue that could potentially engage audiences beyond the science-elite (Nisbet & Scheufele, 2009) is surely worth exploring. Youth should be seen as potential sources of science information and avenues of science engagement, and should be treated as active contributors, not just recipients, in their communities' science learning ecosystems.

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Appendix A: Interview Coding Scheme

Categories-

- Category-First associations
- Category-Competence
- Category-Warmth
- Category-Info quality
- Category-Action
- Category-Interest/Importance
- Category-Trust
- Category-Comparison

About scenario/project/science

1. **News context**—comments related to the context of being on the news. Also comments about how they might respond if it was a different context. Ex: "Since they're talking on the news…"
2. **Topic- good cause—**comments about air quality being a good cause. Ex: "helping the environment", "if they're studying air quality they probably want to benefit the community.."
3. **Topic- complex**—comments about air quality (or science more generally) being very complicated or complex.
4. **Topic- controversy—**comments about the topic being controversial, or not.
5. **Interest/importance**—comments about the respondent being interested in the topic or thinking it's important (or not). Ex: "air quality is obviously important so…" "I'm in to science so I would want to…"
6. **Resources**—comments about the resources available to presenters or project (or lack of). This is about what is available to them (whether or not they used it). Includes comments about equipment being available or not.
7. **Funding**—comments related to funding for the project**.**
8. **Methods—**comments about the methods used (or not used) during the project, or in general. Methods is about what they did, should do, know how to do, etc.
9. **Data**—comments about the data the presenters would have or share (or not have).
10. **Correct/complete**—comments about the "correctness" of the data/findings. Includes correct, mistakes, complete, missing pieces or aspects.
11. **Uncertainty in science**—comments related to the inherent uncertainty in science knowledge, or specific uncertainty related to air quality.
12. **Information source**—comments about where the presenters/project got their information.
13. **Mentor**/professional support—comments about having a 'professional' involved in the project. Could be as mentor or reviewer… includes teacher if they say the teacher reviewed or strongly guided the work. Probably only applies to youth projects.

14. **External validation** – comments about having the project/data externally validated—could be someone repeating it, replicating results, winning award, peer-reviewed, etc or just someone else thinking it's valuable/accurate.
15. **Crisis**—comments about responses being influenced by the urgency of the data or findings.
16. **Potential impact**—comments about the potential impact of the project on the world, not about respondents' individual actions.
17. **Local community**—comments about the project being set in a local community

About presenters

1. **Science/academic experience**—comments about presenters' background and experience (or lack of) with/doing/learning science before the project. Includes specific background ("if they're from Harvard…") and general academic background experience ("if they have a phd they went to school for a long time…"). Also comments about "famous scientists" or "reputation"
2. **Motivated**—comments about presenters' desire to do the project or work (or not). Includes comments about choosing to do the work, being motivated, caring about the topic/project. Ex: "They chose this as their career", "doing it on their own time so they must care", "they care about the topic" "they're just doing it for a school project, they're not that interested"
3. **Effort**—Comments about the effort or time presenters put in to the project. Includes lack of effort (lazy etc).
4. **Ability**—comments about presenters' ability to do science, intellectual work, any work. Includes skills, intelligence, knowledge, creativity—anything about their ability to do the mental work necessary for the project (or not).
5. **Communication skills**—comments about the presenters' communication skills
6. **Personal characteristic**—comments about the presenters' personality, emotional, behavioral characteristics (i.e. responses influenced by something about the presenters not connected to science.).
7. **Intentions-Ulterior motives**-- comments about presenters having motives not just related to science… could be funding, career (publication/grants etc), politics, personal… includes sharing/skewing findings to promote their opinion. Also include comments if they say "I wouldn't expect them to have other motives…" (i.e. specific references to NOT having ulterior motives, not references to having good intentions).
8. **Intentions-Assumed good intentions**—comments assuming the presenters had good intentions with the project (whether or not they did the project well or correctly).
9. **Intentions-questioning intentions**—comments about wanting to know about, or responses being influenced by, the presenters' intentions. "It would depend on why they were doing the project…"
10. **Trust**- comments about trusting the presenter (or the science)
11. **Bias**—comments about the presenters being biased (or not)

12. **Follow through**—comments about presenters "following up" on the project—could be about taking actions because of it, or completing the project, or doing more beyond the project
13. **Know them personally**—comments about responses being influenced by knowing the presenters personally (or not)
14. **Relate to presenter**—comments about the respondents being able to relate to the presenters (or not)
15. **Age**—comments about the presenters age- the simple fact that they are older/younger means… "because teenagers are…" "millennials"…
16. "**if they think it's valuable**"—comments about the project/data being valuable because the presenter thinks it is.

Other

1. **Personal experience**—comments about respondents' experiences influencing their responses. Could be with or as a high school student, observing/working with adult scientists, or about their current role (educator, scientist, business student…) where they indicate their role influences their answers. Ex: "thinking about when I was in high school"… "since I'm a science major now I might…"
2. **Personally relevant**—comments about the project or topic being relevant to the respondent (or not)
3. **Support the presenters/project**—comments about wanting to support the presenters/project
4. **Skepticism**—comments about doubt or skepticism influencing responses
5. **Self-interest**—comments about decisions/project etc being in one's self-interest, rather than based on logic or facts. Also comments about making decisions or trusting data/presenters when they align with what you already/want to think. This is about respondent or society self interest, not about presenters doing things in their own interests. If it's about presenters, code with ulterior motive.
6. **Beliefs about science**—sweeping statements about science or scientists. Ex: "scientists generally" "since science is hard"
7. **Objective/subjective**—comments about the people/project/data being objective or subjective

Action codes

1. **Actions: effort**—comments about the effort or time involved in an action
2. **Actions: public**—comments about the public/private nature of taking action. Includes comments about exposure.
3. **Actions: relevant**—comments about taking action (or not) because the topic is relevant to the individual (or not)
4. **Actions: potential impact**—comments about the potential impact of specific actions.
5. **Actions: knowledge**—comments about respondents' knowledge and how that influences their actions. Includes comments about wanting or needing more information.

6. **Actions: conflict**—comments about particular actions resulting in conflict for the respondent
7. **Actions: passion/interest/importance**—comments about the strength of respondents' thoughts/interest about the topic related to taking action. Ex: "That's really important to me so I would…" or "I don't really care about x so…"
8. **Actions: social/emotional**—comments about social or emotional aspect of taking action—includes both being part of a community, doing with friends, would feel good about it, etc.
9. **Actions: motivated/convinced**—comments about being convinced or motivated to act based on the presentation (or not)
10. **Actions: habits/personal choice**—comments about respondents' typical behavior influencing actions. Ex: "I don't post things on facebook so I wouldn't…" "I do that a lot so…"
11. **Actions: crisis**—comments about taking action because of crisis or immediate need