“Social” Science, Spider Goats and American Science Audiences:

Investigating the Effects of Interpersonal Networks on

Perceptions of Emerging Technologies

By

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"Social" Science, Spider Goats and American Science Audiences: Investigating the Effects of Interpersonal Networks on Perceptions of Emerging Technologies

Abstract

The work offered in this dissertation has as its primary goals 1) greater understanding of the media environment in which communication about emerging technologies occurs, 2) the identification of science-specific audience segmentation that allows for the eventual development of targeted messaging to specific groups of science constituents, and 3) a deeper understanding of how characteristics specific to science audience segments vary in their importance relative to science-related information seeking, discussion and support.

In order to accomplish these goals, this dissertation uses an emerging science, synthetic biology, which has the potential to alter the way science approaches a variety of biological problems ranging from cancer treatment to viral disease vectors. Largely unknown to the public, this emerging technology also has the potential to prompt dystopian reactions that could provide significant obstacles to its development or deployment.

This first study in this dissertation maps the landscape for synthetic biology newspaper coverage and social networking site discourse using a census of daily synthetic biology-related newspaper articles archived in Lexis-Nexis database and synthetic biology-related keyword tweets on the social networking site, *Twitter,* establishing that there is an initial paucity of coverage and a relatively small number of daily tweets for the issue. The study then uses vector autoregression (VAR) to examine potential intermedia agenda setting effects between news

coverage of synthetic biology in print newspapers and social networking site discourse about synthetic biology on *Twitter* over a five-year period from January 1, 2010 through December 31, 2014 when a number of significant synthetic biology breakthroughs occurred.

After establishing an external media environment in which news coverage of synthetic biology occurs infrequently, I then focus on the internal personal predispositions that affect the way that individuals selectively attend to news sources, and news about emerging technologies, if and when such news is encountered. Recognizing the role that issue-related discussion may play in individual attitudes toward emerging technologies, this study is also concerned about the heterogeneity of individual discussion networks and issue-related discussion frequency. Using Ward's Method of hierarchical agglomerative clustering and a small number of value predisposition variables that could be easily and inexpensively used in other research, this second study segments individuals into subgroups that demonstrate strong statistical differences in demographics, science knowledge, media use and heterogeneity of individual issue-related discussion networks, along with issue-related discussion frequency. Where the first study aims to provide a foundation for future work mapping the landscapes for other emerging technologies, the results of this study – i.e. the segments identified here -- could easily and immediately be applied to work on emerging technologies or other contested issues.

In the final study I build on the first two works in this dissertation, using data collected from a representative sample of the United States population, I use ordinary least squares (OLS) regression to focus on the ways that individual value predispositions, media use, heterogeneity of individual discussion networks and issue-related discussion frequency affect three different dependent variables of interest: individual level of support for synthetic biology, the likelihood that one will seek additional information about synthetic biology and the likelihood that one will discuss synthetic biology with others.

I conclude this dissertation by reviewing the findings of the three studies, discussing the implications for communication research and theory, and briefly outlining directions for future research.

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Chapter 1. Introduction: Why is This Topic Important?

Polarized Science Issues

Science has been politicized at least since the days of Servetus and Galileo; it seems to become increasingly so even as the body of scientific knowledge expands. Although we can take comfort in the fact that we no longer burn scientists at the stake or place them under house arrest for life, we should also be humble enough to acknowledge that today's world can be just as divided over science issues as the world was centuries ago.

Consider the theory of evolution by natural selection, a 159-year old theory that has been contested in the public sphere for decades, and also one in which we can identify polarization over a short period of recent time. A study by the Pew Research Center found that although there was overall stability in 60-61 percent of Americans who cite as "true" the statement that "human beings have evolved over time" between 2009 and 2013, there was a significant decrease from 54 percent to 43 percent in the number of Republicans who answered "true" during that time period and smaller increases in the number of Democrats, Independents and "others" who answered the same (Cooperman, Funk, & O'Connell, 2013).

Indeed polarized attitudes have been identified for a number of science issues. Based on results of recent studies by the Pew Research Center, and identified via OLS regression, political ideology and/or party affiliation have been found to play a role in the belief that climate change is caused by human activity, in support for stricter limits on power plant emissions to mitigate climate change, support for offshore drilling, support for hydraulic fracking, support for building new/more nuclear power plants, prioritizing alternative energy development, the attitude that it is appropriate to use genetic modification on human embryos to achieve greater intelligence or reduce disease risk, the attitude that it's appropriate to use biotechnology to bioengineer artificial organs for human transplant, the requirement that children be vaccinated, the belief that foods grown with pesticides are generally safe to eat, the belief that animals should be used in scientific research, the belief that the space station has been a good investment for the country, the belief that population growth will be a major problem and strain resources, the likelihood an individual will say that scientists believe the universe was created in a Big Bang event, and the belief that private funding will be enough for scientific progress as opposed to the belief that government funding is essential (Pew Research Center, 2015).

Although it's a lengthy list, not all science issues are polarized. Notably, this same Pew Research Center report finds no evidence via OLS regression that partisan divides contribute to the belief that individuals should have access to experimental medical treatments, the belief that scientists have a clear understanding about health effects of genetically modified crops, and the belief that genetically modified foods are safe to eat (Pew Research Center, 2015).

Polarization, Filtered Media Use & Individual Discussion Networks

The polarization of science issues has occurred against a backdrop of ideological sorting of liberals and conservatives into specific political parties which has taken place over recent decades in the United States, especially among elites, but also among the mass citizenry, albeit to a lesser extent (Hetherington, 2009). Researchers have documented a trend in American politics over the last 50 years in which the relationship individual citizens have to political parties has grown stronger, moving from one that could be initially characterized as relatively weak with only loose associations to individual members' identity, to one that is stronger with closer associations to individual social identity, social networks, workplace discussions and home life (Iyengar & Westwood, 2015). This shift is concurrent with a polarization in attitudes towards cultural, economic and racial issues that occurs among individuals, especially among those who are most politically engaged (Layman & Carsey, 2002a, 2002b; Layman, Carsey, & Horowitz, 2006). This polarization extends to the way individuals selectively attend to specific media channels (Iyengar & Hahn, 2009), a trend which may be exacerbated by the recent increase in the availability of ideologically-specific media outlets, which has also been linked to greater levels of polarization (see Prior, 2007, 2013). Indeed, the literature has long supported the notion that greater control over media gives individuals the choice to avoid, or filter, counter-attitudinal messages (Festinger, 1957; Prior, 2007, 2013; Sears & Freedman, 1967).

Selective use of media is one of the points at which political polarization intersects with science issues. Media are a significant source of scientific information, particularly for those finished with formal education, serving as a bridge between scientists and the lay public, and potentially facilitating public understanding of science (Brossard & Dudo, 2012; Kahlor & Rosenthal, 2009). Indeed, exposure to media shapes our perception of reality (Gerbner, 1998), including our individual perceptions of science and emerging technologies (Gerbner, 1987). Because of this, the ways in which individuals use media to get information related to science issues -- i.e. how their science reality is constructed through a combination of media use, personal traits and value predispositions -- is of concern to this dissertation.

Of course our reality isn't shaped solely by our exposure to media. People obtain information in a variety of ways. Information gleaned from conversation with others can take different forms ranging from light discussion of issues with like-minded friends to all-out confrontation with family at the Thanksgiving table over contentious issues. In each of these situations individuals use relatively sophisticated strategies in combination with value predispositions to process socially-obtained information (Huckfeldt & Sprague, 1995).

As with personal traits and value predispositions, the anticipation of conversation with like-minded or differently-minded others can direct our attention to specific media channels or content. There is evidence that those who anticipate engaging in opinion-based discussions related to emerging technology with others who oppose their views are more likely to seek out topic-relevant persuasive news content – i.e. opinion pieces – than informational news content (Xenos, Becker, Anderson, Brossard, & Scheufele, 2011). This observation is related to earlier work which found individuals are more likely to seek information on a topic when friends or close contacts persisted in mentioning the topic (Graber, 1988 in Xenos et al., 2011). To that end, this dissertation is also interested in the potential for individual discussion networks to affect emerging science-related information seeking, discussion and support.

The seeking and processing of information is not a neutral activity. Individuals tend to be cognitive misers. When confronted with synthetic biology as a topic, or any other unknown subject, individuals may have little motivation or incentive to learn about the issue, and be substantially less interested in doing so if achieving understanding would require significant effort (Scheufele & Lewenstein, 2005; Scheufele, 2006). As a result, we as individuals tend to rely on heuristics, such as individual value predispositions, to arrive at opinions or inform decisions (Scheufele, 2005). For a variety of reasons ranging from the lack of a strong reason to process information accurately, the cognitive ability to process new or complex information, a strong desire to confirm prior attitudes or the desire to disconfirm counter-attitudinal information, individuals will have incentive to process information toward a predetermined conclusion (Yeo, Cacciatore & Scheufele, 2015; Druckman & Bolsen, 2011). In other words, they will be motivated to reason in a particular direction, toward a predetermined conclusion. This phenomenon has been the subject of a number of recent studies which find the independent variables, deference to scientific authority (Brossard & Nisbet, 2007), political ideology (Nisbet, 2005) and religiosity (Brossard, Scheufele, Kim, & Lewenstein, 2008; Scheufele, Corley, Shih, Dalrymple, & Ho, 2009), all of which figure prominently in this dissertation, can be associated with motivated reasoning related to scientific issues.

The challenge to science communication becomes significantly greater when we add to this mix the understanding that 81 percent of Americans get at least some of their news through websites, apps or social networking sites (Pew, 2016), and acknowledge the extent to which audience-centric filters, media-centric filters (Scheufele & Nisbet, 2012) and search algorithms (Pariser, 2011) filter the news we receive from online sources.

This line of inquiry exists against a background in which our collective media environment is constantly changing. The rise of the "New Right" as a transformative political force has been noted over the past decade (Gross, Medvetz, & Russell, 2011; Nash, 2006) and coincided with, indeed is partially responsible for, the start of a persistent decline in support for science among those who identify politically as conservative (Gauchat, 2012). Armed with its own publishing houses, cable television shows, social networks (Gauchat, 2012; Jacques, Dunlap, & Freeman, 2008) and websites, plus a high degree of sophistication in using media to mobilize its constituents (Blee & Creasap, 2010), and a track record of affecting science-related public policy (Jacques et al., 2008), this group has a strong voice that certainly will impact policy affecting scientific research, including the subject of this dissertation, synthetic biology research.

Science denial is not limited to one political ideology. Highly educated citizens, typically white and often centralized in well-to-do, liberal communities, have been busy rejecting childhood vaccinations based on a flawed and manipulated study discredited years ago. The result has been the dangerous reemergence of diseases like measles and whooping cough, which have been rare enough over the past generation that many of today's parents do not know how to identify these illnesses (Millman, 2015). Food activists continue to push for labeling of GMO-containing foods, a measure widely supported by most Americans, despite the finding that there is "no substantiated evidence of a difference in risks to human health between currently commercialized genetically engineered (GE) crops and conventionally bred crops…" (Annenberg Public Policy Center, 2016; Giller, 2016; National Academies of Sciences, 2016).

The Goals of this Dissertation

The work offered in this dissertation has as its primary goals 1) greater understanding of the media environment in which communication about emerging technologies occurs, 2) the identification of science-specific audience segmentation that allows for the eventual development of targeted messaging to specific groups of science constituents, and 3) a deeper understanding of how characteristics specific to science audience segments vary in their importance relative to science-related information seeking, discussion and support.

Topic: Synthetic Biology

In order to accomplish these goals, this dissertation uses an emerging science, synthetic biology, which is largely unknown to the majority of the public. Synthetic biology is an attractive topic for this dissertation for a variety of reasons ranging from its potential to advance solutions to a number of tricky biological problems to the possibility that the science fiction-like aspects of some synthetic biology advances, which will be outlined at the end of this chapter, have the potential to sour public opinion and thwart its advancement prior to understanding the full benefits and risks of the technology. However the primary attraction for this dissertation is its novelty as an emerging technology. Specifically, very low levels of news coverage and social networking site discourse related to the topic make it possible to identify potentially causal relationships between those variables. Additionally, very low levels of synthetic biology-related knowledge among the public in the technology's earliest stages makes it easier to observe and discern the effects of personal predispositions, such as political ideology, religiosity, media use and issue-related discussion on attitudes toward this issue. Three studies are presented in support of this dissertation's goals:

Study 1: Spider Goats and Science Reporting: The Intermedia Agenda Setting Effects of *Twitter* in an Era of Declining Science News Coverage

One of the key premises underlying this line of scholarship is that the public writ large knows so little about emerging technologies in their earliest stages, in part, because it encounters very little information about such topics in the media. In support of this argument, the work of individual scholars in this line of inquiry often includes studies that map media landscapes as technologies emerge and grow in prominence. Indeed significant work on news coverage of emerging technologies using various communication hypothesis or theories provides context for subsequent work on attitudes towards those issues and has been used successfully for a wide range of topics including stem cells (Nisbet, Brossard, & Kroepsch, 2003a), nanotechnology (Cacciatore et al., 2012; Dudo, Choi, & Scheufele, 2011; Dudo, Dunwoody, & Scheufele, 2011), and climate change (Brossard, Shanahan, & McComas, 2004), among other issues. As much as this study relies on previous work establishing media landscapes for these technologies, it also provides a novel method for using media landscapes to examine intermedia agenda setting effects.

This first study maps the landscapes for synthetic biology newspaper coverage and social networking site discourse using a census of daily synthetic biology-related newspaper articles archived in the Lexis-Nexis database and synthetic biology-related keyword tweets on the social networking site, *Twitter,* establishing that there is an initial paucity of coverage and a relatively small number of daily tweets for the issue. The study then uses vector autoregression (VAR) to examine potential intermedia agenda setting effects between news coverage of synthetic biology in print newspapers and social networking site discourse about synthetic biology on *Twitter* over a five-year period from January 1, 2010 through December 31, 2014 when a number of significant synthetic biology breakthroughs occurred.

Study 2: Champions, Skeptics & Cynics: Segmenting American Science Audiences

After establishing an external media environment in which news coverage of synthetic biology occurs infrequently, this second study focuses on the internal personal predispositions that affect the way that individuals selectively attend to news sources, and news about emerging technologies, if and when such news is encountered. Recognizing the role that issue-related discussion may play in individual attitudes toward emerging technologies, this study is also concerned about the heterogeneity of individual discussion networks and issue-related discussion frequency. Using Ward's Method of hierarchical agglomerative clustering and a small number of value predisposition variables that could be easily and inexpensively used in other research, this second study segments individuals into subgroups that demonstrate strong statistical differences in demographics, science knowledge, media use and heterogeneity of individual issue-related discussion networks, along with issue-related discussion frequency. Where the first study aims to provide a foundation for future work mapping the landscapes for other emerging technologies, the results of this second study – i.e. the segments identified here -- could easily and immediately be applied to work on emerging technologies or other contested issues.

Study 3. Heterogeneity of Networks, American Science Audiences, Information Seeking, Discussion and Support Related to Synthetic Biology

The final study builds on the first two in this dissertation and uses ordinary least squares (OLS) regression to focus on the ways that individual value predispositions, media use, heterogeneity of individual discussion networks and issue-related discussion frequency affect three different dependent variables of interest: individual level of support for synthetic biology, the likelihood that one will seek additional information about synthetic biology and the likelihood that one will discuss synthetic biology with others. This study looks at respondent results from a random sample survey of a cross section of the U.S. population in aggregate, and then applies American Science Audience segments established in the previous study to the same outcome variables to determine if personal predispositions, media habits, heterogeneity of individual discussion networks and issue-related discussion frequency have equal effects on all segments. As with the second study, the application of segments could be easily applied to other existing datasets on emerging technologies or contested issues, provided the questions used as the basis for segmentation were included in the original work.

Context: A Synthetic Biology Primer

More than fifteen years after the first biological switches and toggles were synthesized, scientists in the field still have not written a simple, unanimously accepted definition of the term *synthetic biology* (Church, Elowitz, Smolke, Voigt, & Weiss, 2013). Drawing on a number of papers, this dissertation broadly defines synthetic biology as a multidisciplinary life science that uses engineering techniques -- such as model design, specification and testing -- along with molecular and computational biology to partially or wholly create biological parts, systems or devices that do not occur in natural biological systems (Folcher & Fussenegger, 2012). Synthetic biology differs from genetic modification of organisms in that the goal is not to improve an existing organism through manipulation of its genetic material, but to create a completely novel biological component or system which does new and interesting things that would not be possible solely through genetic modification. Although much of the foundational work for the discipline was conducted on microbial species, such as *Escherichia coli* and *Saccharomyces cerevisiae,* it has expanded to include sub-disciplines specializing in metabolic engineering (Cameron, Bashor, & Collins, 2014), genome construction, therapeutic gene networks (Karlsson & Weber, 2012), and the design of mammalian gene circuits (Auslander & Fussenegger, 2013). While capacities may vary across these sub-disciplines, the common thread among definitions is that each uses forward engineering techniques to standardize, regulate, control and create biological processes at the cellular level.

The vision of a standardized and controllable biology predated its reality by several decades. Although French biologist Stéphane Leduc, coined the term *synthetic biology* in his 1912 treatise La Biologie Synthétique (Leduc, 1912), the true origin of the field is more credibly attributed to the 1961 publication of Jacob and Monod's *On the Regulation of Gene Activity*, which discussed the possible existence of regulatory circuits underlying cell activity (Jacob & Monod, 1961) in (Cameron et al., 2014). For the next four decades, from 1961 through 1999 a number of technical advances laid the foundations for synthetic biology, including the development of cloning techniques, diffusion of automated DNA sequencing technology, and sequencing of the genomes for *Escherichia coli* and *Saccharomyces cerevisiae*. By the mid-1990s, researchers had discovered the functional linkage of cells into biochemical circuits that act as neural networks to transfer information (Bray, 1995), and in January 2000 the journal *Nature* announced the development of the first genetic switches and toggles (Cameron et al., 2014; Elowitz & Leibler, 2000; Gardner, Cantor, & Collins, 2000). Between 2000 and 2003, many of the current techniques and language related to synthetic biology were formalized, and by 2004 the field had grown enough to warrant its first international conference, Synthetic Biology 1.0 (SB1.0), and an undergraduate competition, the International Genetically Engineered Machine (iGem) competition (Cameron et al., 2014). The work of synthetic biology has become easier as advances like multiplex automated genome engineering (MAGE) makes it feasible to edit dozens of changes in genomes, while components of CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) technology using the Cas9 protein are being used to provide powerful, precise and flexible genome engineering across a variety of species (Church et al., 2013). By August 2014, the field had advanced far enough that synthetic biologists at the University of California-Berkley, in partnership with the pharmaceutical company Sanofi, made the first mass shipment of 1.7 million doses of semi-synthetic artemisinin, a key malaria drug derived using synthetic biology technology, to malaria-endemic countries in Africa (University of California Berkley, 17 August 2014).

At Play in the Synthetic Biology Sandbox

Optimistic discussion of successful *E. coli* engineering, robustly attended academic conferences and breakthrough drugs can be misleading. During the past two decades there have been a couple of developments that have the potential to prompt the sort of dystopian public reaction that could affect public support for the emerging technology independent of the technology’s merits. In 2002, a combined team of scientists from Canada's Nexia Technologies firm and the Materials Science Team from the United States Army Soldier Biological Chemical Command published a paper in the journal *Science* describing the successful production of spider silk from mammalian cells (Lazaris et al., 2002). Commercialized by Nexia Biotechnologies, transgenic goats carrying genes of the *Nephilia clavipes*, or Golden Orb spider, produced spider silk in their milk.

The world of art and literature has offered its interpretation of these advances. By 2003, the silk producing spider-goats had achieved literary stardom, meriting a mention in Margaret Atwood's dystopian *Oryx and Crake* series about synthetic biology biohackers who bring about the collapse of human civilization (Atwood, 2004), and in 2012 they played a starring role in an episode of Adam Rutherford's television documentary *Playing God* (Rutherford, 2012). In 2013, the Science Gallery at Trinity College in Dublin invited artists to react to synthetic biology in an exhibition entitled *Grow Your Own: Life after Nature*. The exhibition featured a transgenic mouse supposedly grown with genes taken from a sample of Elvis Presley's hair that was purchased on eBay, cheeses made from the bacteria on people's skin, and e. coli bacteria engineered to smell like bananas (Trinity College, 2013). In 2014, Vienna, Austria hosted the second *BIO-FICTION Science Art Film Festival* interdisciplinary festival and symposium on synthetic biology. BIO-FICTION's raison d'être is a short film competition in which 60 shortlisted films on synthetic biology competed for awards in documentary, animation and fiction film making, and films entered in the competition tour internationally after its completion (Bio-Fiction Science Art Film Festival, 2014). More recently in late 2016, the television version of Marvel Comic's *Luke Cage* explained his superpowers as a result of gene editing courtesy of CRISPR, and NBC announced a "procedural thriller" that would involve biohacking and crime in the form of a new series starring popular actress Jennifer Lopez and titled C.R.I.S.P.R. (Dy, 2016).

Although it's easy to spot the fiction in the superhero *Luke Cage,* the more serious dystopian critiques of *Oryx and Crake, Grow Your Own* and *BIO-FICTION* intentionally blur those lines. Indeed, the difference between fiction and foolishness can be a very fine distinction in synthetic biology. Case in point, a Silicon Valley synthetic biology start-up raised $500,000 on the website Kickstarter.com to create glow-in-the-dark plants. Their pledge to send seed packets to the first 8,000 United States donors sparked international commentary about regulation of synthetic biology and DNA modification, and a rebuke from at least one university synthetic biologist over concerns that frivolity could negatively impact more serious research

(Callaway, 2013; Cha, 2013; Lukacs, 2013). While this is a splashy example, robust, if small, communities of do-it-yourself synthetic biologists, often called DIYbio or biohackers, have been in existence since the late 1980s and served as inspiration for the *Oryx and Crake* series. Although these communities range from loosely organized to well-run, the common thread seems to be the exchange of information and/or sharing of resources (Ayres, 2008a, 2008b; King, 2012; Schrage, 1988, 1992). Despite occasional media attention, and sometimes provocative quotes like "The goal is just to provide lab space for anyone to do whatever the hell they want," from community members like Cory Tobin, co-founder of LA Biohackers (Scudellari, 2013), the DIYbio and biohacker movements seem to have avoided large-scale negative public reaction thus far.

The creative energy in filmmaking, art and literature that surrounds synthetic biology shouldn't be confused with the discipline itself. It’s difficult to interpret the absence of an outcry over the synthetic biology rodent version of Elvis Presley, but it could be a tacit indication that the public understands the difference between artistic interpretation and scientific postulation. Indeed, when confronted with a more personally relevant, potentially dread risk, like transgenic mosquitos, the public ennui that greeted spider-goats could plausibly become something else.

'Mutant' Mosquitoes, Break-Bone Fever and the Dreaded Zika Virus

In its mild form Dengue fever mimics influenza. For the half million people who become seriously ill from the disease, Dengue is a nightmare. Dengue shock syndrome, nicknamed break-bone fever, is characterized by severe abdominal, muscle, joint and bone pain, fevers as high as 106 F, a drop in platelet production that can cause bleeding under the skin and from the nose or mouth, persistent vomiting, and problems with the liver, lungs and heart (Mayo Clinic Staff, 2015). After decades of decline, Dengue is on the upswing as one of the most rapidly spreading viral diseases in the world.

The Zika virus, whose symptoms mimic the flu in otherwise healthy adults, was first documented in humans in Uganda and the United Republic of Tanzania in 1952, but the virus was relatively rare and largely unknown to the public until February 2016 when the World Health Organization noted an increase in microcephaly in infants born in Brazil to infected women after what is now believed to be an outbreak of the virus that affected 7,000 Brazilians in 2015 (World Health Organization, 2016). Zika, like Dengue, is carried by the *Aedes aegypti* mosquito and also by its relative *Aedes albopictus* and has been found residing in mosquitos in Dade County, Florida (Centers for Disease Control, 2016).

Until vaccines, treatments or cures are discovered the only sure way to prevent Dengue or the Zika virus is to douse potentially infected areas with pesticides in the hopes that the chemicals will reach every teaspoon of water that might incubate the eggs of their carriers, the *Aedes aegypti* and *Aedes albopictus* mosquitos (Specter, 2012). Synthetic biology could change that.

In 1996, synthetic biology researchers announced the successful engineering of a female *Aedes aegypti* mosquito designed to disrupt transmission of Dengue fever to humans (Olson et al., 1996), but it wasn't until a male *Aedes aegypti* mosquito was engineered to produce offspring that expired before reproducing or passing on the infection that the transgenic insect became a viable option for fighting Dengue. In 2010, the British firm Oxitec released 3.3 million of the transgenic male mosquitoes on 16 hectares in the Cayman Islands and charted a decrease of 80 percent in wild Aedes aegypti mosquitoes in the test area (Specter, 2012). Field tests in Brazil were similarly successful (Carvalho et al., 2015).

One would think this would be welcome news to people in places like Florida where Dengue has recently made its first appearances since the 1940s. However, a proposed release of the transgenic male mosquitoes in the Florida Keys prompted headlines like "*GMO mosquitoes in Florida: Mutant bugs could come as early as spring, but there's no reason to freak out,"* (Ross, 29 January 2015) or *"Florida is abuzz over plans to introduce 'mutant mosquitoes'"* (Basulto, 10 February 2015) that allude to a different reaction. By January 2015, only weeks after the initial announcement, 130,000 people had signed a petition against the mosquito release on *Change.org* (USA Today, 26 January 2015).

Although the researchers for this paper note that public reaction among Florida residents may now differ since the very recent discovery of Zika-infected *Aedes aegypti* in Dade County, Florida, the manner in which synthetic biology is covered in the media has the potential to sway public opinion. Indeed, negative frames like “mutant mosquitoes” and “GMO mosquitoes” could pre-emptively sway public opinion against the technology without thorough discussion of its benefits and risks.

Therein lies the challenge for the actors in and around synthetic biology. Those in the science community would likely argue that public outcry over unfounded fears of synthetic biology could derail the adoption of biotechnologies that could save millions from misery. Laypeople potentially affected by these innovations could make an equally compelling argument that it is a basic human right to be both informed of potential risks and allowed a reasonable voice in the deployment of technologies that affect their communities. The purpose of this dissertation is to explore the space where these concerns meet.

Current Public Opinion Related to Synthetic Biology

Although a 2013 study found that the public is neutral on synthetic biology (Hart Research Associates, 2013), science itself has become increasingly politicized. The rise of the "New Right" as a transformative political force (Gross et al., 2011; Nash, 2006) coincided with, and is partially responsible for, the start of a persistent decline in support for science among those who identify politically as conservative (Gordon Gauchat, 2012). Armed with its own publishing houses, cable television shows and social networks (Gordon Gauchat, 2012; Jacques et al., 2008), a degree of sophistication in using media to mobilize its constituents (Blee & Creasap, 2010), and a track record of affecting science-related public policy (Jacques et al., 2008).

At this moment, the likely reason that synthetic biology has not yet become a polarizing topic lies with the low level of public awareness about the technology (Akin et al., 2015; Hart Research Associates, 2013). This affords researchers a number of opportunities. First, low levels of awareness provide a chance to see how, in the absence of topic-specific knowledge, variables like personal predispositions, individual traits and social context serve as filters for opinion formation. The insights we can achieve by studying the relatively unknown synthetic biology would not be possible when studying topics such as nuclear energy or climate change, where public awareness is relatively robust and arguments for and against somewhat well known. Second, as awareness grows over time, scholars have the chance to study the development of public opinion related to a complicated science during a media era marked by the decline in the ranks of trusted science journalists who are able to translate the nascent technology for the lay public (Scheufele, 2014).

Specifically, this work will explore the intersection of media and public opinion related to synthetic biology. Why? Communication scholars have long understood that, over time, exposure to media shapes our perception of reality (Gerbner, 1998), and this extends to individual perceptions of science and emerging technologies (Gerbner, 1987). Science communication research also provides evidence that in Western societies fundamental science knowledge and a general deference to scientific authority are cultivated through formal education, but information about new technologies is typically acquired through media exposure (Brossard & Shanahan, 2003). This has important implications for those interested in emerging technologies as there is also evidence that media exposure affects individual perceptions of science and technology issues (M. W. Bauer, 2005; Besley & Oh, 2013; Dudo et al., 2010; Gerbner, 1987; Li, 2012; Shanahan, Morgan, & Stenbjerre, 1997).

Synthetic Biology, Personal Predispositions & the Typical American

To put it in perspective, let's look at a theoretically 'typical' American of median age (37.6 years). This imaginary citizen graduated from an American high school the year before the first animal was cloned and several years before the human genome was fully sequenced. Although she was in elementary school when one of the foundational technologies for synthetic biology - polymerase chain reaction (PCR) analysis - was developed in 1984, it would likely have been too new for inclusion in even the most advanced biology textbooks when she reached high school (Council for the Advancement of Science Writing, 2015). Assuming this median-age citizen attended college, and possibly graduate school, it is still unlikely that she would have encountered synthetic biology as advances even a decade old are still too recent for the general studies curriculum she likely studied. Indeed, if she mentions the latest technologies underlying synthetic biology, i.e. MAGE and CRISPR, in a conversation with her very well educated post-collegiate friends, she is likely to be met with blank stares.

But let's pretend that our imaginary median-ager does encounter synthetic biology in conversation, either in person at a cocktail party or business meeting, or perhaps online through an article on her favorite news site. It's possible that the context in which the information is presented, along with its tone, plays a role in how she reacts. The information she receives, either by chance or because she is motivated to seek it, is filtered through a complicated set of attitudes and beliefs accumulated over her lifetime. These variable personal predispositions work in tandem with media exposure to cultivate her attitude toward science and technology, which now includes the newly acquired information about synthetic biology (Besley & Oh, 2013; Brossard & Shanahan, 2003; Kahan, Braman, Slovic, Gastil, & Cohen, 2009).

Like our imaginary median-ager, the majority of the U.S. public knows little or nothing about synthetic biology. A 2013 survey found that even though only 23 percent of respondents had heard 'a lot' or 'some' about synthetic biology, 76 percent were able to volunteer an answer to the question "What do you think synthetic biology is?" to which 31 percent volunteered "unnatural, man-made, something that isn't real, artificial" and 15 percent volunteered "reproducing/recreating life, cloning, genetic/DNA manipulation." The combination of these answers suggests that individuals may be inferring the definition of the field based on its name (Hart Research Associates, 2013).

Though we may take heart that our fellow citizens can use context clues to infer a definition, as the term “synthetic biology” is somewhat self-explanatory, we may also be taken aback that their admitted lack of knowledge doesn't prevent expression of an opinion. In a 2014 study by the Science, Media and the Public group at the University of Wisconsin-Madison, 74.9 percent of respondents indicated they were uninformed about synthetic biology, and 60.6 percent of respondents felt the issue was not important to them, personally. Despite the lack of knowledge or personal relevance, 64.6 percent of all respondents felt that commercial synthetic biology research should be regulated and 59 percent felt that academic synthetic biology research should be regulated. A total of 31.2 percent of respondents expressed support for synthetic biology research, and an equal number supported its use. However, support was neither evenly nor randomly distributed, but positively related to education, deference to scientific authority, synthetic biology factual knowledge and trust in scientists. In contrast, conservative ideology, religiosity and female gender were negatively related to support for the use of synthetic biology (Akin, et al. 2015).

Chapter 2. Spider Goats and Science Reporting: The Intermedia Agenda Setting Effects of *Twitter* in an Era of Declining Science News Coverage

Study Goals

The reduced capacity of newspapers to cover science has coincided with the rise of social networking sites, like *Twitter*, which have increased individuals' ability, like that of our theoretical median-ager, to be producers as well as users of news and information. These twin phenomena provide science communication researchers with the opportunity to study how news coverage of science issues influences social networking site discourse about those issues, and whether social networking site discourse influences coverage in any way. This study harkens back to earlier studies on the influence of prestigious and highly influential media, such as the *New York Times*, in legitimizing news topics and thus setting the agenda for other media in what is termed intermedia agenda setting (McCombs & Reynolds, 2009). Intermedia agenda setting studies themselves were extensions of the original agenda setting work, which found that mass media coverage of issues is highly correlated to those cited by individuals as the most important issues facing the country, and by influencing the salience of issues the media plays an important role in setting the civic agenda (McCombs & Shaw, 1972).

This study examines the interdependent effects of the daily volume of news coverage on the daily volume of synthetic biology keyword *Twitter* discourse as a single collected corpus of 140-character texts posted by thousands of individuals over the study period. Thus, this study both maps the landscape for early newspaper coverage of synthetic biology, and also closes the loop that first began with the original agenda setting studies establishing the influence of media on individual perceptions of which issues were important, and then continued with intermedia agenda setting studies establishing the influence of first tier media in setting the agenda for second tier media coverage of topics. Specifically, by examining the interdependent effects of newspaper coverage of synthetic biology to influence the volume of synthetic biology *Twitter* discourse alongside the ability of individual *Twitter* users en masse to influence coverage of synthetic biology, this study brings the agenda setting/intermedia agenda setting loop full circle.

Twitter is a useful platform to study for a number of reasons. Between 2013 and 2015 the number of *Twitter* users who reported turning to the platform as a news source grew from 52 percent to 63 percent, nearly half (46%) reported following news organizations and 59 percent reported following a news event on *Twitter* as it was happening. In comparison, only 28 percent of Facebook users report following a news organization and 31 percent report following a news event on *Facebook* as it was happening (Barthel, Elisa, Gottfried, & Mithcell, 2015). Indeed, the use of social networking sites, *Twitter* in particular, by journalists has been documented across the globe (Barnard, 2016; Broersma & Graham, 2013; Engesser & Humprecht, 2015; Knight, 2012; Nielsen & Schroder, 2014) for a number of reasons ranging from access to news sources (Artwick, 2013; Farhi, 2009; Moon & Hadley, 2014; Parmelee, 2013), including science sources (Liang et al., 2014) to its usefulness as a vehicle to communicate with end users (Artwick, 2013; Lasora, 2011; Revers, 2014).

Additionally, *Twitter* was selected for this study because it has been successfully used to examine discourse around science issues (Kim, Brossard, Scheufele, & Xenos, 2016; Runge et al., 2013; Yeo et al., 2016) which provides context for the way in which the platform is used to communicate about emerging technologies. To that end, *Twitter* is especially useful for this study because of its unique position as a relatively popular social networking site platform in which the daily volume of spontaneous conversation around an issue is publicly observable for issues that attract mass audiences as well as those that attract relatively small numbers of *Twitter* users (Runge et al., 2013). As a result, this study is able to track the daily volume of each variable – newspaper coverage and Twitter discourse - in order to better discern the immediate temporal relationship between media coverage of an emerging science issue at the very earliest stages of public awareness and spontaneous discourse related to that issue, albeit within the parameters of the two respective media variables. In tandem, and along with vector autoregression (VAR) and Granger causality testing, these variables provide a stronger approximation of the degree to which media coverage of synthetic biology and social networking site discourse about synthetic biology influence one another, if at all, over time than was possible with early intermedia agenda-setting studies. Although similar conversations surrounding science issues may occur on other social networking sites, notably *Facebook*, these are not always publicly observable, and would preclude the same level of examination this study is able to achieve via the use of *Twitter*.

In order to better understand these dynamics, and because there is a lack of comparable studies using this particular methodology for similar emerging technology topics, this study compares the relationship between these variables for two countries with similar, even shared, synthetic biology research trajectories, similar degrees of openness with regards to press freedom and similar citizen access to the Internet: the United States and the United Kingdom. The study covers a five-year period from January 1, 2010 through December 31, 2014 when a number of significant synthetic biology breakthroughs occurred and were reported in newspapers in both study countries. Using vector autoregression, a census of synthetic biology newspaper coverage archived in Lexis Nexis and a census of synthetic biology keyword tweets, I conduct a time series analysis to examine and compare the interaction between newspaper coverage of the issue along with volume and sentiment valence on *Twitter* in both countries.

Twitter

Twitter is one of several Internet-based platforms that are distinguished from other Internet-based platforms or media by several characteristics. SNS platforms provide a bounded system in which users can construct and curate a public or semi-public profile, identify other users with whom they share a connection, (boyd & Ellison, 2007) connect to those users, and distribute existing content produced by others within the SNS as well as produce their own content for distribution. Although a number of SNS platforms, such as Facebook or LinkedIn, require two-way confirmation that a relationship between users exists, the subject of this study, *Twitter*, does not. Thus *Twitter* users are able to follow and share information posted by other users with whom they do not have an offline connection.

The social networking site *Twitter* offers a unique opportunity to observe spontaneously generated public conversation surrounding issues like the one presented here. With a limit of 140 characters per message, *Twitter*'s content consists of brief messages that allow users to conduct publicly observable asynchronous conversations through the use of websites, mobile Internet devices, and SMS (Runge et al., 2013). At the start of the study period, *Twitter* had 106 million active monthly users, 60 percent of whom were located outside the United States, (Arthur, 2010) growing to 241 million active monthly users in 2014, 78 percent of whom were outside the United States (Bennett, 2015). In the United States Pew Research Center tracks the demographics of social networking site users and finds that *Twitter* use is consistently higher among younger Internet users, African Americans, those with at least some college education and urban users, although the geographic and racial gaps were closing during the study period (Table 2.1). It should be noted that *Twitter* users tend to be younger, more urban, and more likely to be minority than the general population, and thus are not representative of the general population of the United States. Although those characteristics fluctuated during the five-year study period, it still cannot be claimed that *Twitter* users, or any social networking site user population, is fully representative of the general American population. That user populations do not reflect characteristics of the U.S. population, however, is true of users of newspapers as well, and is not limited to users of social networking sites (Pew Research Center, 2007). Comparable data for the United Kingdom was not available at the time of this writing.

Studies focused on *Twitter* discourse surrounding science issues have been insightful. There is evidence that for the emerging science of nanotechnology, at least, the presence of a U.S. federally-funded research center is related to higher numbers of nanotechnology-keyword tweets in its host state (Runge et al., 2013). Research has documented *Twitter* as a platform to disseminate online information about science issues though linked content (Kim et al., 2016) and refute the findings of peer-reviewed research prior to publication in academic journals (Yeo et al., 2016). Lest we think science on *Twitter* is the domain of science partisans and promoters only, there is evidence that the *Twitter* agenda for hydraulic fracking was driven by fracking activists, even though journalists and media outlets appeared in the top mentioned users for this issue (Hopke & Simis, 2015).

Table 2.1: United States Twitter users 2010-2014; percent of all Internet users in each group who use Twitter

Of All Internet Users	2010 *8%*	2011 *13%*	2012 *15%*	2013 *18%*	2014 *19%*
Men	7	14	14	17	24
Women	10	11	15	18	21
White, Non-Hispanic	5	9	12	16	21
Black, Non-Hispanic	13	25	28	29	27
Hispanic	18	19	14	16	25
18-29	14	18	26	31	37
30-49	7	14	14	19	25
50-64	6	8	9	9	12
65+	4	6	4	5	10
High school	5	8	12	17	16
Some college	9	12	14	18	24
College +	9	16	17	18	30
Less than 30,000/year	10	12	19	17	20
$30,000-49,999	6	14	12	18	21
$50,000-74,999	10	12	14	15	27
$75,000+	6	15	17	19	27
Urban	11	15	19	18	25
Suburban	8	14	14	19	23
Rural	5	7	8	11	17

Source: (Pew Research Center, 2010, 2011, 2012, 2013, 2014b)

Comparing the United Kingdom and United States

Both of the study countries share traits necessary for comparison. The United Kingdom and the United States share a common language which is spoken by a majority of residents. Although English is the primary language of only 80 percent of U.S. residents (Central Intelligence Agency, 2016), it is the dominant language for media and science in the U.S. Both countries maintain sufficiently similar scientific research environments, open press environments and do not restrict citizen access to the Internet. In 2010, at the start of this study period, 73 percent of households in the United Kingdom and 68.7 percent of households in the United States had Internet access at home (Office for National Statistics, 2010; United States Census Bureau, 2010). Additionally, 73 percent of Britons and 77 percent of Americans reported using the Internet in 2010 (Office for National Statistics, 2010; Pew Research Center, 2014a). Although a more significant proportion of *Twitter* users were located in the United States than Britain at the start of the study period, 50.8 percent of all *Twitter* users as compared to 7.2 percent. When normalized for population the difference is less stark, as the equivalent of roughly one out of every six residents of the United States reported using *Twitter* as compared to one out of every eight residents of the United Kingdom in the initial year of the study (Sysomos, 2010).

In addition to sharing similar media environments, the national governments of the United Kingdom and the United States have made significant investments of public dollars in synthetic biology research (Engineering and Physical Sciences Research Council, 2016; Wilson Center, 2015), and a number of significant innovations have crossed borders between the countries. For example, the altered *Aedes aegypti* mosquitos proposed for release in Florida were developed by the British firm Oxitech. The transgenic goats that secreted spider silk in their milk were developed as a partnership between the United States Army and a firm in Canada, a member of the British Commonwealth, and featured prominently in the BBC documentary *Playing God*. Additionally, prominent synthetic biology researchers, such as George Church and Craig Ventner were featured in news coverage of synthetic biology in both countries.

However, newsroom cultures differ in the study countries. In the U.S. journalists embrace an opinion-less objectivity stance, in which non-partisanship is a highly valued. In comparison, the U.K. embraces media sovereignty where facts and fairness are the goal, but a degree of opinion is allowable. Although Reuters and the BBC adhere to a policy of objectivity, most British newspapers fall somewhere along the spectrum between a U.S. style hard news paradigm - which emphasizes balanced reporting and a separation of news and editorial opinion - and a paradigm that embraces interpretive journalism and/or strong fact-based advocacy (Esser & Umbrecht, 2014). In the United Kingdom a distinction is made between broadsheet newspapers and tabloids, where broadsheets focus on investigative journalism and newsworthy events with a particular attention to government, elected officials, national and foreign affairs. In contrast, the tabloids devote less space to hard news than soft news (Uribe & Gunter, 2004), and have a more populist focus on sensational events, celebrity and personalities (Connell, 1998).

Comparisons of media coverage for science issues in each country have been conducted for anthropogenic climate change (Boykoff, 2007; Grundmann & Scott, 2014; Schmidt, Ivanova, & Schafer, 2013) and for the U.S and U.K., along with France and Canada, for climate science discourse on *Twitter (*Jang & Hart, 2015).

Intermedia Agenda Setting & Emerging Technologies

Communication scholars, including this author, study emerging technologies, such as synthetic biology, because the low levels of knowledge for these topics makes it easier to observe the effects of personal predispositions, like political ideology and religiosity, and media use on attitudes toward these issues. One of the key premises underlying this line of scholarship is that the public writ large knows so little about these topics because it encounters very little information about such topics in the media. In support of this argument, the work of individual scholars in this field often includes studies that map media landscapes as technologies emerge. Indeed as mentioned in the introduction to this dissertation, significant work on news coverage of emerging technologies using various communication hypothesis or theories provides context for subsequent work on attitudes towards those issues and has been used successfully for a wide range of topics including stem cells (Nisbet et al., 2003a), nanotechnology (Cacciatore et al., 2012; Dudo, Choi, et al., 2011; Dudo, Dunwoody, et al., 2011), and climate change (Brossard et al., 2004), among other issues. To the extent that media landscape mapping occurs, it is useful to ask who sets the media agenda for emerging technologies, particularly in an era marked by declining numbers of science news reporters and increasing numbers of social networking site users, some of whom post about science issues.

Indeed, changes in the media environment over the past decade have opened up new avenues for intermedia agenda setting research. The rise of synthetic biology has coincided with declines in paid newspaper subscriptions and the elimination of dedicated science sections in newspapers, the combination of which has had a negative impact on science reporting (Dudo, Dunwoody, & Scheufele, 2011; Mooney & Kirshenbaum, 2009), and possibly relegated coverage of science to online news sources (Zara, 2013). One pragmatic result is that synthetic biology-related newspaper reporting may be left to a few remaining science journalists and select news organizations (Dudo, Dunwoody, et al., 2011) thus reducing the number of skilled science journalists who are able to translate and contextualize developments in the field.

Alongside the reduced capacity of newspapers to cover science, social networking sites, such as *Twitter*, have increased individuals' ability to be producers as well as users of news and information. For over a decade communication researchers have explored the intersection of these phenomena and the circumstances in which social networking sites may shape traditional coverage of issues. One particular line of research, intermedia agenda setting, is useful in understanding the media environment in which these interactions occur.

Specifically, intermedia agenda setting is the process by which attention to an issue by one branch or entity in the media "sets the agenda" for other branches or entities (McCombs & Reynolds, 2009). This line of research has been useful in explaining the influence of the *New York Times* and *Washington Post* in legitimizing topics as newsworthy (Denham, 2014; Golan, 2006; Mazur, 1987; Reese & Danielian, 1989), the influence of the Associated Press wire service on broad news coverage of issues (Whitney & Becker, 1982), as well as the role of external news sources – i.e. elected officials – in creating news agendas (McCombs, Gilbert, & Eyal, 1982; Sigal, 1973).

This study is concerned with potential intermedia agenda setting effects between newspapers and social networking sites for synthetic biology. At least one study across a large number of news topics found a fairly clear intermedia agenda-setting effect for traditional media on trending topics for certain issues on social networking sites, along with instances in which social networking sites set the agenda for traditional media coverage of certain topics (Groshek & Groshek, 2013). Indeed, research on intermedia agenda setting has noted a source cycle in which blogs and newspapers depend on one another for material (Chadwick, 2011b; Kushin, 2010), sometimes to the extent that a "news cycle" could be considered an "information cycle" given the participation of non-traditional media sources in the dispersion of news (Chadwick, 2011b).

There is evidence for intermedia agenda setting between online and traditional media during presidential and gubernatorial election campaigns where candidate websites act as influential news sources for journalists (Ku, Kaid, & Pfau, 2003; Sweetser, Golan, & Wanta, 2008), as well as issue-related political events (Ragas & Kiousis, 2010) for a variety of online channels including blogs (Heim, 2013), YouTube (Wallsten, 2010), and *Twitter* (Frederick, Burch, & Blaszka, 2013; Parmelee, 2013).

However, there are questions about the direction and regularity of intermedia agenda setting effects between online and traditional media. Despite the heavy reliance of online participatory media on traditional sources (Chadwick, 2011a; Groshek & Groshek, 2013; Leccese, 2009) there are indications that traditional media is limited in its ability to set online agendas (Meraz, 2011) and scant evidence of intermedia agenda setting between specific entities, such as the *New York Times* and *Twitter* (Kushin, 2010). When effects are found, they may be short-term (Vliegenthart & Walgrave, 2008), topic or issue-dependent, and vary according to medium (Groshek & Groshek, 2013; Vliegenthart & Walgrave, 2008). Still, there is documentation that news coverage of issues can forecast the amount of *Twitter* chatter an issue receives (Vargo, Guo, McCombs, & Shaw, 2014) such that spontaneous tweets sometimes reflect news media agendas (Groshek & Groshek, 2013; Wilkinson & Thelwall, 2012). Most agenda setting research documents effects for topics with widespread appeal, i.e. focusing on the most important issues of the day. There is little research on which media outlets set the agenda for emerging science and technology issues in the earliest stages of public awareness when the development of discourse around the issue can have a dramatic effect on public perceptions.

Media Coverage of Synthetic Biology

There has been limited research documenting synthetic biology news coverage. A pair of studies on news coverage in the United States and Europe from 2003 through 2011 found a sharp increase in synthetic biology news after 2008, much of it event or personality driven. Coverage in the United States was initially focused on work conducted in universities, but commercial news related to synthetic biology began to receive an increase in attention toward the end of the study period. Coverage in the United Kingdom continued to be focused on university-based research (Pauwells & Ifrim, 2008; Pauwells, Lovell, & Rouge, 2012). However, these studies were based on a keyword search limited to the specific term "synthetic biology." As noted by one academic study on news coverage of synthetic biology in German-language newspapers from 2004-2009, which also found coverage to be event and personality-driven, early coverage of the topic was not clearly distinguished from coverage of gene technology (Gschmeidler & Seiringer, 2012).

Related research on biotechnology news coverage may provide insight into how media covers emerging science and technology. A study reviewing 29 years of biotechnology news coverage found that, although media attention steadily increased over time, news was episodic with sharp increases in response to major scientific announcements, and an early focus on research and discovery that shifted to a focus on controversy in later years (Nisbet & Lewenstein, 2002). This is consistent with other studies finding industry announcements related to unique scientific achievements (Goodell, 1979; Nisbet, Brossard, & Kroepsch, 2003b), or policy decisions prompt news coverage (Nisbet et al., 2003b), and that coverage of emerging technologies is initially focused on optimistic outcomes, shifting to more pessimistic tones as the press begins to address the potential risks and controversies related to the technology (Dudo, Dunwoody, et al., 2011; Goodell, 1979; Shanahan & Scheufele, 2001).

Research Questions

One result of changes in the volume of science news is that information about new technology is simply not reaching the public in an adequate manner. Based on this, and literature establishing intermedia agenda setting effects between first tier and second tier news organizations, I propose the following questions:

RQ: Will there be evidence of intermedia agenda setting via a causal relationship between newspaper coverage of synthetic biology and volume of synthetic biology keyword tweets in either the United States or the United Kingdom?

The units of analysis for this study will be synthetic biology keyword tweets and synthetic biology-related newspaper stories. Therefore:

H1a/H1b: The overall volume of synthetic biology keyword tweets will be Granger-caused by newspaper coverage in the United States (H1a) and the United Kingdom (H1b).

Previous research suggests a possible bi-directional relationship between coverage of an issue in traditional media and issue-related posts on social networking sites. For an emerging technology, such as synthetic biology, we hypothesize:

H2a/H2b: The overall volume of synthetic biology keyword tweets will Granger-cause (forecast) coverage in newspapers in both the United States (H2a) and the United Kingdom (H2b).

Methods

LexisNexis Sample Procedure

The procedure for this study was designed to collect a complete sample of English-language newspaper articles about, or referring to, synthetic biology that were archived on the LexisNexis Academic database. The study period began on January 1, 2010 and extended through December 31, 2014. Taking into consideration the relative novelty of the term *synthetic biology*, the global nature of 21st century scientific research and commerce, and the study goal to capture as much print newspaper coverage as possible, the search was not limited to specific elite national newspapers but extended to all newspapers archived in LexisNexis from the United States and the United Kingdom.

Keyword List - Newspaper

Beginning with a complex Boolean search term based on Oldham, Hall, Burton & Gilbert's 2012 work mapping the synthetic biology scientific landscape, LexisNexis was used to identify English-language newspaper articles containing synthetic biology-related keywords beginning January 1, 1912 through December 31, 2014 (Table 2.2) (Oldham, Hall, Burton, & Gilbert, 2012). Search terms used were designed to err on the side of inclusiveness while also eliminating as many false positives as practical (see Table 2.2). In order to collect the most comprehensive list of articles possible, the LexisNexis search was conducted by working backward from the most recent year in the study period, 2014. Collected articles were reviewed to identify common synthetic biology-related terms that were not included in the initial Boolean search. These terms were then incorporated into the Boolean search term, and the search was repeated using the expanded list. This increased the likelihood that the search would capture new synthetic biology-related language as it emerged. This procedure was conducted several times throughout the collection.

Newspaper Census Procedure

A total of 1,553 English-language newspaper articles containing synthetic biology-related keywords were collected. Because the sampling frame only included print newspapers, we culled from articles that were published solely through wire services, web publication, web-only newspapers, trade journals, patent notifications and newsletters along with non-articles, such as news summaries for a newspaper edition that contained references to a synthetic biology article in that same edition. Obituaries, marriage announcements, job promotions and corrections were also omitted. Each remaining article was reviewed to ensure it was published in a print newspaper, and the keywords it contained referred to synthetic biology, and not related technologies that may use the same or similar keywords. Articles need not have synthetic biology as a main topic, but must refer to the technology in such a way that a reader without prior knowledge would receive some sort of information about the technology itself. Therefore, articles simply listing synthetic biology without contextual information were also eliminated, i.e. an article with the sole mention “A lecture on synthetic biology was delivered at the university on Tuesday,” would be eliminated, but articles defining or contextualizing the technology would be included, i.e. “Minister Smith has great hope that synthetic biology, with its ability to edit genes and produce biological parts or components not possible through traditional genetic modification, will be a key to economic growth in Scotland," would be included. After culling, 518 of the 1,553 collected newspaper articles were valid and qualified for this study. Of those collected and qualified, 221 were published in United States newspaper and 297 were published in United Kingdom newspapers during the study period.

Newspapers were categorized into synthetic biology-first tier and synthetic biology-second tier. Synthetic biology-first tier newspapers were those with daily publication, national distribution and higher circulations that published a minimum of five synthetic biology news articles, for a minimum average of one per year, over the study's time period. In the United States synthetic biology-first tier newspapers included the *New York Times*, *Washington Post* and *USA Today*. The *Wall Street Journal*, which is widely considered a leading national newspaper based on subscriptions and national coverage, only filed two synthetic biology reports during the study period and was thus included among synthetic biology-second tier newspapers. In the United Kingdom, synthetic biology-first tier newspapers included the *Daily Telegraph*, the *Guardian*, the *Times* and the *Independent.*

Keyword List – *Twitter*

The keyword list adapted from Oldham, Hall, Burton & Gilbert (Oldham et al., 2012) for newspaper article collection was modified for the abbreviations and short-hand common to *Twitter* (Table 2.1). This keyword list was used to collect a census of all synthetic biology-related keyword tweets posted between January 1, 2010 and December 31, 2014 using an algorithm-based software program that automatically tracks linguistic patterns. Given the 140 character limit for tweets, and the likelihood that synthetic biology-related tweets may not always use variations on the term *"synthetic biology"* for the sake of character economy, the list used in the LexisNexis sample was further expanded to use additional keywords that referred to specific methods and technologies used in synthetic biology. For example, "genetic oscillator" and "CRISPR," were included in the *Twitter* search, but not in the LexisNexis search, in order to err on the side of inclusiveness when tweets were gathered for coding. Likewise the term “living foundry” and its variation “living foundries” were included in the *Twitter* search after the Defense Advanced Research Projects Agency (DARPA) announced a new synthetic biology program entitled “Living Foundries” in 2011.

Table 2.2: Synthetic biology keyword strings for LexisNexis and Twitter

LexisNexis	***Twitter***
"synbio" OR "syn bio" OR "synthetic biolog!" OR "syn! bio!" OR "synth! life" OR "synth! gen" OR "DNA circuit" OR "eng! yeast" OR "bioCAM" OR "gene edit!" OR "biobrick" OR "bio brick" OR "gene drive" OR "gen! circuit" OR "syn! cell" OR "genet! syn!" OR "Template dna" OR "genom! syn!" AND NOT synapapsis AND NOT synaposes AND NOT sync AND NOT synagogue AND NOT "synap!" AND NOT general AND NOT syndrome AND NOT genesis AND NOT synageva AND NOT "genes that drive" AND NOT "English yeast" AND NOT "gentle circuit" AND NOT "synaptic" AND NOT "synchron!" AND NOT synovial AND NOT syndicate AND NOT "general!" AND NOT "generation circuit" AND NOT syngenta AND NOT synod AND NOT genesee AND NOT synch AND NOT synsorb	"syn! bio!" "syn! gen!" "Synthetic Biology" "synbio" "synthetic bio" "synth biology" "synth bio" "syn biology" "synthetic life" "synth life" "syn life" "syntheticbiology" "bioengineering" "engineered biology" "engineering biology" "Synthetic biologist" "synthetic genome" "syn genome" "living foundry" "living foundries" "engineered bacteria" "engineering bacteria" "DNA circuit" "engineered yeast" "bioCAM" "gene editing" "gene editing" "biobrick" "bio brick" "bio brick" "gene drive" "crispr" "biological part" "biological parts" "genome design" "genetic circuit" "synthetic cell" "synthetic genome" "genome synthesis" "gene synthesis" "Template dna" "genome assembly" "genetic oscillator" "PCR amplification" "synthetic riboswitch" "template dna"

Twitter Census Procedure

Based on the keyword list, and using a hybrid human/computer content analysis methodology based on that outlined by Su et al. (Su et al., 2017), the automated nonparametric content analysis software used for this study (Crimson Hexagon Forsight) pulled a random series of tweets from public *Twitter* content. During the initial software training period, the lead author of the study used the software to sample and code randomly selected tweets into “on-topic” and “off-topic” categories (Table 2.3). Tweets in the “off-topic” category were those which contained words included in the keyword search list but used out of context for synthetic biology. These tweets were then randomized and sent to two other trained coders along with a set of coding guidelines. Only those tweets that achieved 100 percent independent agreement among coders were included in the final software algorithm (Table 2.3).

Table 2.3: Sample coded tweets

Category	Tweet
On Topic	Science News: **Genetically Engineered** Bacteria can save lives! T @GMWatch "to put a natural label on **#synbio** products is dishonest and will devastate small farms" -Mexican vanilla farmer http://t.co/Jnu815CBf7 **Synthetic Biology** Begins To Deliver **#synbio** Basic Tools of **“Synthetic Biology”** Are Falling Into Place http://t.co/6ceaFsCE2E
Off Topic	Hate the **biological part** of psychology so much Free waxing session **@bioengineering** lab! SILKY SMOOTH! Omg it seem like I missed a whole year in **syn life**

Once programming was complete and verified through a trial run, the software identified and coded a census of synthetic biology keyword tweets from the *Twitter* firehose, which is an archive of all public tweets. A total of 289,905 tweets containing synthetic biology-related keywords were collected, of which 251,602 qualified as valid synthetic biology-related tweets, and 198,881 of the valid tweets were geotagged. Geographic locations were provided by the software and derived from a combination of geo-tagged coordinates from mobile devices, and other attributes such as user profiles, biographic information, time zones, languages and content of tweets. A total of 76,911 *Twitter* tweets originated from the United States and 27,656 originated from the United Kingdom. After accounting for population, the United Kingdom had a significantly higher rate of synthetic biology-related keyword tweets, with 435.53 per 100,000 residents as compared to 241.18 per 100,000 residents in the United States.

Time Series Analysis Procedure

Once a census of synthetic biology-related keyword tweets and newspaper articles were collected, attention turned to identifying potentially causal relationships between daily volume of synthetic biology keyword tweets and daily volume of synthetic biology coverage in print newspapers. The challenge in identifying relationships between social networking site posts and coverage in individual newspapers is that these individual variables likely influence one another. Leading newspapers report issues which are picked up by smaller newspapers (Golan, 2006; Groshek & Groshek, 2013; McCombs, 2005), which prompt individuals, particularly those with issue-related influence or interest, to post relevant messages on social networking sites that may garner attention and coverage from media entities (Groshek & Groshek, 2013; Meraz, 2011; Parmelee, 2013). Because of this, presumptively declaring one medium or entity independent introduces bias into the analysis; therefore, analysis should not contain a priori assumptions about the influence of one variable over another. In order to avoid this our analysis used vector autoregression (VAR).

VAR is a type of multivariate time series analysis often used in econometrics where complex relationships between many variables require a model that can estimate intertemporal linear dependencies across various time lags. The goal of VAR is to identify the extent to which each variable in the model influences or forecasts the values of all other individual variables in the model. For this study, VAR is preferable to structural equation modeling because it does not require a priori knowledge of which variables exert influence on others as VAR treats all variables symmetrically. VAR assumes that the value of an individual variable is a linear function that is autoregressive and related to past lags of itself as well as past lags of other variables, effectively making each item a dependent variable in one equation and an independent variable in others (Holden, 1995; Lautman & Pauwels, 2009; Vliegenthart, 2014; Zivot & Wang, 2006). Additionally, VAR does not assume a causal direction between variables and allows us to determine the size and delay of any interdependent effect of one variable on another by sequentially adding time lags as the model is developed and improved (Holden, 1995; Vliegenthart, 2014).

However in order for a time series to qualify for proper use of VAR it must be stationary, which is typically confirmed using a Dickey-Fuller test. Once qualified, the data is fit to several iterations of the VAR model, and the final model is chosen based on relative quality assessed by comparing and choosing the version with the lowest value of Akaike's Information Criteria (AIC) test. The selected model is then subject to two additional post-hoc tests. Hannan and Quinn information criteria (HQIC) and Schwarz's Bayesian information criterion (SBIC) tests are used to determine the optimal number of time lags. For this analysis, it was determined that a VAR using six lags for the United States data and seven lags for the United Kingdom data were optimal, where each lag equals one day.

Relationships between variables discovered in VAR are subject to post hoc Granger causality testing in order to determine the joint significance of the other variables, including dependent variable lags. Variable X is said to Granger-cause variable Y if past values of X forecast values of Y above and beyond what is predicted by the past values of Y by itself (Lautman & Pauwels, 2009). Granger causality tests do not indicate direction of a response, therefore variables are plotted onto impulse response frequency (IRF) graphs using a moving average over time to visually represent the response of one variable to an impulse of another variable, which then allows us to examine the speed and magnitude of that response and compare it to others in the same series (Soroka, 2002). Although VAR is frequently used as a forecasting tool, this study uses it solely for post hoc analysis to describe the dynamic behavior of multiple variables that may have causal relationships (Zivot & Wang, 2006). In this study the VAR and its related tests were conducted on STATA.

Results

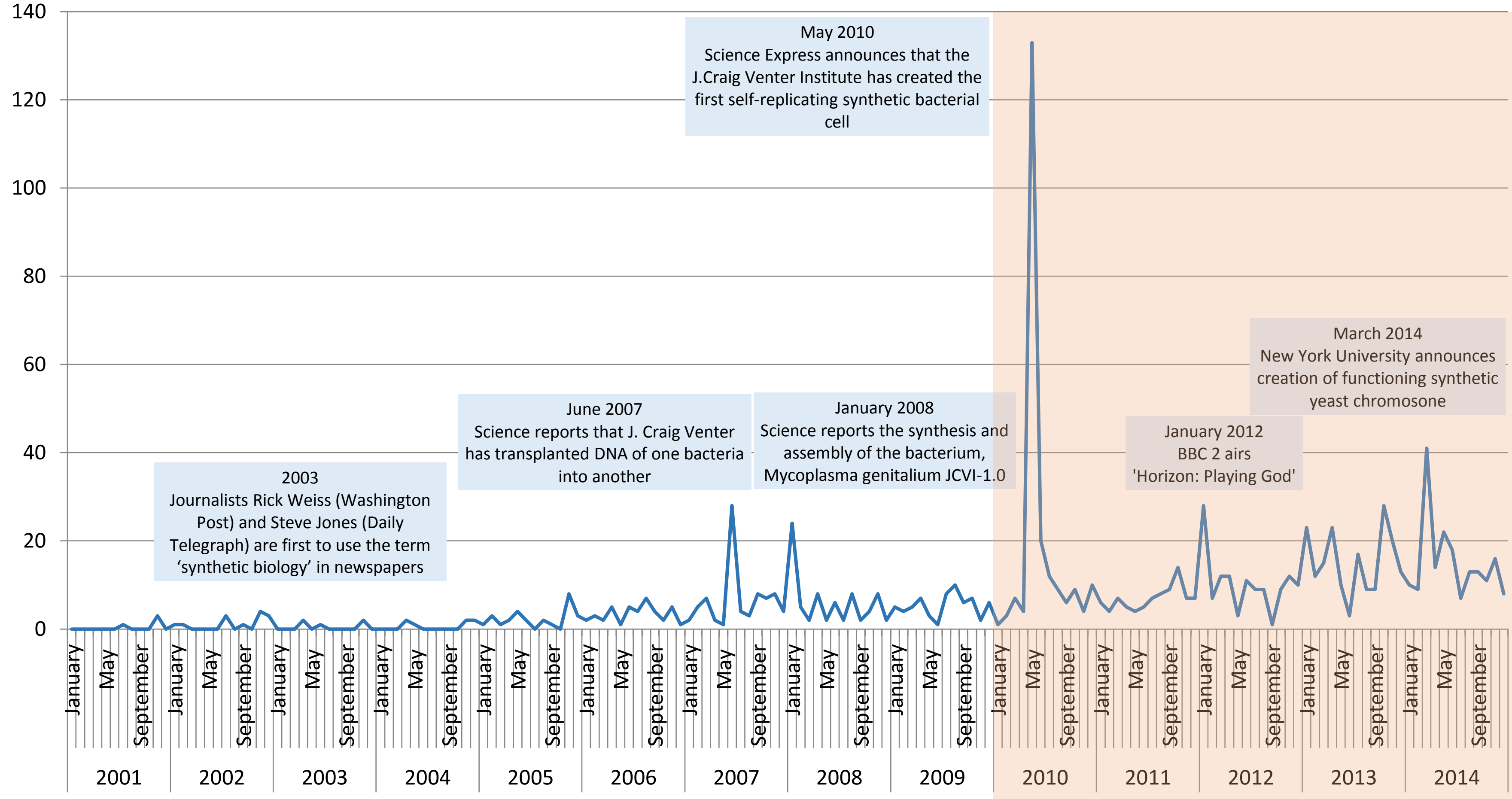
Newspaper Volume: Pre-Study Period

Although the study period is limited to 1 January 2010 through 31 December 2014, a search of the Lexis Nexis database from 1912 forward was conducted in order to ensure the final result was as accurate as possible, and also to better understand how technology-specific language and news coverage evolved since the first mention of the term *synthetic biology.* A total of 1,158 English-language newspaper articles about, or containing references to, synthetic biology were authored by more than 479 journalists and published in 288 different newspapers from 1912 through 2014. The first appears in 1981 and the last in December 2014. Figure 2.1 depicts synthetic biology news coverage beginning in the first year of this century, 2001, through the end of the study period, 31 December 2014.

The specific language related to synthetic biology does not appear in this collection of English-language newspapers until 1981 when a February 2 *New York Times* article on a biotechnology pact in Canada refers to "recombinant DNA, or gene splicing; DNA ***synthesis***; cell fusion and hybridoma technologies," (emphasis author) all technologies incorporated by synthetic biology (UPI, 1981). Still, the specific term *synthetic biology* was not used in this 1981 article.

Coverage related to synthetic biology is sparse throughout the 1980s and 1990s. Newspaper articles identified using the Lexis Nexis search string (Table 2.2) during these decades refer to 'synthetic cells,' ‘synthetic DNA’ or 'genetic synthesis’ when reporting innovations that could eventually fall under the umbrella of synthetic biology, but fall short of using the explicit term. Although coverage related to the subject in 1999 and 2002 briefly exceeds 10 articles published, the first uses of the term *synthetic biology* appear in separate articles written by Steve Jones (*Daily Telegraph*) and Rick Weiss (*Washington Post*) in 2003. Jones uses the term in a long-form piece published in the April 16, 2003 edition of the *Daily Telegraph* (London) titled “DNA: More questions than answers” (Jones, 2003). Later that year Weiss refers to *synthetic biology* in a 2 November 2003 *Washington Post* article, titled "Researchers Create Virus in Record Time; Organism Not Dangerous to Humans," which describes the synthetic replication of 'phiX', a virus that infects bacteria (Weiss, 2003). Eight newspaper articles use the term in 2004, and in 2005 newspaper reports using the term 'synthetic biology' begin to gain momentum and grow steadily. By 2006, the term had been widely adopted and used in newspaper reporting to describe the new field of synthetic biology and work of a new group of scientists called synthetic biologists (Figure 2.1). Notable months include June 2007, when the J. Craig Ventner Institute announced it transplanted the DNA of one bacteria into another; January 2008 when the journal Science reports the synthesis and assembly of the bacterium Mycoplasma genitalium JCVI-1.0; May 2010 when the J. Craig Ventner Institute announces the creation of the first self-replicating synthetic bacterial cell; January 2012 when the BBC airs Adam Rutherford's synthetic biology documentary *Playing God*; and March 2014 when New York University announced the creation of a functioning synthetic yeast chromosome (Figure 2.1).

Figure 2.1: Monthly volume of newspaper articles about, or referring to, synthetic biology, 2001 through 2014, all English-language newspapers. Study period highlighted in red.



Newspaper Volume: Study Period

A total of 297 (daily average = 0.16; SD=1.19) English-language newspaper articles about, or containing references to, synthetic biology were published by print newspapers in the United Kingdom, and 221 (daily average=0.12; SD=0.82) were published in the United States during the study period (Figure 2.2a and 2.2b). English-language newspaper coverage of synthetic biology hit its zenith in both countries in May 2010 after the J. Craig Ventner Institute announced the creation of the first self-replicating synthetic bacterial cell; during this month, 42 synthetic biology related newspaper articles were published in United Kingdom and 22 were published in the United States. Other notable months include January 2012 when the BBC airs Adam Rutherford's synthetic biology documentary *Playing God,* and 23 synthetic biology related articles were published in the United Kingdom; and March 2014 when New York University announced the creation of a functioning synthetic yeast chromosome, and 13 synthetic biology articles were published in the United Kingdom and 11 in the United States.

Tables 2.4 lists the top reporters by volume for synthetic biology, exclusive of medium. Although this study focuses on synthetic biology news coverage in the United States and the United Kingdom, Table 2.4 makes it clear that English-language newspaper reporters in Canada, Australia, Ireland, India and Singapore contributed a significant number of reporting over the study period, all of which may have been visible on *Twitter* when users searched using synthetic biology keywords.[1]

Table 2.5 lists the top newspapers for synthetic biology coverage by circulation and number of articles published. Synthetic biology-first tier newspapers were selected from this list

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[11]Preliminary tests of effects of extra-national newspaper reporting on the volume of keyword tweets in either the United States or United Kingdom found no observable, statistically significant effects.

according to guidelines established earlier which, for the purpose of this study, were required to be published daily, distributed nationally and print a minimum of five articles, for an average of at least one per year, during the study period. All other newspaper coverage of synthetic biology was included in the variable "synthetic biology-second tier newspapers," enabling the study to capture all coverage of synthetic biology during the study period. For the United States, The *New York Times*, *Washington Post* and *USA Today* qualified as synthetic biology-first tier newspapers for this study. In the United Kingdom, the *Daily Telegraph*, *Guardian*, Independent and *The Times* qualified as synthetic biology-first tier newspapers for this study.

Table 2.4: Top 25 journalists by volume for synthetic biology articles printed in English-language newspapers between 1912 and 2014.

Author	Title	Total Articles	Newspaper	Country
Steve Connor	Science Editor	31	The Independent	United Kingdom
Ian Sample	Science Editor	18	The Guardian	United Kingdom
Andrew Pollack	Science Reporter	15	The New York Times	United States
Lisa M. Krieger	Science/Health Reporter	14	San Jose Mercury News	United States
Margaret Munro	Science/Health Reporter	13	Windsor Star	Canada
Ian Hoffman	Staff Writer	8	Inside Bay Area News	United States
Deborah Smith	Science Editor	7	Sydney Morning Herald	Australia
Dick Ahlstrom	Science Editor	7	The Irish Times	Ireland
Mark Henderson	Science Editor	7	The Times	United Kingdom
Robert S. Boyd	Science/Technology Reporter & Bureau Chief	7	The McClatchy Company	United States
Roger Highfield	Editor	7	New Scientist	United States
Adam Rutherford	Science writer	6	The Guardian	United Kingdom
Nicholas Wade	Science writer	6	The New York Times	United States
Aloh Jha	Science writer	5	The Guardian	United Kingdom
Dinesh C. Sharma	Science writer	5	Mail Today	India
Andy Ho	Op-ed columnist	4	The Straits Times	Singapore
Carol Cadwalladr	Features writer	4	The Observer	United Kingdom
Dan Vergano	Science Writer	4	USA Today	United States
David Chater	Broadcast journalist	4	The Times	United Kingdom
Faye Flam	Science writer	4	Philadelphia Inquirer	United States
James Randerson	Science correspondent	4	Canberra Times	Australia
Jonathan Leake	Science & environment editor	4	The Sunday Times	United Kingdom
Peter Ranscombe	Science writer	4	The Scotsman/ Scotland on Sunday	United Kingdom
Rick Weiss	Science writer (Former), Fellow at Center for American Progress (Current)	4	Washington Post	United States
Tom Spears	Science reporter	4	Ottawa Citizen	Canada

Source: Lexis Nexis *Note Vivek Wadhwa, Arthur & Toni Rembe Rock, Center for Corporate Governance, Stanford University, contributed four opinion editorials to the St. Paul Pioneer Press but are not included in the list of journalists they were guest contributors.

Table 2.5: Top newspapers for synthetic biology coverage by circulation and number of articles published 1 January 2010 through 31 December 2014

Newspaper	Country	2010 Circulation	2014 Circulation	Synthetic Biology Articles
The Guardian	UK	302,285	207,958	47
New York Times	US	876,638	2,134,150	43
The Independent	UK	66,576	185,815	29
The Observer (Sunday Only)	UK	354,565	225,474	20
San Jose Mercury News (Regional)	US	477,592	523,725	24
The Times	UK	508,250	384,304	16
Washington Post	US	545,345	377,436	16
The Daily Telegraph	UK	691,128	544,546	16
Independent Print/Extra (Weekly)	UK	n/a	63,505	11
The Sunday Times (Sunday Only)	UK	1,144,929	817,642	11
The Scotsman (Regional)	UK	45,352	29,452	7
USA Today	US	1,830,594	4,139,380	6

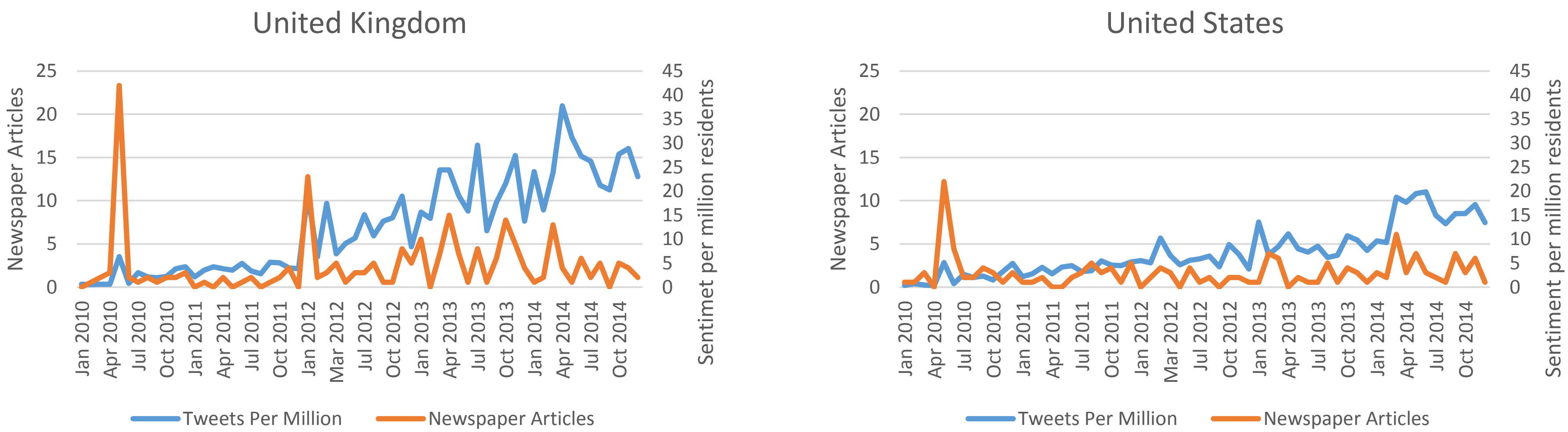
Source: LexisNexis

Twitter Volume

A total of 76,911 synthetic biology keyword tweets were posted in the United States and 27,656 were posted in the United Kingdom over the five year study period for an average of 42.12 (SD=52.02) tweets per day in the United States and 15.15 (SD=20.94) tweets per day in the United Kingdom. Although the average daily volume of synthetic biology keyword tweets was greater in the United States than the United Kingdom, the per capita volume was reversed. Using 2014 population tallies, the United Kingdom posted a higher average daily volume per capita than the United States, 0.23 (SD=0.32) tweets per million U.K. residents as compared to 0.13 (SD=0.16) tweets per million residents in the U.S., although the number was very small in each country when considered on a per capita basis. Despite the tiny average daily volume of synthetic biology keyword tweets per million residents, the conversation on *Twitter* would have been observable for those seeking information about the technology on *Twitter*.

Figure 2.2 uses monthly volume to illustrate the trend in synthetic biology subject print newspaper coverage and synthetic biology keyword tweets over the study period. The sharp increases in response to the May 2010 announcement by the Ventner institute is clearly observable in each graph, along with the increase related to the United Kingdom airing of *Playing God.* At face value, it appears as if *Twitter* sentiment is related to newspaper coverage, but perhaps more closely in the United Kingdom than the United States (Figure 2.2).

Figure 2.2: Monthly volume synthetic biology keyword sentiment on Twitter per million residents and synthetic biology subject print newspaper articles published between January 1, 2010 and December 31, 2014.



Newspaper articles: N=297 United Kingdom; N=221, United States. Synthetic biology keyword tweets: N=27,656 United Kingdom; 76,911 United States.

The initial research question examined intermedia agenda setting effects between print newspaper coverage and synthetic biology keyword tweets. The first hypotheses predicted that synthetic biology keyword tweets would be Granger-caused by print newspaper coverage in the United States (H1a) and the United Kingdom (H1b). Post hoc Granger Wald causality testing revealed that over the five-year study period, *USA Today* was the only print newspaper that Granger-caused overall synthetic biology keyword tweet sentiment in the United States (Table 2.5). Although H1a was only partially supported, the *Twitter* response to a one-story increase in synthetic biology coverage in *USA Today* was considerable given the daily U.S. average of 42.12 (SD=52.02) synthetic biology keyword tweets (Figure 2.2).

Applying the same test to the United Kingdom data, we found that synthetic biology news coverage in the *Times*, the *Daily Telegraph* and synthetic biology-second-tier newspapers Granger-caused synthetic biology keyword tweets (Table 2.6), but synthetic biology news coverage in the *Guardian* and *Independent* did not. Therefore, H1b was largely supported. Looking at the comparative responses in each country, there was partial support for the hypothesis that newspaper coverage of synthetic biology Granger-caused an increase in synthetic biology keyword tweets in the United States, but the response in the United Kingdom was more universal as it involved more newspapers (Table 2.6 and Table 2.7).

Table 2.6: Granger causality test Chi-square and vector autoregression (VAR) results predicting volume of tweets and news coverage for synthetic biology January 1, 2010 through December 31, 2014 in the United States.

	All Twitter Sentiment	New York Times	Washington Post	USA Today	Second Tier
All Twitter	---	13.22*	---	13.92*	15.29*
New York Times	---	---	---	---	28.10***
Wash Post	---	---	---	---	---
USA Today	17.20**	---	---	---	---
Second Tier	---	16.21*	---	---	---
ALL⁺	---	37.56*	---	---	57.33***

All variables autoregressive. *P≤.05; ** P≤.01; *** P≤.001; Degrees of freedom=6; ⁺ Degrees of freedom=24

Table 2.7: Granger causality test Chi-square and vector autoregression (VAR) results predicting volume of tweets and news coverage for synthetic biology January 1, 2010 through December 31, 2014 in the United Kingdom.

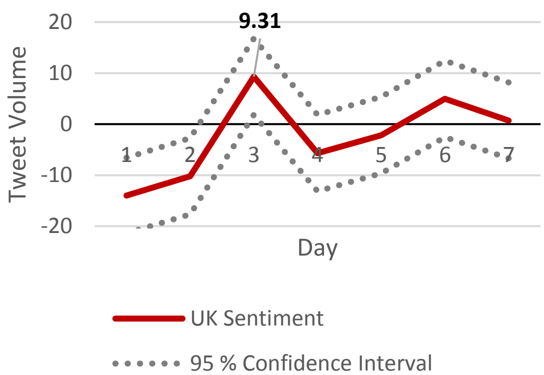
	All Twitter Sentiment	Daily Telegraph	Guardian	Independent	The Times	Second Tier
All Twitter	---	32.29***	---	51.56***	26.61***	23.63**
Daily Telegraph	15.85*	---	---	26.22***	25.62***	17.78*
Guardian	---	22.81***	---	15.94***	31.20***	48.92***
Independent	---	---	---	---	---	---
The Times	32.28***	26.04***	---	39.00***	---	25.30***
Second Tier⁺	46.36***	127.52***	33.74***	53.46***	84.75***	---
ALL	116.02***	319.56***	131.76***	323.76***	184.62***	128.79***

All variables autoregressive. *P≤.05; ** P≤.01; *** P≤.001; Degrees of freedom=7; ⁺ Degrees of freedom=35

Since Granger-Wald causality testing only determines the presence, but not the magnitude or direction of the effect, each statistically significant effect of interest was graphed as an Impulse Response Frequency (IRF) graph. Figures 2.3a through 2.3c depict *Twitter* response to a one-story impulse in synthetic biology news coverage in the *Times* (Figure 2.3a), the *Daily Telegraph* (Figure 2.3b) and synthetic biology-second-tier newspapers (Figure 2.3c) in the United Kingdom. Figure 2.3d depicts *Twitter* response to a one-story impulse in synthetic biology news coverage in *USA Today* in the United States.

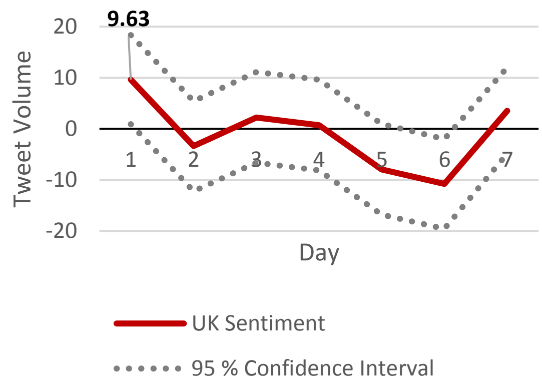
Figure 2.3a - 2.3d: Synthetic biology keyword tweet response to impulse of one story on synthetic biology in statistically significant newspapers in the United Kingdom (2.3a-2.3d) and United States (2.3d)

Figure 2.3a: Twitter response for synthetic biology keyword tweets to an impulse of one story about synthetic biology in the Times



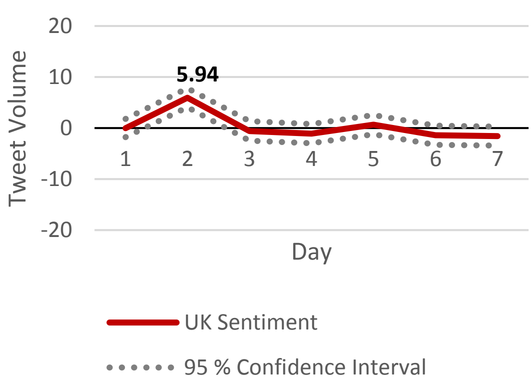
January 1, 2010 through December 31, 2014
Daily average=15.12 (SD=20.94)

Figure 2.3b: Twitter response for synthetic biology keyword tweets to an impulse of one story in the Daily Telegraph



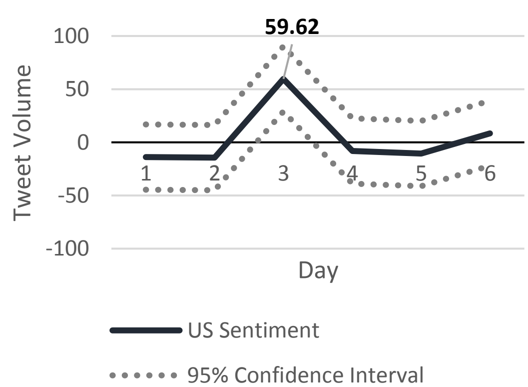
January 1, 2010 through December 31, 2014
Daily average=15.12 (SD=20.94)

Figure 2.3c: Twitter response for synthetic biology keyword tweets to an impulse of one story about synthetic biology in second tier newspapers



January 1, 2010 through December 31, 2014
Daily average=15.12 (SD=20.94)

Figure 2.3d: Twitter response for synthetic biology keyword tweets to an impulse of one story about synthetic biology in second tier newspapers

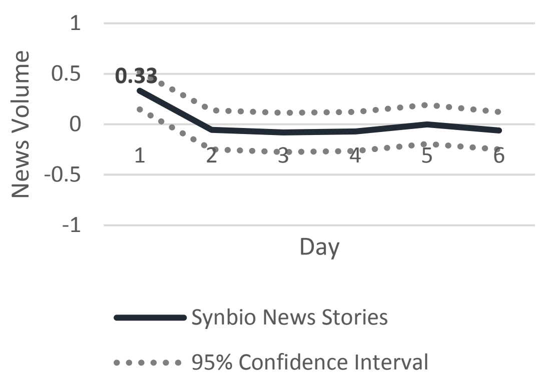


January 1, 2010 through December 31, 2014
Daily average=41.12 (SD=52.02)

I was also interested in the possibility that the volume of tweets with synthetic biology keywords would forecast, or Granger-cause, newspaper coverage for synthetic biology. Tests found that H2a, which examined coverage in the United States, was mostly supported (Table 2.6) as daily volume of synthetic biology keyword tweets Granger-caused print newspaper coverage in the *New York Times*, *USA Today*, and synthetic biology-second tier newspapers, but not the *Washington Post*. Because the predictive value of a single tweet is miniscule, newspaper response to *Twitter* in the in the United States was graphed on an impulse of 1,350 synthetic biology keyword tweets to reflect the maximum daily collected in the United States during the study period (Figure 2.4a – 2.4c).

Figure 2.4a - 2.4c: Newspaper response to impulse of daily maximum number of tweets observed in the United States during the study period

Figure 2.4a: Impulse response frequency graph depicting New York Times response to an impulse of 1,350 synthetic biology keyword tweets in the United States

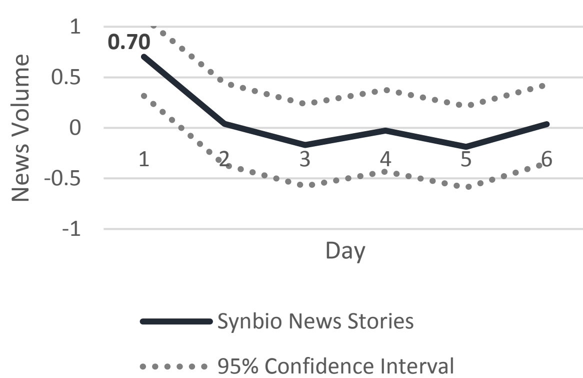


January 1, 2010 through December 31, 2014;
Daily average= 0.12 (SD=0.82)

Figure 2.4b: Impulse response frequency graph depicting USA Today response to an impulse of 1,350 synthetic biology keyword tweets in the United States

January 1, 2010 through December 31, 2014;
Daily average= 0.12 (SD=0.82)

Figure 2.4c: Impulse response frequency graph depicting response in U.S. second tier newspaper response to an impulse of 1,350 synthetic biology keyword tweets in the United States

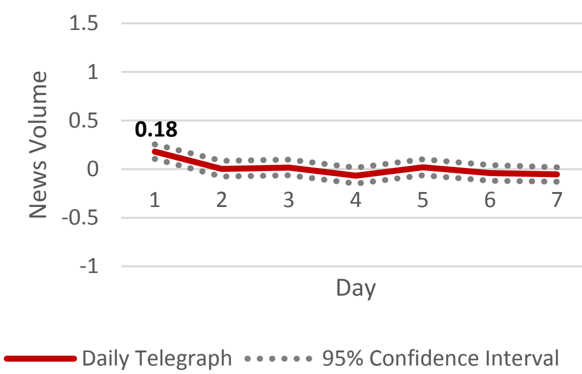


January 1, 2010 through December 31, 2014;
Daily average= 0.12 (SD=0.82)

H2b was also robustly, but not fully, supported as overall volume of sentiment for synthetic biology keyword tweets Granger-caused synthetic biology coverage in the *Daily Telegraph, Independent*, the *Times* and synthetic biology-second-tier newspapers (Table 2.7), but not the *Guardian*. Again, because the predictive value of a single tweet is miniscule, newspaper response to *Twitter* in the United Kingdom was graphed on an impulse of 274 synthetic biology keyword tweets to reflect a the maximum daily volume collected in the United Kingdom during the study period (Figures 2.5a-2.5c).

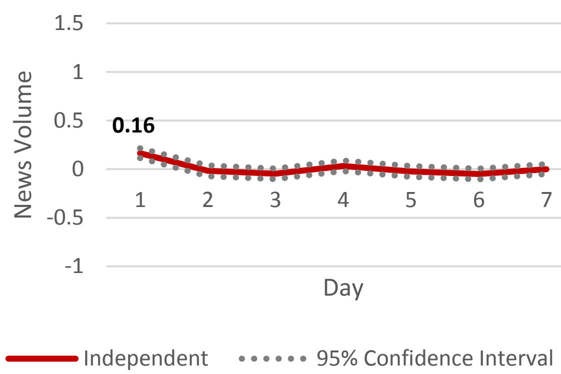
Figure 2.5a - 2.5c: Newspaper response to impulse of daily maximum number of tweets observed in the United Kingdom during the study period

Figure 2.5a: Impulse response frequency graph depicting response in the Daily Telegraph to an impulse of 274 synthetic biology keyword tweets in the United Kingdom



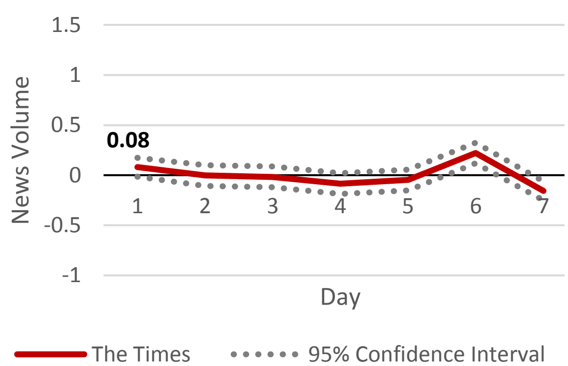
January 1, 2010 through December 31, 2014
Daily average=0.16 (SD=1.19)

Figure 2.5b: Impulse response frequency graph depicting response in the Independent to an impulse of 274 synthetic biology keyword tweets in the United Kingdom



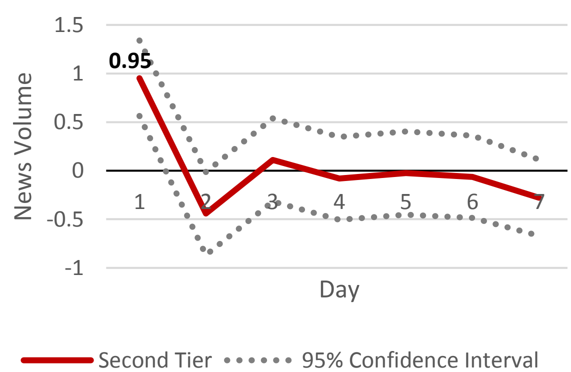
January 1, 2010 through December 31, 2014
Daily average=0.16 (SD=1.19)

Figure 2.5c: Impulse response frequency graph depicting response in the Times to an impulse of 274 synthetic biology keyword tweets in the United Kingdom



January 1, 2010 through December 31, 2014
Daily average=0.16 (SD=1.19)

Figure 2.5d: Impulse response frequency graph depicting response in second tier newspapers to an impulse of 274 synthetic biology keyword tweets in the United Kingdom



January 1, 2010 through December 31, 2014
Daily average=0.16 (SD=1.19)

Chapter Discussion

The goal of this study was to examine the agenda setting effects of synthetic biology keyword tweets and synthetic biology newspaper coverage on one another in two separate countries with similar citizen access to the Internet, similar scientific research climates and similar cultures ensuring freedom of press. There were clear differences in the ability of news coverage to set the agenda for synthetic biology discourse on *Twitter*, both on a country level and across individual newspapers. The most significant difference is in the broad ability of newspapers in the United Kingdom to Granger-cause synthetic biology keyword tweets in the U.K. as compared to the limited effects of news coverage in the United States. There are a few possible explanations. First, in terms of absolute volume of newspaper stories about synthetic biology, and also in terms of stories reported per capita, coverage was greater in the United Kingdom than in the United States. More coverage results in more discourse, which is evident in the data from the United Kingdom; less coverage results in less discourse, which is evident in the data from the United States. This underscores the critical role news coverage of science plays in public deliberation surrounding emerging science and technology issues. If the public is meant to discuss these issues, then those issues must be presented in the media.

Second, the BBC documentary *Playing God* aired in the United Kingdom in January 2012 and coincided with a sharp increase in newspaper articles about synthetic biology, many of which were related to the documentary itself. Although we were unable to include broadcast reports in this study as archives are incomplete, it is reasonable to say that newspaper reporting related to the airing of *Playing God* had a lasting effect on *Twitter* discourse about synthetic biology in the United Kingdom, indirectly if not directly. Again, this supports the notion that media coverage of emerging science and technology prompts public discourse, and absence of coverage is detrimental to public discussion.

A third explanation may be the base rate at which the topic is discussed on *Twitter* in each country. Synthetic biology is discussed more widely on *Twitter* and covered more frequently by newspapers in the United Kingdom than in the United States. This trend in the United Kingdom becomes apparent in March 2012 when the number of synthetic biology keyword tweets begins to diverge from the number of synthetic biology newspaper articles (Figure 2.1). Up until this point, *Twitter* discourse about synthetic biology in the United Kingdom appears to vary more closely with newspaper coverage. However, in January of 2012, roughly concurrent with the airing of *Playing God*, and then four to six weeks after the airing, two sharp increases in synthetic biology discourse occur and the topic appears to take on a life of its own as seen when the trend line between newspaper coverage and discourse begin to diverge (Figure 2.1). Closer examination of the tweets posted during early 2012 with particular attention to the sources of those tweets might indicate that an issue public is formed around synthetic biology discourse on *Twitter* during this time period, possibly prompted by media coverage of the issue. Additional research should look closely at this time period.

The more surprising and important finding from this study was the extent to which daily volume of synthetic biology keywords set the agenda for newspaper coverage of the topic for the *New York Times*, *USA Today* and synthetic biology-second tier newspapers in the United States, along with the *Daily Telegraph*, the *Independent*, the *Times* and synthetic biology-second tier newspapers in the United Kingdom (Table 2.6 and Table 2.7). This strongly suggests that journalists at these newspapers are attending to *Twitter* for synthetic biology news, either in whole by following synthetic biology as a subject, or as part of a larger effort to cover science by attending to accounts of specific scientists, peer-reviewed journals or fellow science-interested mass media sources. More importantly, this finding challenges the notion that print newspapers, even elite newspapers like the *New York Times* or the *Guardian*, operate as the chief agenda setters for emerging science and technology topics.

Impulse response frequency (IRF) graphing indicated that synthetic biology keyword tweet volume had the strongest agenda-setting effect on synthetic biology-second tier newspapers in both the United Kingdom and the United States, although the effect of tweet volume on the *New York Times* was also notable. IRF graphing also indicated that the size of agenda setting effects of synthetic biology keyword tweets were smaller for the *Daily Telegraph,* the *Independent,* the *Times* and *USA Today*, but we note that the study used the maximum number of tweets observed in one day as the impulse, which was very small, only 1,350 in the United States and 274 in the United Kingdom. This suggests that a larger, but not unrealistic, impulse in the volume of synthetic biology keyword tweets on a single day, perhaps 4,000 in the United States or 1,500 in the United Kingdom, could Granger-cause increases in newspaper coverage that would equal or surpass a one-story threshold that might indicate synthetic biology keyword tweets could be a sole forecast variable, rather than one of several variables forecasting news coverage. Still, the effect is there, albeit small, and future research should track sentiment and news coverage to see if this effect remains as the technology continues to develop.

The presence or absence of synthetic biology news in particular newspapers during the study period is also worth noting, especially in the United States. American newspapers whose editorial pages tend to be conservative – i.e. the Chicago Tribune or widely-read conservative Murdoch-owned American newspapers including the Wall Street Journal and New York Post – did not publish sufficient news about synthetic biology to be considered synthetic biology-first tier newspapers as defined in this study. In comparison, synthetic biology news coverage in synthetic biology-first tier newspapers in the United Kingdom was distributed more widely across the political spectrum. Based on editorial pages and election endorsements, the *Daily Telegraph* could be considered conservative, the *Guardian* as liberal, the *Independent* as center-left and the *Times* as historically moderate, given the variation in its endorsements made by the *Times* over the past decades, but center-right since purchase by Murdoch-owned News UK (see (Croucher, 2015; The Guardian, 2010). The result is that news users of all ideological stripes in the United Kingdom may have had a similar chance of encountering synthetic biology news in their daily news diet, but the chance of American conservatives encountering the same is less likely as there was less coverage of the topic in conservative newspapers. Of course this presumes that individuals are attending to media which are ideologically consistent with their own political views, which is a phenomena supported by research (Iyengar & Hahn, 2009), and one that will be discussed in the next study. Although conservatives in the United States may not be intentionally filtering synthetic biology news from their standard diets, such a filter may naturally, but unintentionally, be the result.

I note some limitations to this study. The primary interest was in identifying intermedia agenda-setting relationships between *Twitter* and print newspaper coverage, rather than agenda-building activities of sources and news outlets. Based on this interest the study omitted press releases, scientific papers, online-only newspapers and other information subsidies or sources of news that may have prompted both tweets and newspaper coverage. The effects of television and radio coverage of synthetic biology were also not included in this research as Lexis Nexis archives for broadcast transcripts and re-runs of shows are not as complete as its archiving of newspaper coverage, prompting the exclusion of broadcast as a variable. Future work could explore these sources. Additionally, it is likely that online news sites or social networking sites other than *Twitter* play a role in disseminating news, and this was not captured.

An additional limitation is the inclusion of tweets from all sources – media and laypersons – as a single variable. It is almost certain that journalists and newspapers posted tweets promoting synthetic biology-related news stories in their outlets; the existence of these tweets prompts questions regarding their unique effect on the overall model as compared to the effect of tweets by non-media persons or entities. Given the number of journalists and newspapers identified over the study’s five-year period, the data required to answer this question alongside the research questions addressed by this study would be unwieldy for a single paper. Instead, a follow-up study using this paper as a starting point, but narrowing the number of newspapers as variables, should specifically address the question "How did media tweets affect the intermedia agenda setting effects of synthetic biology keyword tweets on synthetic biology-related newspaper coverage?"

Finally, we acknowledge that the *Twitter* keyword list, while diligently and thoughtfully constructed, cannot account for every variation in spelling, terminology or slang related to synthetic biology. Therefore, although we collected a census of keywords in our list, there is always the possibility that relevant tweets remained uncollected.

Chapter Conclusion

The goal of this paper was to establish statistical evidence for bi-directional intermedia agenda-setting effects between print newspaper coverage of, and *Twitter* discourse about, synthetic biology over a five-year period in which a number of breakthroughs occurred in the field. By using vector autoregression (VAR) and post-hoc Granger-Wald causality testing, we were able to first establish evidence that intermedia agenda-setting effects do occur, though these effects vary by newspaper. Next, by using impulse response frequency (IRF) graphs we were able to visualize the direction and duration of newspaper coverage responses to *Twitter* and *Twitter* responses to newspaper coverage. We concluded that the volume of synthetic biology keyword tweets does indeed set the agenda for news coverage for all but two of the nine newspaper variables included in this study. The intermedia agenda setting effect we observed was not uni-directional, as print newspaper coverage also set the agenda for *Twitter* discourse of synthetic biology within certain parameters. By comparing results across two countries with free presses, liberal citizen access to the Internet and similar science research cultures, we were able to discern the effects of robust news coverage on *Twitter* discourse.

Although intermedia agenda setting effects are well trodden territory for communication researchers, the results presented here, and methods used to obtain these results, provide new insights into the ways in which social networking sites and print newspaper shape one another's agendas for emerging science and technology topics. Notably, the study occurs at a point in time when print newspaper coverage of science topics is declining and coverage of synthetic biology is scant. Despite this, I was able to uncover clear evidence supporting our conclusions.

Beyond the contribution to the intermedia agenda setting literature, this study demonstrates the scant amount of coverage received by synthetic biology over the study period, which is important to the context of this dissertation. With a daily average of 0.16 (SD=1.19) synthetic biology newspaper articles in United States newspapers, or one synthetic biology newspaper article every 6.25 days, in combination with a daily average of 42.12 (SD=52.02) synthetic biology keyword tweets, it would be difficult to imagine our hypothetical median-ager encountering news about this topic by chance during the study period. To that end, it is worth asking how she arrives at attitudes about, and decisions related to, synthetic biology if she isn't encountering a sufficient amount of information on the topic.

Indeed, as the next study illustrates, attention to media channels is not evenly distributed among all people, and individuals within certain demographic groups attend to some media channels more than others. As might be reasonably assumed, newspapers and social networking sites are not used universally, nor is information about emerging technologies attended equally by all Americans. If our imaginary median-ager is intensely interested in the topic, and attends to the newspapers used in this study or synthetic biology keywords on *Twitter*, then she may be sufficiently informed. However, if she isn't particularly interested in the topic, or uses newspapers or media that haven't covered the topic very often – such as the Chicago Tribune or Wall Street Journal, among other relatively widely-read newspapers – then she may not even be aware that such a thing as synthetic biology exists.

Chapter 3. Champions, Skeptics & Cynics: Segmenting American Science Audiences

The previous chapter examined the relationship between newspaper coverage of synthetic biology volume of synthetic biology keyword tweets in the United States and United Kingdom. Among other findings, the study highlighted the scant amount of news coverage devoted to synthetic biology in the United States, averaging only one newspaper article every 6.25 days and tilted towards newspapers with liberal editorial leanings, at least at the synthetic biology-first-tier level. Given the small average number of daily synthetic biology tweets, 42.12 (SD=52.02), *Twitter* may not substantially ameliorate the effects of low information unless one is not just on the platform but specifically searches out the appropriate keywords, hash tags or users for this topic. The practical result of this landscape is that any one individual may not encounter enough synthetic biology news in their regular media diet to be informed about the topic.

Of course, the existence of the possibility that any one individual will encounter a synthetic biology-related newspaper story or synthetic biology-keyword tweet is partially premised on the assumption that these media outlets or social networking sites are either widely used, or their use is evenly distributed across populations in some way. In reality, attention to specific media outlets varies by age, political affiliation, devices used to access news and other factors (Mitchell, Gottfied, Barthel & Shearer, 2016). In other words, we cannot assume that either the presence of synthetic biology-related news or keyword tweets is substantially noticeable by all members of the public. Rather, it seems logical that synthetic biology information on specific media outlets, such as the *New York Times*, or social networking sites, such as *Twitter*, are more likely to be noticed by members of the public that have similar demographic profiles to the users of those media. Now that we know what the media landscape looks like for synthetic biology, let's examine who among the general public would be most likely to encounter synthetic biology-related newspaper stories or synthetic biology-related keyword tweets.

To put this in context, let's think once again about our hypothetical median age citizen. It's important to examine how she arrives at attitudes about, and decisions related to, synthetic biology if she isn't encountering a sufficient amount of information in the media, as the previous study indicates is likely. The literature on science communication provides strong evidence that her personal value predispositions, such as religiosity, conservative/liberal ideology and deference to science, influence her thinking related to emerging technologies. Additionally, if she is like the 81% of Americans that get at least some of their news from websites, apps or social networking sites (Pew, 2016), which are reliant on audience-centric filters, media-centric filters (Scheufele & Nisbet, 2012) and search algorithms (Pariser, 2011), then our median-ager may be receiving information that is largely consistent with what she is already exposed to, and not necessarily fed a diet of news that broadens her horizons or increases her chances of encountering new topics or opinions. This study explores how those predispositions can be used to segment individuals into subgroups that demonstrate strong statistical differences in demographics, science knowledge, media use and issue-related discussion networks and habits.

A Rationale for Science Segmentation in an Era of Polarization

The polarization of certain science topics is resulting in a public in which large numbers of individuals have established attitudes, preferences and behaviors toward science issues, such as climate change, evolution, and genetic modification of foods or vaccinations. In this communication climate, developing a single overarching message suitable for a diverse audience is expensive and impractical to the point where it may be impossible. Indeed, if an organization had the money and skill to develop and widely distribute a successful one-size-fits-all message, it still might not successfully break the filter bubbles that use algorithms to match our search results to our search history (Brossard & Scheufele, 2013) or match our social networking site feeds to previous "likes" while also allowing us to opt out of certain news streams (Pariser, 2011). A more pragmatic approach would be to create order within a heterogeneous audience by segmenting its members into homogeneous subgroups according to common characteristics that are relevant to a specific issue or purpose. This allows those interested in communicating about an issue the ability to focus scarce resources on critical audience segments (Choffray & Lilien, 1978) and tailor communication to the specific needs of that particular group with a focus on placing that communication in news outlets they are likely to use

A single, comprehensive overview of segmentation literature would be difficult as more than 2,700 studies have been authored on the topic, a significant number of which focus on statistical methods for segmenting audiences (Thoeni, 2014). However, audience segmentation has been used widely in commercial marketing (Kotler & Keller, 2013), social marketing (Allyson

Dooley, C. Jones, & Iverson, 2012), industrial marketing (Boejgaard & Ellegaard, 2010) and healthcare communication (Fogarty, Harrison, Jing, & Yip, 2014).

Despite its popularity, segmentation methodologies are sometimes haphazard and there is a need for a strong and sound social science approach to the topic. A 2008 review of empirical marketing segmentation studies based on the actual practice of firms that were published in academic journals found “a preponderance of exploratory and descriptive research designs; a heavy reliance on non-probabilistic sampling methods; relatively small sample sizes; lack of adequate psychometric assessment of the measures employed; and, with few exceptions, rather basic statistical analyses of the collected data,” (Foedermayr & Diamantopoulos, 2008). A limited number of studies reviewed utilized hypothesis tests and/or construction of confidence intervals, instead relying on descriptive statistics (Foedermayr & Diamantopoulos, 2008).

Segmentation and Science Issues

When compared to the volume of research published in marketing journals, there has been relatively little published on how standard approaches to segmentation can be applied to audiences surrounding science and technology issues. Although there are a substantial number of segmentation studies in health communication (See Kubacki et. al., 2017), these are typically aimed at interventions or behavior modification, which differs significantly from the goals of this dissertation. The issue of climate change is the exception to this rule and sufficiently similar to the goals of this dissertation to warrant comparison. Between 2010 and 2014, 19 principal investigators authored 25 studies on public perceptions of climate change using some form of segmentation (Hine et al., 2014). Consistent with the criticism of many marketing studies, 10 of the 25 papers reviewed by Hine et. al were based on non-probability samples, and five of the studies either used simple descriptive methods to identify segments or used unspecified methods for cluster analysis. Ward's Method hierarchical cluster analysis, K-means clustering and latent class analysis (LCA) were most often used by studies relying on more complex statistical methodologies (Hine et al., 2014).

Of the 15 studies using probability methods of data collection and established segmentation methodologies, the most influential have been led by the Yale Project on Climate Change Communication as part of their Global Warming's Six Americas segmentation. This research group's battery of 36 bases variables, defined as the specific variables that were used as the basis to segment individuals, assessing global warming and energy-related beliefs is thoroughly grounded in social science research. These studies have been replicated by the center a number of times and has also been deployed by other research groups on large national samples in Australia and India (Hine et al., 2014; see also Maibach, Leiserowitz, Roser-Renouf, & Mertz, 2011).

Although the work of the Yale Project on Climate Change Communication provides a model for science communication researchers, it is limited in its application as segmentation was conducted using bases variables specific to the issue at hand. This provides excellent results with regard to public perceptions of climate change and the related issues that were included on the battery, but makes it difficult to draw valid comparisons by applying the segments from these studies to other science and technology issues. Thus an opportunity to compare attitudes across diverse science issues among members of homogeneous segments is missed. Additionally, replicability is difficult as a 36-item battery of questions specific to a single issue is expensive and hard to justify in studies with multiple objectives or dependent variables. In contrast, the goal of work presented here is to create a battery that is both efficient in terms of the number of questions necessary to administer, and effective in creating distinct and robust science audience segmentations.

Segmentation Bases Variables

Because a goal of this dissertation was to create an efficient and effective battery, the bases variables for segmentation were selected from previous science communication research. Studies have highlighted the importance of personal predispositions like deference to science (Anderson, Scheufele, Brossard, & Corley, 2011; Lee & Scheufele, 2006; Liang et al., 2015), political ideology (Ho, Brossard, & Scheufele, 2008) and religiosity (Brossard, Scheufele, Kim, & Lewenstein, 2008; Liang et al., 2015; Scheufele, Corley, Shih, Dalrymple, & Ho, 2009) in attitude formation toward science issues. Values such as religiosity and deference to science are developed early in life and remain fairly stable (Anderson et al., 2011) making them both sound and useful. Prior to using these as the bases variables for segmentation, it is useful to explicate these concepts.

Deference to Science

"Deference to science follows from the idea that citizens should not develop their own ideas about what is good or bad relative to a scientific controversy because legitimate authorities have already laid down the rules" (Altemeyer, 1996) in (Brossard & Nisbet, 2007) pp. 30). Deference to science is considered a long-term socialized trait that guides individual responses to a range of technical controversies that operates relatively independently from knowledge and may exist in conflict with other value predispositions, such as religiosity or conservative ideology (Brossard & Nisbet, 2007) p. 10). There is a degree of utility to this predisposition, as Bloom and Weisberg (2007) point out the direct evaluation of science is difficult or impossible for most individuals, and deference to real or supposed scientific authority serves as a necessary heuristic in the absence of this ability. Additionally, they posit that the opposite of deference, resistance to science, may be rooted in childhood experiences when children hear competing claims about science, when scientific claims are contested within a society, championed by people thought of as reliable or trustworthy, or when claims run counter to emerging intuition (Bloom & Weisberg, 2007, pp. 997).

Deference to science is not a trait that is evenly distributed among the population. Age, general education and science education are positively related to science deference, and men tend to be more deferent than women (Brossard & Nisbet, 2007). Since this study concerns American science audiences, it is worth noting that deference to scientific authority is cultivated by the American educational system, which fosters a narrative that science is politically neutral, unproblematic and seeking of natural truths (Irwin, 2001). Classroom instruction privileges knowing objective 'truths' about science, and does not focus on controversies or how differences are solved within the scientific community (Bauer, Petkova, & Boyadjieva, 2000).

Political Ideology

Political ideology has been defined as "a set of beliefs about the proper order of society and how it can be achieved," (Erikson & Tedin, 2003) pp. 64), as an "endeavor to describe or interpret the world as it is - by making assertions or assumptions about human nature, historical events, present realities and future possibilities - and to envision the world as it should be, specifying acceptable means of attaining social economic, and political ideals" (Jost, Federico, & Napier, 2009) pp. 309), a way to interpret the social world and normative specifications for the proper way to address problems (Jost, Blount, Pfeiffer, & Hunyady, 2003), or in a very broad sense as any "configuration of ideas and attitudes in which the elements are bound together by some form of constraint or functional interdependence" (Converse, 1964). For the purpose of this research, this study will use Denzau and North's broad definition that political ideologies are "the shared framework of mental models that groups of individuals possess that provide both an interpretation of the environment and a prescription as to how that environment should be structured" (Denzau & North, 2000) pp. 24).

Since the late 18th century, political ideology in the United States has been classified as right and left. Right-leaning, or conservative views, privilege the status quo, and left-leaning, or liberal views, privilege change (Bobbio & Cameron, 1996; Jost et al., 2009). More specifically, the two are concerned with "(a) advocating versus resisting social change (as opposed to tradition), and (b) rejecting versus accepting inequality (Jost, Blount, et al., 2003; Jost et al., 2009; Jost, Glaser, Kruglanski, & Sulloway, 2003). While there exist concerns that survey and experimental research subjects are "innocent of ideology," meaning their conceptualization of right/conservative and left/liberal differs from that of political scientists and communication scholars, survey measures of ideological self-placement is a valid measure for even relatively uninformed citizens (Jost et al., 2009) pp. 311).

Recent work has conceptualized political ideology in these ways but added the distinction that research subjects may hold internally competing or differing ideologies depending upon the issue with which they are confronted; specifically, research subjects may have alternating ideologies for social and economic issues (Carmines, Ensley, & Wagner, 2012) (Carmines et al., 2012). The practices of the Science Media and the Public (Scimep) Lab have also begun to include separate measures of social and economic liberalism/conservatism. Thus this dissertation will use these two measures of political ideology.

Religiosity

Literature reviews almost universally acknowledge that definitions of religion vary widely. Although religion differs from religiosity, the lack of a clear definition for the noun, religion, complicates the careful explication of its companion term, religiosity. Despite this, the study of religion as a psychological phenomenon dates to the early part of the 20th century, but the modern concept of religiosity as a cognitive style, personality trait or motivation takes hold in the 1950's and 1960's. Allport & Ross' 1967 paper *Personal Religious Orientation and Prejudice* serves as a nice starting point for contemporary reviews of the development of religiosity as a concept. Likely one of the most cited papers on religiosity in the modern literature, Allport and Ross conceptualized subjects as having either an intrinsic or extrinsic religious orientations. Subjects with intrinsic religious orientations were described as those who "...find their master motive in religion. Other needs, strong as they may be, are regarded as of less ultimate significance, and they are, so far as possible, brought into harmony with the religious beliefs and prescriptions. Having embraced a creed, the individual endeavors to internalize it and follow it fully. It is in this sense that he lives his religion." (Allport & Ross, 1967) pp 434). In contrast were those subjects who used religion more instrumentally; a subject with an extrinsic religious orientation "turns to God without turning away from self; embraced creed it held lightly or else selectively shaped to fit more primary needs." (Allport & Ross, 1967) pp 434).

Surprisingly Allport and Ross do not define religion in their paper, and subsequent authors make it clear that there is a growing discussion of the definition of religion and differences between religiosity and spirituality by the early 1970's that is extended from the intrinsic/extrinsic notion. Religion is variously defined as 'an institution consisting of culturally patterned interaction with culturally postulated superhuman beings" (Spiro, 1966) pp 96); supporting social values to conserve human meaning, within which individuals interpret their experiences and organize their conduct (Geertz, 1973); "a system of beliefs in a divine or superhuman power, and practices of worship or other rituals directed toward such a power," (Argyle & Breit-Hallahmi, 1975) pp 1); a subjective experience of the sacred (Vaughn, 1991); [religion] 1) deals with ultimate concerns of people, 2) provides personal and social identity within the context of a cosmic or metaphysical background, 3) stipulates behavioral patterns, 4) encourages adherents to practice certain forms of religious expression (Marty & Appleby, 1991); the concrete practices of those who profess a faith (Doyle, 1992); a search for significance in ways related to the sacred (Pargament & Park, 1997) pp32; membership and participation in the organizational structures, beliefs, rituals, and other activities related to a religious faith like Judaism, Hinduism, Islam, or Christianity (Moberg, 2008).

Despite lacking a concrete definition for term, the important contribution Allport and Ross make is the conceptualization of religiosity as both internal sentiment toward the divine as well as outwardly-directed actions. Implied in this contrast between intrinsic and extrinsic, and supported by the definitions in the previous paragraph, is the notion that religion is both a hidden individual spiritual experience and often a visible communal experience rooted in the dogma of an articulated religion, and that subject perception of both elements – formal religion and individual spirituality – are involved in how a particular person experiences the combination of the two as the abstract concept of religiosity.

Based on this literature, the definition of religiosity for this dissertation: Religiosity is a degree of spirituality within the context of an established set of norms and behaviors that are often, but not necessarily, created through a formalized community of like-minded individuals; it involves outwardly visible actions as well as hidden internal emotions and cognitive states.

Basis Variable Measures

Deference to science consisted of two questions measured on an 11-point scale with zero indicating “do not agree at all,” and 10 indicating “agree very much,” “How much do you agree or disagree with the following statements: Scientists know best what is good for the public," and "Scientists should do what they think is best, even if they have to persuade people that it is right," (Pearson's r=0.82; mean=3.91; SD=2.60).

The political ideology measure consisted of two questions measured on a seven point scale, "In terms of economic issues, would you say you are … very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative" and "Now, thinking in terms of social issues, would you say you are … very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative," (Pearson's r=0.82; mean=4.18; SD=1.41).

The religious guidance measure consisted of a single question "How much guidance does religion provide in your everyday life?" measured on an 11-point scale, with zero indicating "no guidance at all" and 10 indicating "a great deal of guidance" (Mean=5.43; SD=3.58).

Research Questions

Based on the literature this study asks:

RQ1: *Will segmentation based on deference to science, religiosity and conservative/liberal ideology result in stable and distinct clusters?*

In order to be useful, segmentation clusters must also demonstrate strong statistical differences when subject to discriminant analysis using variables other than those that served as bases for segmentation. Because Western education cultivates deference to science (Anderson et al., 2011) we propose the following:

H1: *Clusters with greater deference to science will report higher levels of education.*

H2: *Clusters with greater deference to science will demonstrate greater levels of science-related knowledge.*

Non-white audiences tend to perceive greater risk related to a wide variety of science issues (Slovic, 1997) and race can be as least as important as education and knowledge in predicting risk (Gauchat, 2012). Additionally, reporting White as an individual's race is related to greater trust in scientists and the government as sources of information for nanotechnology, an emerging science issue (Anderson et al., 2011). Therefore, we propose the following:

H3: *Clusters with greater deference to science will contain larger proportions of White individuals.*

This study is particularly interested in differences in science-related media use among clusters as media use has a direct effect on attitude toward science issues (Anderson et al., 2011; Hmielowski, Feldman, Myers, Leiserowitz, & Maibach, 2013; Scheufele & Lewenstein, 2005). Therefore this study asks:

RQ2: *Will segmentation based on deference to science, religiosity and conservative/liberal ideology result in clusters with distinct differences in attention to media and affect related to media?*

Media use sometimes acts in tandem with interest in science, prompting individuals with interest in science to seek information online while eschewing television as a source (Takahashi & Tandoc, 2015). Based on this we propose:

H4: *Clusters with greater deference to science will report higher levels of attention science in the media.*

Data and Sampling

This study used data from a survey created by the Scimep Lab and administered by GfK Knowledge Networks, between July 31, 2014 and August 19, 2014. The survey was administered to an online panel whose members were drawn from an address-based probability sampling frame that covers approximately 97 percent of the U.S. population. A total of 3,166 respondents finished the survey for a completion rate of 48 percent. Among respondents who completed the survey, subjects for this study must have answered each of the five bases variable questions which resulted in a final sample of 2,858.

The average age of subjects for this study was 46.73 years (SD=17.44) as compared to the median age of 46 years. There were slightly more women, 51.8 percent, in the sample than men, 48.2 percent. Income was measured categorically, with median income falling between $50,000 to $59,999 for subjects. About 12.4 percent of respondents had less than a high school education, 29.6 percent had a high school diploma or GED, 29.0 percent had attended some college and 29.0 percent had earned a bachelor’s degree or higher. About 66.2 percent of respondents identified as white, non-Hispanic, 11.6 percent identified as black, non-Hispanic, 6.1 percent identified as other, non-Hispanic, 14.9 percent identified as Hispanic and 1.3 percent identified as two or more races, non-Hispanic.

Questions used as bases for segmentation were chosen to reflect relatively stable individual characteristics across three dimensions: conservative/liberal ideology, deference to science and religiosity. Conservative/liberal ideology was measured with two questions, “In terms of social issues, would you say you are … (very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative)?” and “In terms of economic issues, would you say you are … (very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative)?” Deference to science and religiosity were measured with questions on an 11-point scale (0=low; 10=high). Deference to science was measured with two questions: “How much do you agree with the following statements … Scientists should do what they think is best, even if they have to persuade people that it is right,” “Scientists know best what is good for the public.” Religiosity was measured with the question “How much guidance does religion provide in your everyday life?” All variables were standardized prior to segmentation in order to account for the variation in scales. For ease of interpretation by readers, we present the non-standardized variables in the results section.

Analysis

Ward's minimum variance method of agglomerative hierarchical cluster analysis (Ward's Method) defines a cluster by using the error sum of squares to create mutually exclusive subsets of a population where units of analysis are maximally similar to one another with respect to specified characteristics (Ward, 1963). Ward's Method makes it easier to scrutinize relationships between variables in a large sample (Ward, 1963). It has been validated as strongly and more optimally predictive than single, average and complete linkage methods, and is the preferred method of cluster analysis when the covariance structure of observations are complex (Blashfield, 1976), and the presence of outliers is suspected (Milligan & Cheng, 1996), which is consistent with expectations for this data set.

K-means segmentation was strongly considered as a second step for this analysis, but ultimately discarded for a number of reasons. First, K-means is sensitive to outliers, which can significantly affect the mean and results. Second, K-means is preferable when clusters are of roughly equal size and density, which we cannot assume with this data set. Third, when using K-means segmentation, the number of clusters needs to be determined a priori, which can be difficult if pervious work on similar data for this purpose hasn't been done. Finally, K-means starts with random cluster centers making it difficult to repeat clustering and end with the same results.

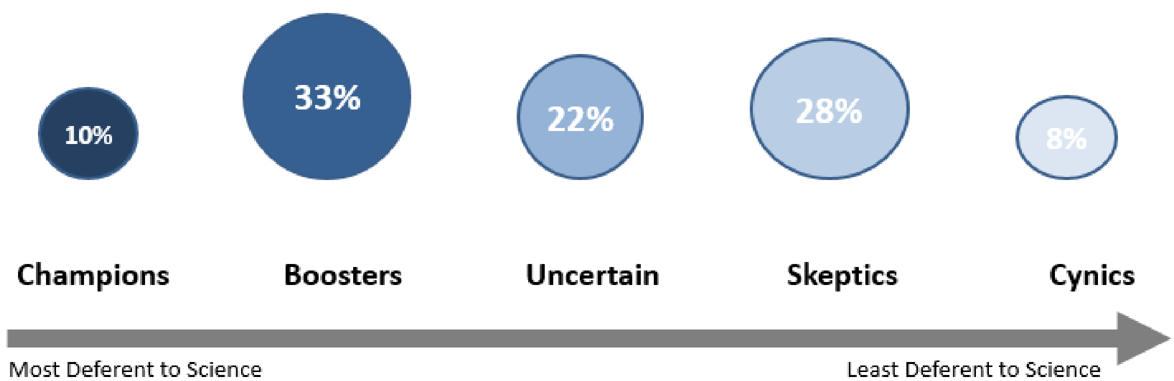
Latent class analysis is often an attractive alternative in clustering and has been used effectively in previously mentioned work. However, because all variables in this study were continuous as opposed to categorical, and we were not tracking the movement of individuals over time, we did not select latent class analysis.

Using Ward's Method, three iterations were performed entering the variables in different order by category, (religiosity, liberal/conservative ideology and deference to science), to gauge the stability of clusters. Subjects consistently clustered into one of five (5) major segments which demonstrated strong statistical differences in values of discriminant variables.

Bases Results

Five statistically distinct clusters emerged after three iterations (Figure 3.1).

Figure 3.1: Cluster Results for American Science Audiences



n=2858

Champions

Champions (10%) demonstrate the most deference to science, as characterized by a strong belief that scientists know best what is good for the public (Mean=5.92; SD= 2.03) and scientists should do what they think is best (Mean=7.14; SD=1.86), in combination with very low levels of religiosity (Mean=1.15; SD=1.60), liberal economic ideology (Mean=2.28; SD=0.77) and social ideology (Mean=1.82; SD=0.70) (Table 3.1) (Figure 3.2).

Although political party identification was not included as a basis variable, we report results in this section. About 94 percent of Champions identified as Democrats, 4.4 percent described themselves as Republican and 1.5 described themselves as “other.” When the two questions regarding social and economic conservative/liberal ideology were combined into a single index, 100 percent of Champions were categorized as liberal (Figure 3.2).

Boosters

Boosters (33%) may share with Champions the firm belief that scientists know best what is good for the public (Mean=5.57; SD=1.89) and scientists should do what they think is best (Mean=6.20; SD=1.87), but this segment distinguishes itself with significantly higher levels of religiosity (Mean=4.37; SD=3.37), moderate to conservative ideologies for economic issues (Mean=4.21; SD=1.64) and social issues (Mean=3.69; SD=1.12) than their pro-science brethren (Table 3.1).

About 58.4 percent of Champions identified as Democrats, 38.2 percent described themselves as Republican and 3.4 described themselves as “other.” When the two questions regarding social and economic conservative/liberal ideology were combined into a single index, 61.3 percent of Boosters were categorized as moderates, the largest of all segments and one of its distinguishing traits. In contrast, 17.6 percent were categorized as conservatives and 21.1 percent were categorized as liberals (Figure 3.2).

Uncertains

Uncertains (22%) are distinguished by the second highest levels of religiosity (Mean=7.91; SD=1.90) in combination with conservative economic ideologies (Mean=5.65; SD=0.92), social ideologies (Mean=5.6; SD=0.99) and median-of-the-pack agreement on whether scientists know best what is good for the public (Mean=3.79; SD=2.39) and scientists should do what they think is best (Mean=5.28; SD=2.28).

Uncertains claimed the second-highest percentage of members identifying as Republican (72%) or categorized as conservative (95.5%). Only 25.7 percent identified as Democrats, and 2.3 percent as “other.” Only 4.3 percent were categorized as moderate and 0.3 percent as liberal (Figure 3.2).

Skeptics

Skeptics (28%), like Boosters, are characterized by moderate levels of religious guidance (Mean=4.82; SD=3.60) along with moderate economic ideologies (Mean=3.6; SD=1.06) and social ideologies (Mean=3.47; SD=1.19). The key trait separating Skeptics from Boosters is a low level of deference to science as characterized by their strong disagreement that scientists know best what is good for the public (Mean=1.63; SD=1.68) along with disagreement that “scientists should do what they think is best even if they have to persuade people that it is right” (Mean=1.96; SD=2.00) (Table 3.1) (Figure 3.2).

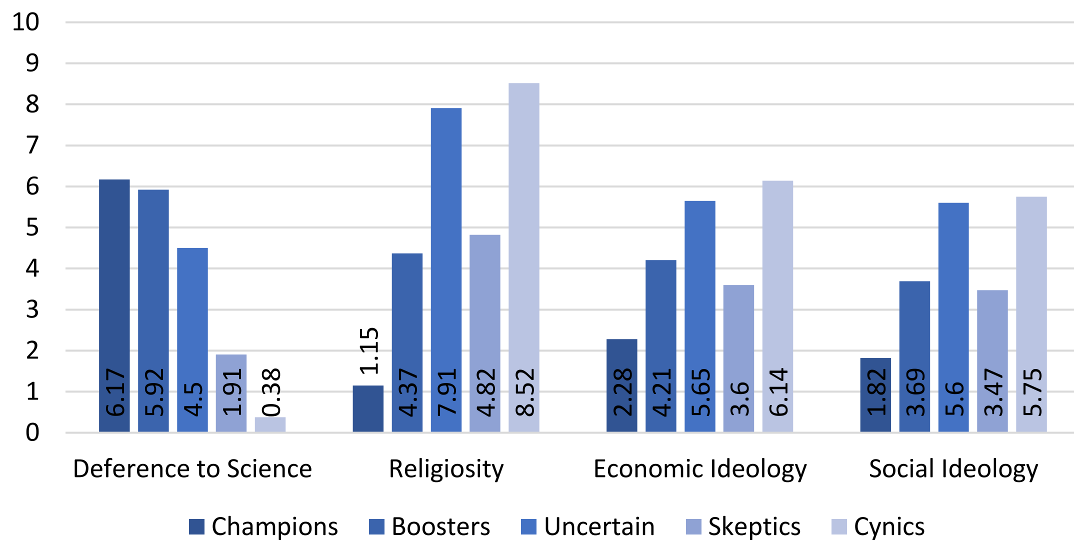
Like Boosters, a strong majority of Skeptics identify as Democrats (63.2%), but a sizable portion identifies Republicans (31.3%), and a small portion as “other” (5.6%). In total 50.8 percent of Skeptics are categorized as ideological moderates, which is somewhat comparable to the categorization of Boosters (61.3%) and in strong contrast to the categorization Uncertains (4.2%). The difference lies in their deference to science (Figure 3.2).

Cynics

Cynics (8%) fall on the opposite end of the spectrum from Champions, scoring the lowest numbers where Champions scored the highest. Cynics overwhelmingly reject the notion that scientists know best what is good for the public (Mean=0.41; SD=0.79) and that scientists should do what they think is best, even if they have to persuade people that it is right (Mean=0.38; SD=0.66). Cynics demonstrate the highest levels of religiosity (Mean=8.52; SD=1.94), conservative economic ideology (Mean=6.14; SD=0.70) and conservative social ideology (Mean=5.75; SD=1.14) (Table 3.1) (Figure 3.2).

A strong majority of Cynics identify as Republican (80.1%), with a smaller number identifying as Democrats (17.7%) or “other” (2.2%). Nearly all (98.1%) identify as conservative, with the remainder identifying as moderate (1.9%).

Figure 3.2: ANOVA results for American Science Audience segments by bases variables



All variables p≤.001; 0 indicates *disagree strongly*, 10 indicates *agree strongly*

Table 3.1: Mean and standard deviation for bases variable by American Science Audiences segment

Segment	Deference to Science Mean (SD)	Religious Guidance	Economic Ideology	Social Ideology
Champions	6.17 (1.51)	1.15 (1.60)	2.28 (0.77)	1.82 (0.70)
Boosters	5.92 (1.74)	4.37 (3.37)	4.21 (1.04)	3.69 (1.12)
Uncertains	4.50 (1.81)	7.91 (1.90)	5.65 (0.92)	5.60 (0.99)
Skeptics	1.91 (1.53)	4.82 (3.61)	3.60 (1.06)	3.47 (1.19)
Cynics	0.39 (0.58)	8.52 (1.94)	6.14 (0.70)	5.75 (1.14)
All	3.92 (2.59)	5.29 (3.60)	4.33 (1.46)	4.03 (1.59)

All variables; N=2858; 0 indicates *disagree strongly*, 10 indicates *agree strongly*

After examining mean and standard deviations for the bases variables, segments were subjected to a multinomial logistic regression to determine the impact of each bases variable on assignment to segments. The Uncertains segment was used as a reference group (Table 3.2).

Table 3.2: Multinomial logistic regression impact of base variable on log odds of subject assignment to American Science Audiences segment

	Parameter Estimates for Champions	Parameter Estimates for Boosters	Parameter Estimates for Skeptics	Parameter Estimates for Cynics
Base Variable	Exp(B)	Exp(B)	Exp(B)	Exp(B)
Scientists Know Best	---	8.25***	0.22***	0.57***
Scientists Should do Best	0.54***	3.03***	0.31***	0.12***
Religious Guidance	0.15***	0.03***	1.56***	0.15***
Economic Ideology	---	---	3.50***	---
Social Ideology	0.78*	---	1.54***	1.45*

Nagelkerke Pseudo R2 =96.9%
Chi-Square Model Test X2 = 10,644.66 df=844 P≤ .001

Reference category is Uncertains;
N=2858; *P≤ .05, **P≤ .01, *** P≤ .001

Discriminant Variables

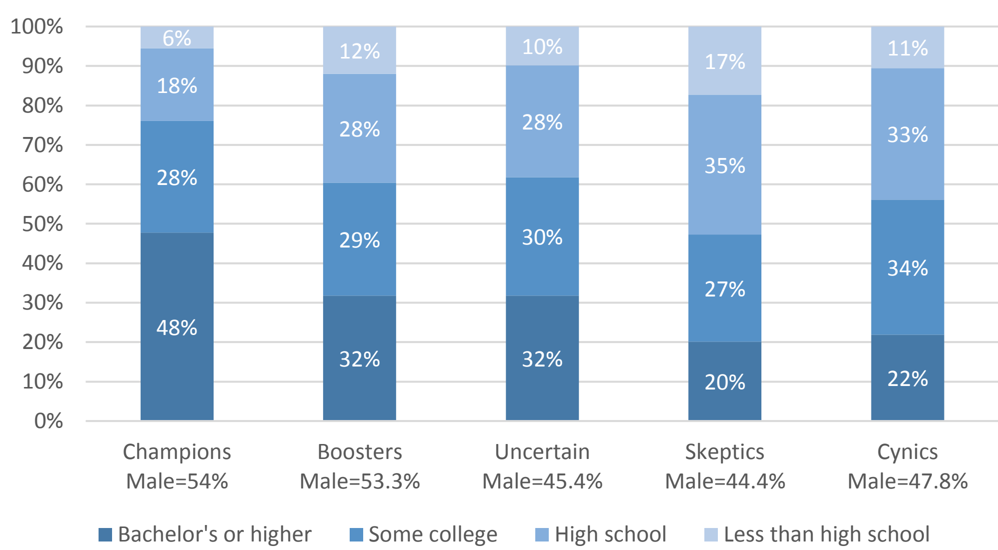
After segmenting by bases variables, the results were subject to ANOVA tests to determine if segments demonstrated statistically significant differences across a number of variables of interest. These included demographics, science knowledge, attention to specific media outlets, attention to social networking sites and interpersonal discussion networks. Variables in these categories are explicated in the sections related to their analysis for ease of reading.

Demographic Discriminants

After segmenting by bases variables, the results were subject to ANOVA tests to determine if the clustering resulted in statistically distinct groupings. The first set of these tests concerned demographics. There were slightly more men than women in Champions and Boosters, the segments most deferent to science, with the opposite true for Uncertains, Skeptics and Cynics (Figure 3.3).

Arranging segments by deference to science in Figure 3.3, with the segment most deferent on the left, it is clear that levels of education generally, but not monotonically, decline as deference to science declines. Roughly 48 percent of Champions have earned at least a Bachelor's degree with an additional 28 percent completing some college. In comparison, only 20 percent of Skeptics and 22 percent of Cynics have earned a Bachelor's or higher, with 27 percent and 34 percent, respectively, reporting some college (Figure 3.3). Therefore, H1 was supported.

Figure 3.3: ANOVA results for education and gender by American Science Audience segments



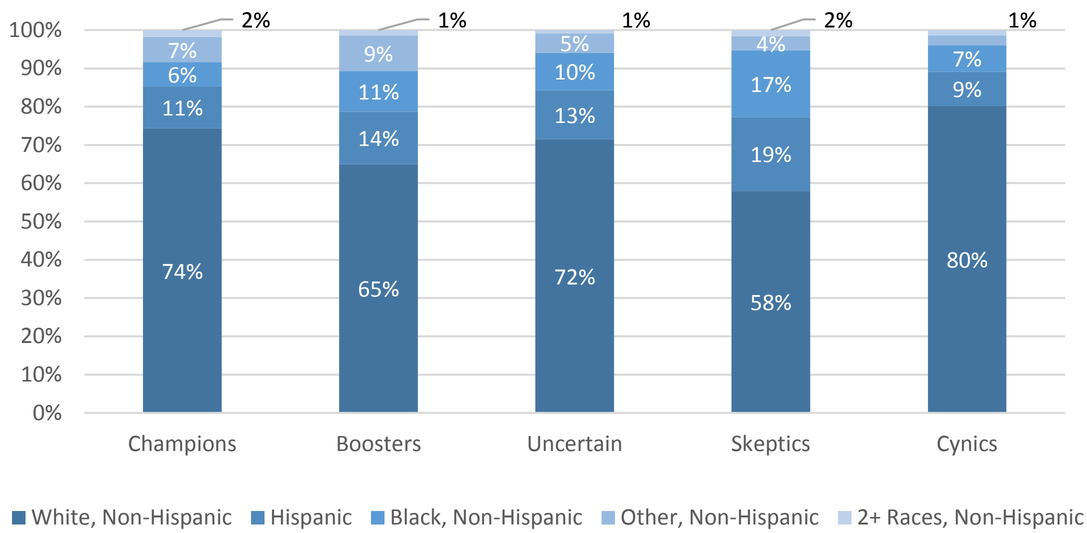
All variables p≤.001

Champions averaged 42.21 years old (SD=16.74); Boosters averaged 44.76 years (SD=16.76), Uncertains averaged 48.66 years (SD=17.75), Skeptics average 46.78 years (SD=17.08) and Cynics averaged 53.23 years (SD=17.05).

Although there were members of all racial groups in each segment, individuals were not distributed evenly. At the time of the survey, the U.S. Census Bureau reported that the American public 62.5 percent White, non-Hispanic, 13.2 percent Black/African-American, 17.4 percent Hispanic, 6.8 percent Asian and 2.5 percent were two or more races (United States Census Bureau, 2016). Assuming that the survey category “other, non-Hispanic” included a significant number of Asian residents of America, Boosters and Skeptics would be the segments most closely mimicked the general American population. However, differences in racial distributions between each segment and the general U.S. population are strongly statistically different (Figure 3.4) , where 77.1 percent of the U.S. population identifies as White alone, 13.3 percent identify as African-American/Black, 17.6 percent identified as Hispanic or Latino, 2.6 percent identified as two or more races The U.S. Census also includes Asian (5.6%), Native Hawaiian or Pacific Islander (0.2%), American Indian and Alaska Native (0.9%), which are categories tallied under “other” in the data set (United States Department of Commerce Census, 2016).

Skeptics were the most racially diverse segment with 42.1 percent of members identifying as something other than White, non-Hispanic, followed by Boosters with 35 percent. In contrast only 19.8 percent of Cynics and 25.7 percent of Champions identified as something other than White, non-Hispanic (Figure 3.4). Although there were strong statistical differences in distribution of race among the clusters, there was an ample distribution of racial identities across all groups, the cluster with the least deference to science, Cynics, also had the highest proportion of members identifying as White, non-Hispanic. As a result H3 was not supported.

Figure 3.4: ANOVA results for racial composition of American Science Audience segments



All variables p≤.001

Science Knowledge

The clusters were subjected to a second round of ANOVA testing to determine if groups demonstrated statistically significant differences in science knowledge and attitude towards media.

Science knowledge was measured cross three areas of emerging science and technology: synthetic biology, nanotechnology and fracking, all of which were included in discriminant analysis despite this dissertation's focus on synthetic biology. Synthetic biology knowledge was measured with "Could you tell us for each of the following statements if you think it is true or false? … Recently, the Obama Administration banned all synthetic biology research (false) … Synthetic biology is the application of artificial intelligence to biological systems (false) … The first biosynthetic insulin went on sale as early as the 1980s (true)." Nanotechnology knowledge was measured with "Nanotechnology involves materials that are not visible to the naked eye (true) … Federal regulations require manufacturers to label all products that contain nanomaterials (false) … Currently, there are only a few dozen consumer products on the market using nanotechnology (false)." Fracking knowledge was measured with "Scientists are concerned that fracking could cause small earthquakes (true) … New York, Pennsylvania, California and Washington are all states with active or proposed fracking (false)… Federal law requires companies to disclose all chemicals used in natural gas drilling (false).[2]"

Champions

Champions demonstrated the strongest science knowledge with 20 percent of members correctly answering all three questions about synthetic biology, and 22 percent correctly answering all three questions about nanotechnology. Only 3.9 percent correctly answered all three questions about fracking, which was low but consistent with overall results for this set of knowledge questions (Figure 3.5).

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[2] egulations requiring the disclosure of chemicals used in fracking went into effect in 2015 after the administration of this survey

Boosters

Boosters knowledge of science was similar to that of Uncertains and Cynics, with 11.8 percent correctly answering all three questions about synthetic biology, 13.2 percent correctly answering questions about nanotechnology and only 2.2 percent correctly answering all questions about fracking (Figure 3.5).

Uncertains

Uncertains' levels of knowledge for synthetic biology and nanotechnology were statistically identical to knowledge levels of Boosters and Cynics, with 11.7 percent and 13.3 percent correctly answering all three questions about synthetic biology and nanotechnology, respectively. As with all segments, knowledge related to fracking was low, with only 4.0 percent of Uncertains answering all three correctly.

Skeptics

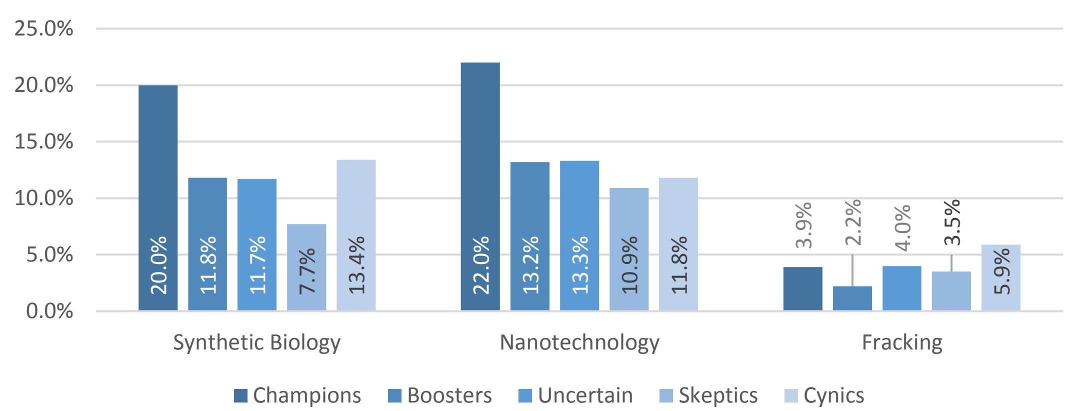
Skeptics knew slightly less than Boosters about synthetic biology and nanotechnology with 7.7 percent and 10.9 percent, respectively, correctly answering all three questions about the technologies. As with other segments, fracking knowledge was low with only 3.5 percent of Skeptics correctly answering all three questions.

Cynics

Cynics demonstrated the strongest knowledge of fracking with 5.9 percent of its members correctly answering all three questions about the topic (Figure 3.5). Although their knowledge of knowledge of synthetic biology and nanotechnology was roughly in line with Boosters, Uncertains and Skeptics, they collectively knew less than Champions (Figure 3.5).

Champions demonstrated the highest overall levels of knowledge for synthetic biology and nanotechnology. Boosters, Uncertains and Cynics demonstrated similar levels of knowledge for these topics. Cynics demonstrated the highest levels of fracking knowledge among all groups, although knowledge for this topic was consistently low among all survey participants. Although differences in knowledge among groups was strongly statistically different, knowledge did not vary based on deference. Based on these results, H2 was not supported.

Figure 3.5: ANOVA results for proportion of each American Science Audience segment correctly answering three questions about each of three topics: synthetic biology, nanotechnology and fracking



All variables p≤.001

Science Media Use & Media Affect

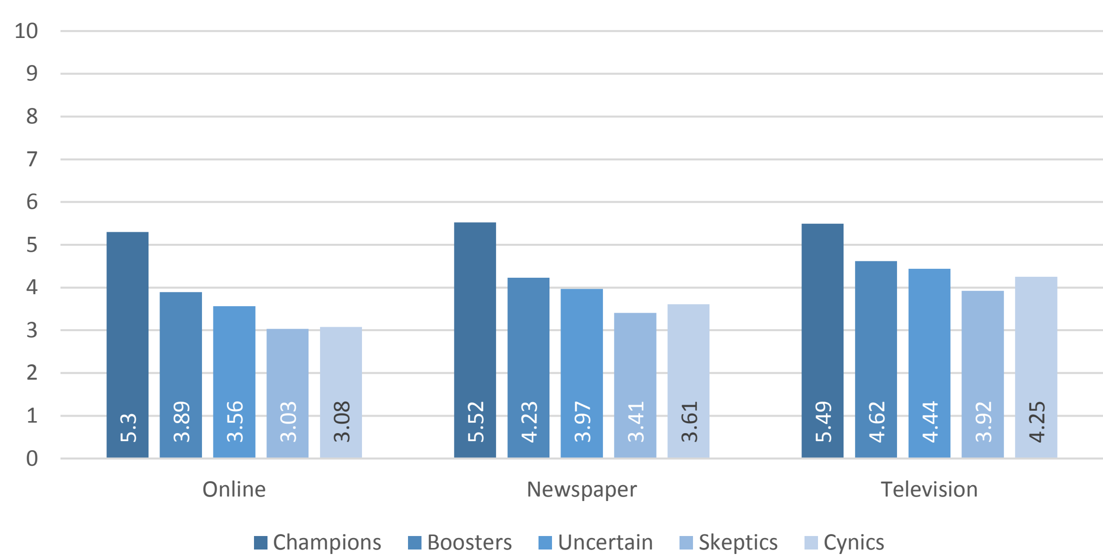
Science media use and affect were the longest battery of questions. Attention to science in media was measured with three questions across three media channels, "How much attention do you pay to news stories about the following topics [science and technology … new scientific developments … the political and ethical implications of emerging technologies] when you … go online … read the newspaper, either in print or online … on television." Answers ranged from 0 to 10 with the lower end of the scale representing "none at all" and the higher end of the scale representing "a great deal."

Attitude toward media was measured with six questions organized into two indexes. Results for individual questions and their indexes are both reported. A media cosmopolitanism index included the questions "How much do you agree or disagree with each of the following statements? … I often reserve my judgment until I have had a chance to hear the different opinions represented in the media … I use media sources that represent a wide variety of backgrounds and cultures … I tend to have a more diverse media diet than most of my friends." A media affect index included "How much do you agree or disagree with each of the following statements? … There are certain media personalities I avoid because I strongly disagree with their views … There are certain media personalities I have come to hate because of the things they stand for … The viewpoints expressed in certain media make me angry." Answers ranged from 0 to 10 with the lower end of the scale representing "disagrees strongly" and the higher end of the scale representing "agree strongly."

Champions consistently show greater attention to science-related stories in nearly all channels when compared to other segments. This segment's stronger-than-average attention to science in the media may partially explain their above-average science-related knowledge.

Champions reported statistically significant greater levels of attention to news stories about science and technology on television (Mean=5.48; SD=3.39), newspaper (Mean=5.52; SD=3.34) and online (Mean=5.30; SD=3.34) than other segments (Figure 3.6).

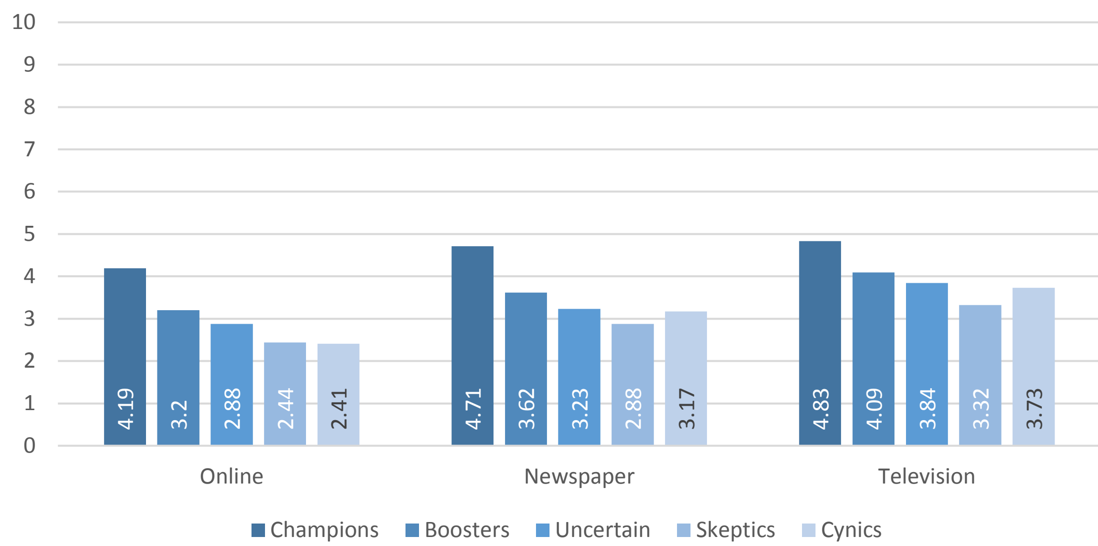
Figure 3.6: ANVOA results for American Science Audiences segments, "How much attention do you pay to news stories about *science and technology* when you go online … read the newspaper (either in print or online) … watch television?"



All variables p≤.001; 0 indicates *none*, 10 indicates *a lot*

Champions, like all segments, reported paying less attention to new scientific developments than science and technology in general. Champions report less attention to this topic in newspapers (Mean=4.19; SD=3.32) and on television (Mean=4.71; SD=3.35) as compared to online (Mean=4.82; SD=3.29) (Figure 3.7).

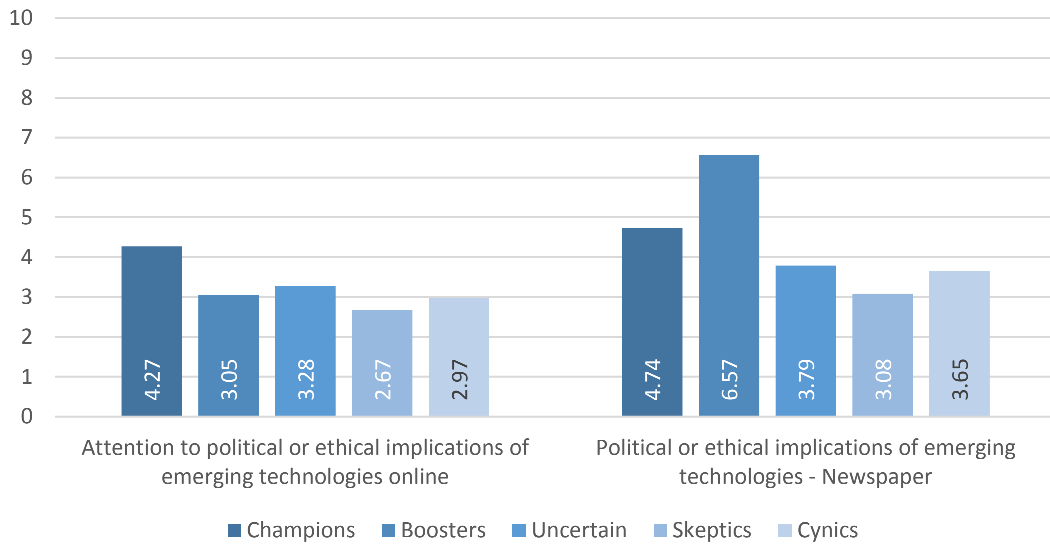
Figure 3.7: ANOVA results for American Science Audiences "How much attention do you pay to news stories about *new scientific developments* when you go online … read the newspaper (either in print or online) … watch television?"



All variables p≤.001; 0 indicates *none*, 10 indicates *a lot*

Although Champions report paying greater attention to the political and ethical implications of emerging technologies online (Mean=4.27; SD=3.11) than all other segments, Boosters report much greater attention to the same in newspapers (Mean=6.57; SD=3.02) than other segments paid to the topic online or in newspapers (Figure 3.8).

Figure 3.8: ANOVA results for American Sciences Audiences "How much attention do you pay to news stories about *political or ethical implications of emerging technologies* when you go online … read the newspaper (either in print or online)?"



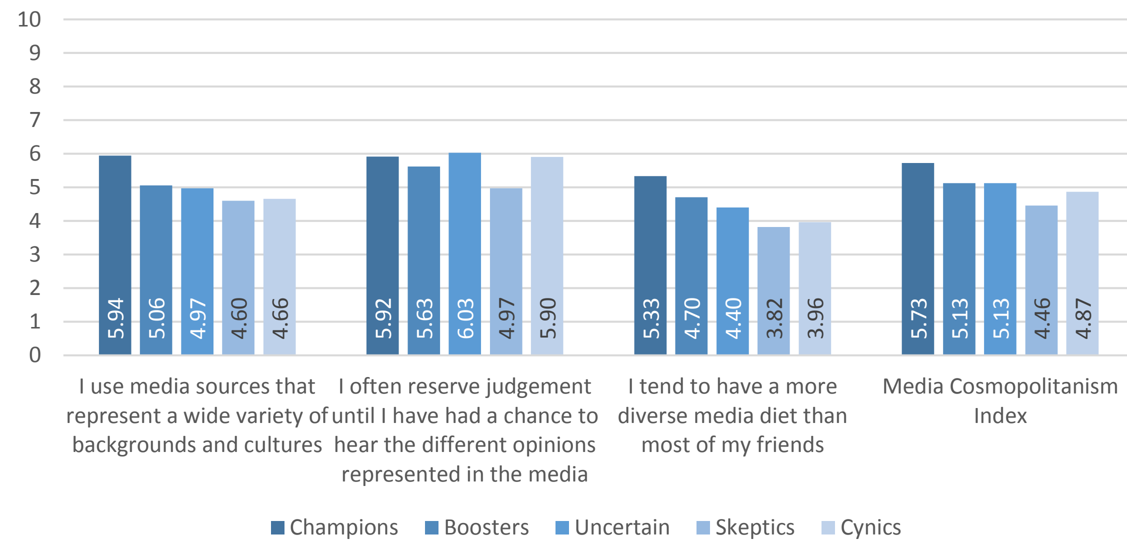
All variables p≤.001; 0 indicates *none*, 10 indicates *a lot*

Champions and Boosters, the segments reporting the highest levels of deference to science, also reported higher levels of science-related media use across all nine of the ten questions used to test H4. However, Cynics, the segment reporting the lowest levels of deference to science, ranked third in science media use for nine of the ten questions used to test H4. As a result there is qualified support for H4, as high levels of science deference are related to greater science media use, but the lowest levels of science deference were also related to greater science media use in this data set.

The literature did not support the creation of a hypothesis related to media affect, but the unique opportunity to explore this warranted RQ2. Two indexes were used to explore this research question, one focusing on media cosmopolitanism and another focusing on media affect.

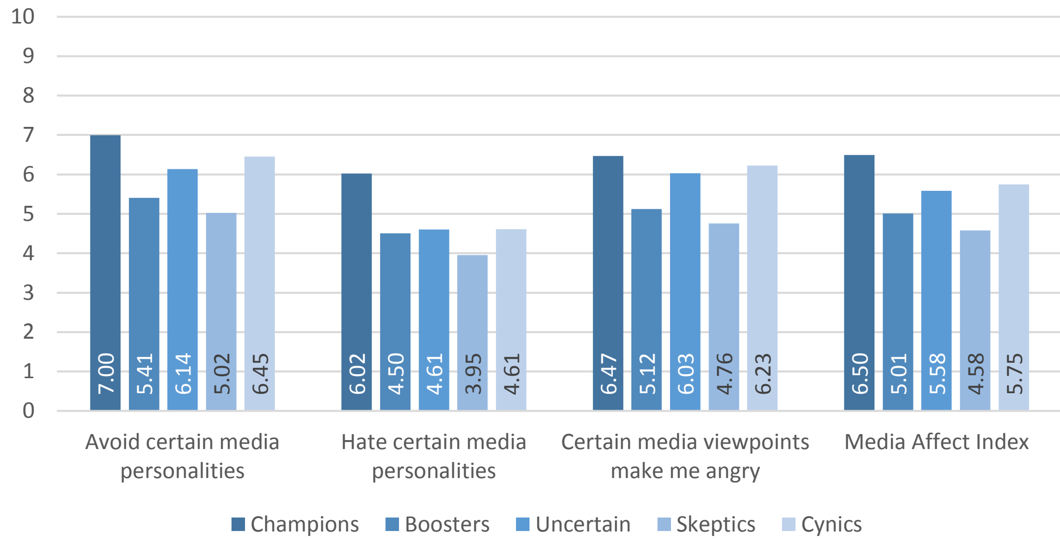
Questions in the media cosmopolitanism index (Figure 3.9) and media affect index (Figure 3.10) produce statistically significant results despite the fact that there aren't clear trends across all segments.

Figure 3.9: ANOVA result for American Science Audiences, media cosmopolitanism. "How much do you agree or disagree with the following statements…."



All variables p≤.001; 0 indicates disagree strongly, 10 indicates agree strongly

Figure 3.10: ANOVA results for American Science Audiences, media affect. "How much do you agree or disagree with the following statements…."



All variables p≤.001; 0 indicates disagree strongly, 10 indicates agree strongly

Champions

Champions scored the highest on the media cosmopolitanism index (Mean=5.73; SD=2.31) (Figure 3.9), and they were also the segment that agreed most strongly with the media affect index statements "There are certain media personalities I avoid because I strongly disagree with their views" (Mean=6.99; SD=3.18), "There are certain media personalities I have come to hate because of the things they stand for" (Mean=6.03; SD=3.49) and "The viewpoints expressed in certain media make me angry" (Mean=6.47; SD=3.12), and scored the highest on the media affect index as a result (Mean=6.50; SD=2.86) (Figure 3.10).

Boosters

As compared to other segments, Boosters scored relatively low on the media affect index (Mean=5.08; SD=2.82) (Figure 3.10), and were in the middle ground for media cosmopolitanism (Mean=5.13; SD=5.13) (Figure 3.9).

Uncertains

Perhaps consistent with their name, among all segments Uncertains agreed most strongly with the statement “I often reserve my judgment until I have had a chance to hear the different opinions represented in the media” (Mean=6.03; SD=2.76), although agreement on other questions in the media cosmopolitanism index placed them in the middle of all segments (Figure 3.9). Despite this, an average of 6.14 (SD=3.28) on the statement “There are certain media personalities I avoid because I strongly disagree with their views,” and 6.03 (SD=3.02) on “The viewpoints expressed in certain media make me angry” might indicate that this group reserves judgment but is not necessarily seeking contrary views in media (Figure 3.10).

Skeptics

Skeptics scored lowest on the media cosmopolitanism index (Mean=4.46; SD=2.77) (Figure 3.9) and were least likely to reserve judgment until after they heard a variety of opinions in the media (Mean=4.97; SD=3.27). Interestingly, they also scored lowest on the media affect (Mean=4.58; SD=3.21) index and were the least likely to avoid certain media personalities (Mean=5.02; SD=3.71), hate certain media personalities (Mean=3.95; SD=3.51) or become angered by viewpoints they encountered in the media (Mean=4.76; SD=3.38) (Figure 3.10).

Cynics

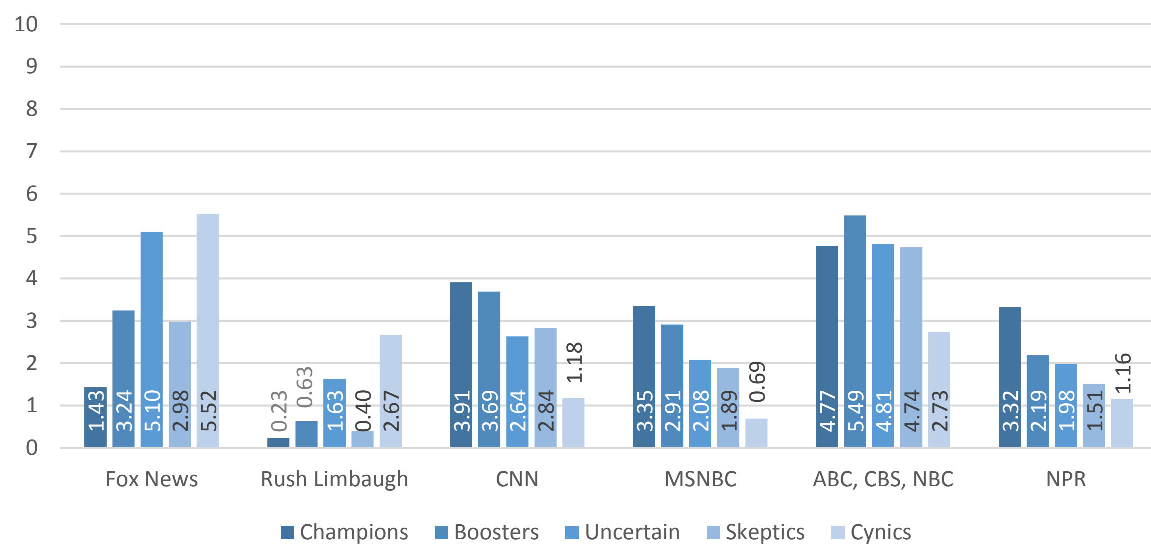
Along with Champions, Cynics make the strongest claims that they reserve judgment until they have had a chance to hear different viewpoints in the media (Mean=5.90; SD=3.32) (Figure 3.9), admit avoiding certain media personalities (Mean=6.45; SD=3.70) and becoming angered when they encounter certain viewpoints in the media (Mean=6.23 SD=3.42) (Figure 3.10). But unlike Champions, Cynics do not report using diverse media sources (Mean=3.96; SD=3.21), or more diverse media than their friends (Mean=4.61; SD=3.84). Also like their reverse doppelganger, Cynics avoid certain media personalities and are angered when they encounter certain viewpoints in the media (Figure 3.10).

Attention to Specific Media Outlets

A subset of the survey sample was asked "How much attention do you pay to the following sources of news?" With the exception of Cynics, all segments reported paying higher levels of attention to network news (ABC, CBS and NBC) than any other news outlet

Cynics reported paying higher levels of attention to Fox News than any other outlet, and higher levels of attention to Fox News and the Rush Limbaugh Show than any other segment. All other segments reported paying higher levels of attention to network news (ABC, CBS and NBC) than any other outlet, although Uncertains reported a small difference of 0.39 between attention paid to network news and Fox News (Figure 3.11). Champions and Boosters reported paying higher levels of attention CNN, MSNBC, network news and NPR than other segments. In general, Cynics reported low levels of attention to all other news outlets, and despite the fact that this segment paid greater attention the Rush Limbaugh Show (Mean =2.67;SD=3.28) this outlet didn't serve as a major source of news given the average score of 2.67 (Figure 3.11).

Figure 3.11: ANOVA results for American Science Audiences attention to specific media outlets by American Science Audience segment



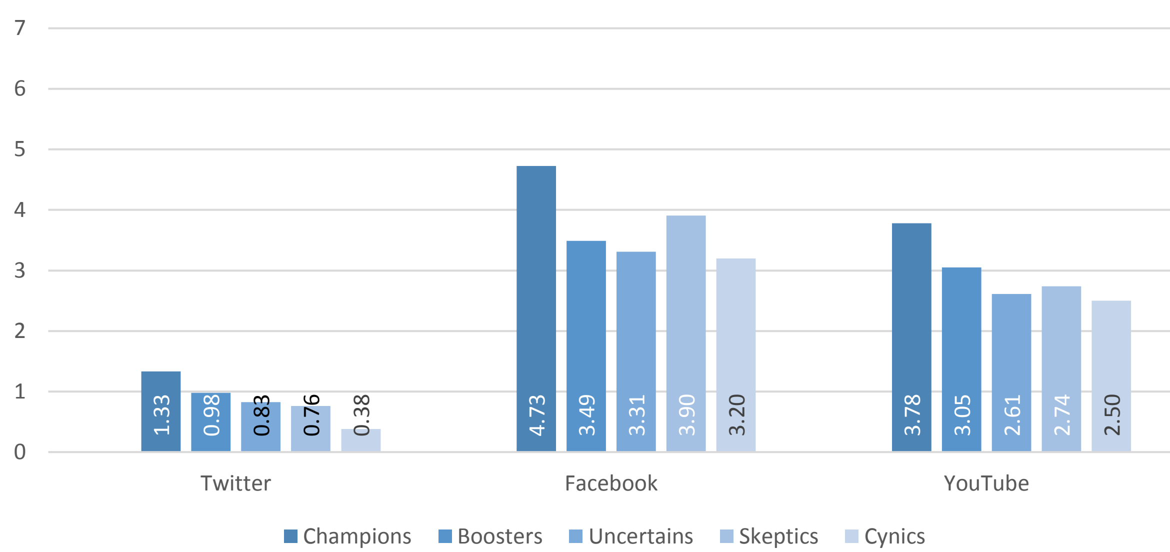
n=583; All variables p≤.001; Asked of a subset of survey respondents; 0 indicates *none*, 10 indicates *a lot*

Attention to Social Networking Sites

Social networking site use is of particular interest to this dissertation and was measured with the following question, "How often do you use the following sites or platforms [*Twitter/Facebook/YouTube*], if at all?" Answers ranged from 0 to 7, where 0 indicates never, 1 indicates less than once a month, 2 indicates once a month, 3 indicates two to three times per month, 4 indicates once a week, 5 indicates two to three times a week, 6 indicates daily and 7 indicates multiple times per day.

Champions reported higher levels of social networking site use than other segments across all platforms, including *Twitter* (Mean=1.33; SD=2.14), *Facebook* (Mean=4.73; SD=2.51) and *YouTube* (Mean=3.78; SD=1.85). Cynics reported the lowest levels of social networking site use, with an average of 0.38 (SD=1.40) for *Twitter,* 3.20 (SD=2.80) for *Facebook,* and 2.50 (SD=2.22) for *YouTube* (Figure 3.12).

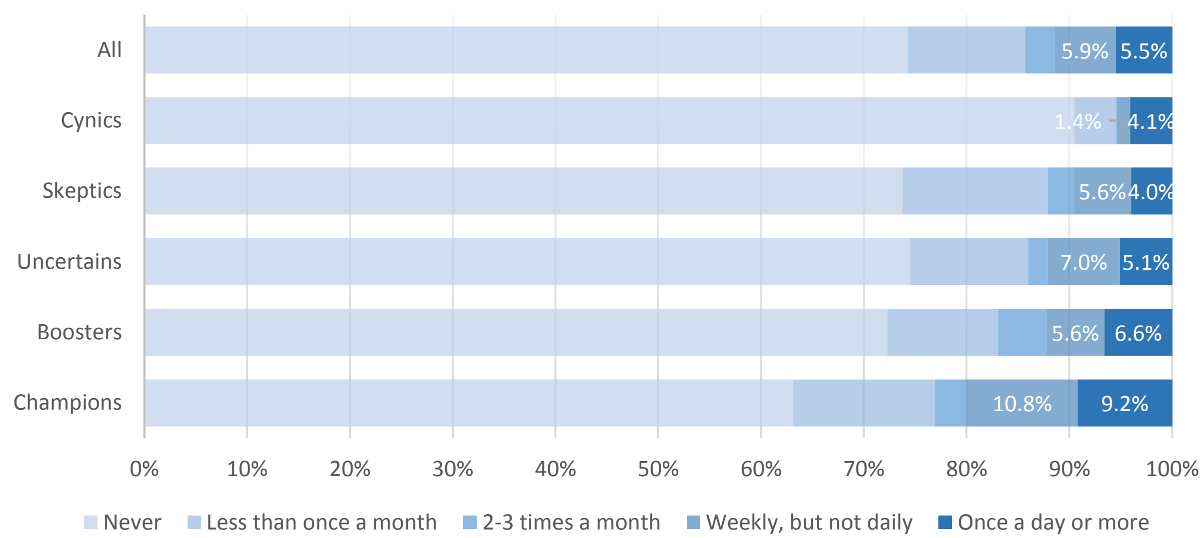
Figure 3.12: ANOVA results for American Science Audiences attention to specific social networking site platforms by segment



All variables p≤.001; 0 indicates *less than once a month*, 2 indicates *once a month*, 3 indicates *two to three times per month*, 4 indicates *once a week*, 5 indicates *two to three times a week*, 6 indicates *daily* and 7 indicates *multiple times per day.*

Given the large numbers of individuals within each segment that do not use specific platforms, it is more useful to examine the distribution of users within each segment as opposed to the average levels of use by segment. As illustrated in Figure 3.13, the majority of respondents in all segments do not use *Twitter* at all. However, 9.2 percent of Champions use *Twitter* once a day or more. If we consider that regular use is weekly or more, then the addition of the 10.8 percent of Champions who report that level of use means that a total of 20 percent in this segment are regular users. In contrast, 12.2 percent of Boosters are regular users of *Twitter,* as defined by use levels of once a week or more, 12.1 percent of Uncertains are regular users, 9.6 percent of Skeptics are regular users and only 5.5 percent of Cynics are regular users (Figure 3.13).

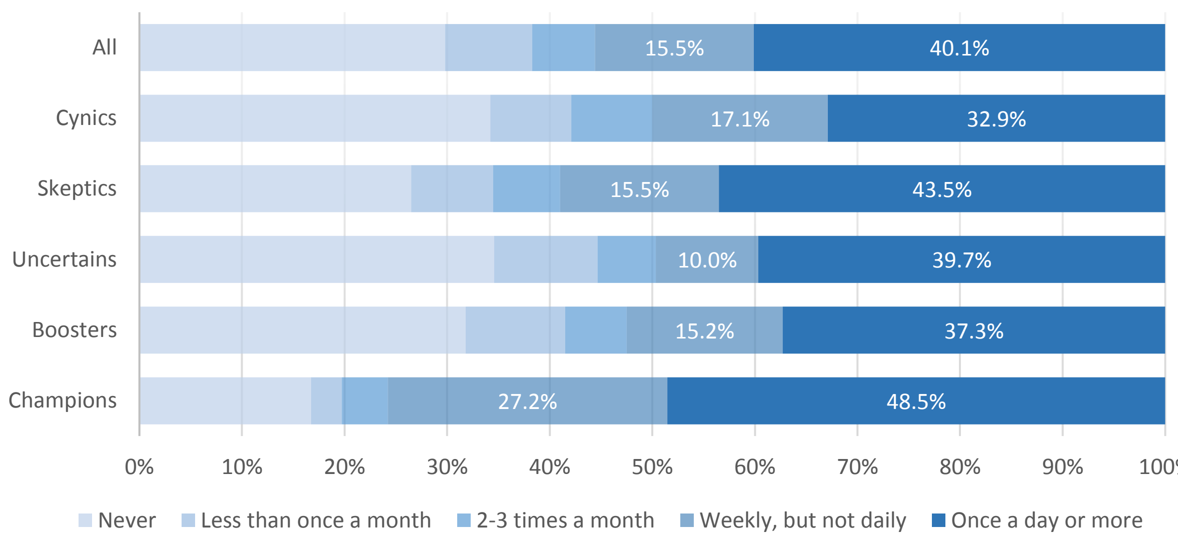
Figure 3.13: Distribution of Twitter users by segment and frequency of use



All variables $p \leq .001$

Using the same definition of regular use as weekly or greater, Champions report the highest levels of *Facebook* use with 75.7 percent of segment members reporting weekly or greater use, as compared to 52.5 percent of Boosters, 49.7 percent of Uncertains, 59.0 percent of Skeptics and 50.0 percent of Cynics reporting the same (Figure 3.14).

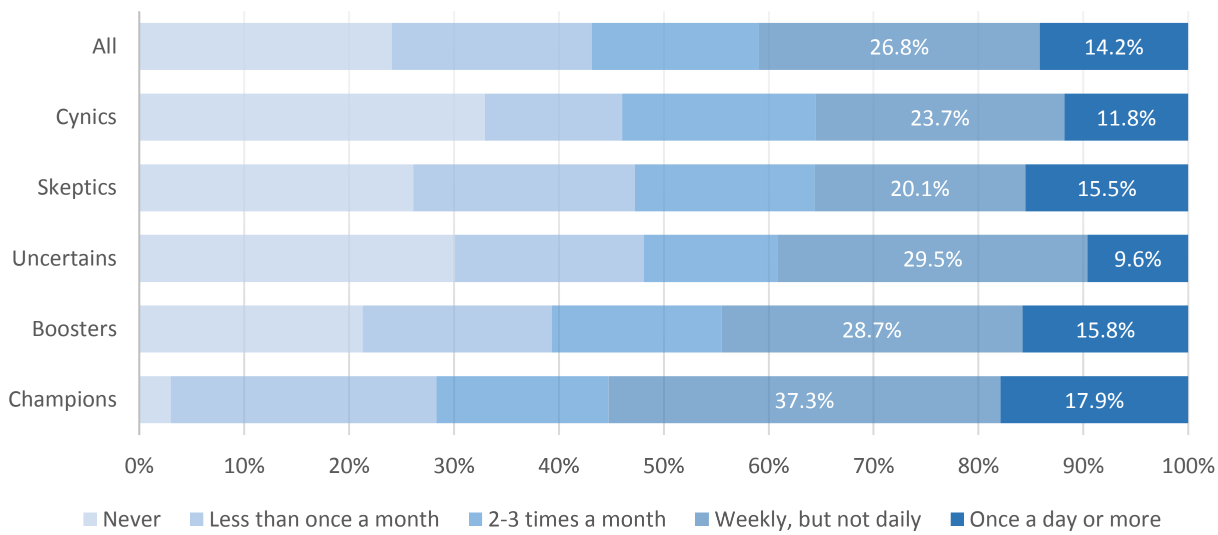
Figure 3.14: Distribution of Facebook users by segment and frequency of use



All variables p≤.001

YouTube use is largely consistent with other patterns, with 55.2 percent of Champions reporting weekly or greater use, and 44.5 percent of Boosters, 39.1 percent of Uncertains, 35.6 percent of Skeptics and 35.5 percent of Cynics reporting the same (Figure 3.15).

Figure 3.15: Distribution of YouTube users by segment and frequency of use



All variables p≤.001

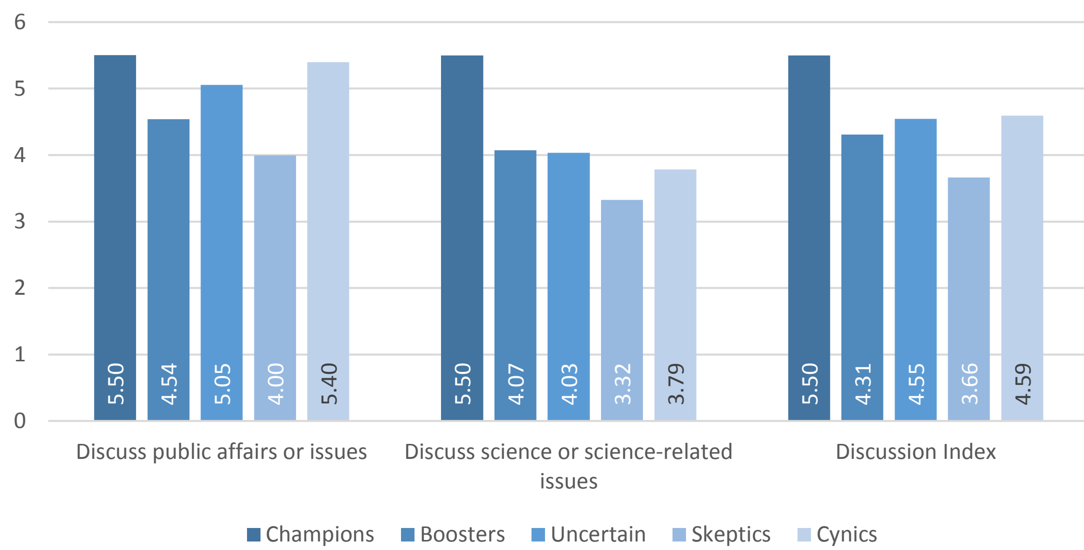
Interpersonal Discussion Networks

One of the key focal areas of this dissertation is the extent to which issue-related discussion is associated with individual perceptions of emerging technologies, and how those differences manifest in American Science Audience segments.

Champions

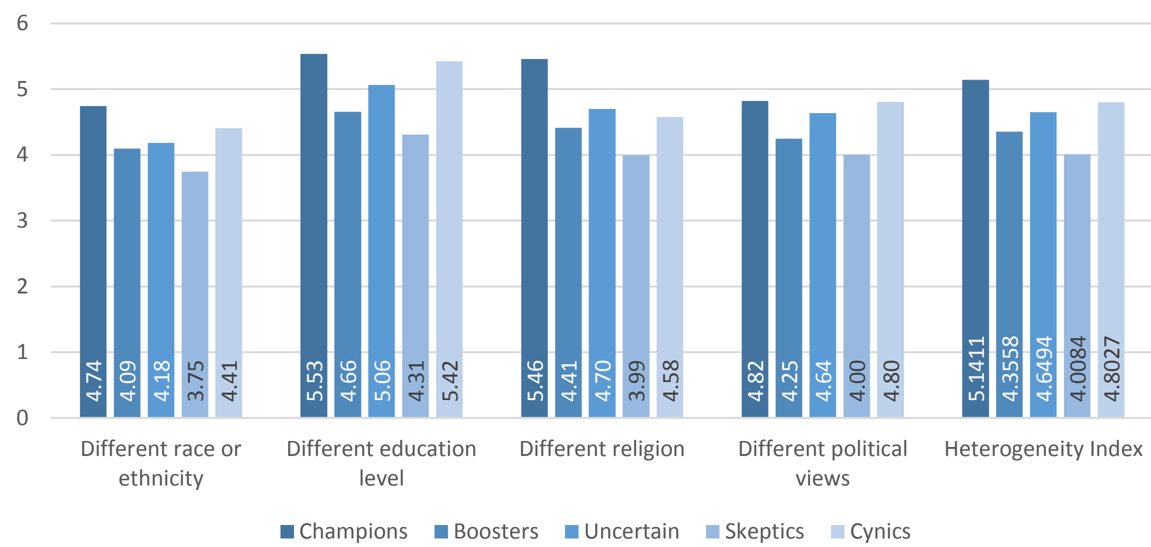
Champions report the highest frequency of discussion related to public affairs/issues (Mean=5.50; SD=2.93) and science or science-related issues (Mean=5.50; SD= 2.85) (Figure 3.16), along with the highest levels of discussion with people who are a different race or ethnicity (Mean=4.74; SD=2.94), different education levels (Mean=5.53; SD=2.98), different religion (Mean=5.46; SD=3.14) and those with different political views (Mean=4.82; SD=2.80) (Figure 3.17).

Figure 3.16: ANOVA results for American Science Audiences "How often do you discuss public affairs or public issues with others?" and "How often do you discuss science or science-related issues with others?"



n=2858; All variables p≤.001; 0 indicates *never*, 10 indicates *very often*

Figure 3.17: ANOVA results for American Science Audiences "How frequently do you discuss public issues with people who are of a different race or ethnicity than you … people who have different education levels than you … people who are of a different religion than you … people who have different political views than you?"



n=2858; All variables p≤.001; 0 indicates *never*, 10 indicates *very often*

Boosters

Boosters tie for third or fall to fourth place among all segments for this set of questions including frequency of discussion related to public affairs/issues (Mean=4.51; SD=2.93), discussion related to science or science-related issues (Mean=5.50; SD= 2.85) (Figure 3.16), along with discussion with people who are a different race or ethnicity (Mean=4.09; SD=3.05), different education levels (Mean=4.66; SD=3.11), different religion (Mean=4.41; SD=3.08) and those with different political views (Mean=4.25; SD=2.95) (Figure 3.17).

Uncertains

Uncertains claim the middle territory for frequency of discussion and heterogeneity of discussion related to science or science-related issues (Mean=4.03; SD=2.87) (Figure 3.16), along with discussion with people who are a different race or ethnicity (Mean=4.09; SD=3.05), different education levels (Mean=4.66; SD=3.11), different religion (Mean=4.41; SD=3.08) and those with different political views (Mean=4.25; SD=2.95) (Figure 3.17).

Skeptics

Skeptics report the lowest frequencies of discussion related to public affairs/issues (Mean=4.00; SD=3.18) and science or science-related issues (Mean=3.32; SD=3.07) (Figure 3.16). Skeptics also have the most narrow discussion networks, reporting relatively infrequent discussions with people who are of a different race or ethnicity (Mean=3.75; SD=3.36), different education level (Mean=4.31; SD=3.44), different religion (Mean=3.99; SD=3.41) or hold different political views (Mean=4.00; SD=3.37) (Figure 3.17).

Cynics

Cynics have fairly heterogeneous networks, reporting discussions with people who are of a different race or ethnicity (Mean=4.41; SD=3.47), different education levels (Mean=5.42; SD=3.32), different religion (Mean=4.58; SD=3.43) or hold different political views (Mean=4.81; SD=3.36) relatively often (Figure 3.17). Although Cynics discuss public affairs/issues (Mean=5.40; SD=3.20) more frequently than all segments except Champions, they discuss science or science-related issues (Mean=3.79; SD=3.19) less often than any group except Skeptics (Figure 3.16).

Discussion & Implications

The goal of this paper was to create an efficient and effective means of segmenting science audiences that produced distinct segments with strong statistical differences when subject to ANOVA discriminant testing. We were able to accomplish that task by using Ward's Method, identifying five science audience segments based on deference to science, religiosity, conservative/liberal social ideology and economic ideology which had strong statistical differences in regards to demographics, science knowledge, science-related media use, media cosmopolitanism and media affect.

Segmentation of an audience is only useful if groupings possess four characteristics: 1) segments must be internally similar and externally dissimilar, 2) characteristics of individuals within the segment must be observable, 3) segments must be of a sufficient size to justify the resources necessary to target for communication and 4) there must be practical means of communicating with the segment (Kotler & Keller, 2013).

Segments must demonstrate internal similarity and external dissimilarity. Post hoc ANOVA testing on demographic characteristics, science knowledge, science media use, media affect, media cosmopolitanism and attention to specific mass media channels validated the useful dissimilarity of segments and gives science communication practitioners a vivid profile of American Science Audiences.

Champions & Cynics

Those who follow science communication research would have easily predicted the existence of both the science Champions and Cynics segments. The specific proportion of the public that could be considered Science Champions might have been inscrutable, but the existence of a cohort of well-educated individuals with very low levels of individual religiosity, strong liberal leanings and high levels of deference is not a surprise. Likewise, the existence of a portion of the public that could be classified as Science Cynics, with strong religious guidance, conservative social and economic leanings and low levels of deference to science, is also not a surprise. Members of these segments for whom science issues are salient are the voices we perceive hearing in public discourse about the inclusion or exclusion of contested science in school curriculums, debates over public funding of science research and discussions about the regulation of science. Indeed the implied existence of these two segments guides much of the work that needs to be done in the field of science communication.

When considering targeting strategies, these segments warrant very different messaging and channel strategies. Champions report paying closer attention to news stories about science and technology, along with news stories about new scientific developments, across television, newspaper and online sources at high rates than all other segments (Figure 3.6 and Figure 3.7). However, despite their beliefs that they use a wide variety of media sources (Figure 3.9), have a more diverse media diet than their friends, and reserve judgment until they've heard different opinions in the media, Champions also admit to avoiding, hating and being angered by certain media personalities at higher rates than other segments (figure

3.10). Based on this, messages targeting Champions might be received best if they appeal to their perceived open-mindedness and deference to science, but are strongly channeled through moderate media channels, i.e. CBS, NBC or ABC networks and CNN, and delivered by media personalities or scientists/technical experts whose reporting is consistent with their views. Given the political leanings of Champions, messaging placed on MSNBC and NPR, which this segment uses at higher rates than other segments, might also be effective. Additionally, 20 percent of Champions report using *Twitter* at least weekly (Figure 3.13), 75.7 percent report using *Facebook* at least weekly (Figure 3.14) and 55.2 percent report using *YouTube* at least weekly (Figure 3.15), making these more attractive social networking sites as compared to other segments.

In contrast, Cynics report the lowest or second lowest rates of attention to science and technology online, along with new scientific developments online, in newspapers and on television (Figure 3.6 and Figure 3.7). Although this segment also the second lowest levels of media use that represents a wide variety of backgrounds and cultures, and lower levels of media diversity as compared to friends, Cynics do report that they reserve judgment until they've heard different opinions in media at the same rates as Champions (Figure 3.9). Despite reporting high levels of avoidance for certain media personalities, and being angered by certain viewpoints in the media, Cynics are less likely to claim they hate certain media personalities as compared to Champions. As with Champions, an appeal to perceived open-mindedness is important. For a strongly non-deferent segment, this might be achieved by using experts who are willing to deliver two-sided messages, i.e. the pro and con of a technology. Regarding channels, ABC, CBS and NBC may be just as useful for Cynics as Champions. But it should be noted that this segment attends to Fox News at greater rates and may benefit from messaging through that channel (Figure 3.11). Only 5.5 percent of Cynics report using *Twitter* at least weekly (Figure 3.13), 50 percent report using *Facebook* at least weekly (Figure 3.14) and 35.5 percent report using *YouTube* at least weekly (Figure 3.15). Based on this, *Facebook,* and to a lesser extent *YouTube,* may be useful channels. There isn't justification for *Twitter* as an approach to this segment.

It's important to note that although Cynics pay less attention to science in media than other segments, and have the lowest levels of deference to science, they are not markedly less knowledgeable than other segments. While Champions collectively score higher on the nanotechnology and synthetic biology-related knowledge questions in this study, Cynics collectively possess the greatest knowledge of fracking among all segments and perform on par with Boosters, Uncertains and Skeptics with regards to nanotechnology and synthetic biology (Figure 3.5). I note with caution, for the reader, that, with the exception of fracking, the other emerging science topics were chosen because they are somewhat unknown to the U.S. public. Because of this, there is a risk of over-interpreting results and mistakenly arriving at a conclusion that is not warranted by the results, and wrongly asserting that Cynics know less than the general public about science issues. Had the knowledge questions for this study focused on well-known science topics or controversies, the results might have been different. Therefore, instead of naming this segment the Disregarders, the Ignorant or the Deniers, all of which incorrectly imply a potentially value-laden basis for the segment, the name Cynics was chosen as a plain and direct reference to the segment's low levels of deference to science. Like the Cynics of ancient Greece, this segment may make a cult of indifference – to science, in this instance – but it may well be a thinking position rooted in their personal predispositions – low deference to science, high religiosity and high conservatism - rather than one taken out of ignorance.

Boosters & Skeptics

The existence of Boosters and Skeptics, given their similarities and their differences, are more interesting. These two groups are similar in terms of religious guidance and social ideology, and not too far from one another in terms of economic ideologies. The strong difference between the two groups occurs with regards to deference to science, where Boosters are strongly deferent and Skeptics significantly less so. Indeed, the results of the multinomial regression indicate that religious guidance, economic ideology and social ideology play a strong role in sorting individuals into the Skeptics segment, and deference to science plays a much smaller role. In contrast, both items measuring deference to science play a nearly exclusive role in sorting individuals into the Boosters segment. In other words, world views with regards to economic and social ideologies, and levels of religious guidance matter for one group, Skeptics, but not the other, Boosters, despite the fact that these world views are similar in both groups. Put another way, deference to science plays a strong role for one group, Boosters, but not the other, Skeptics.

Education might explain the difference between the two as Boosters have significantly greater levels of education than Skeptics. Perhaps gender and race also play a role, as Boosters are more likely to be male or White than Skeptics. The differences with one segment that is somewhat religious, moderate and deferent and another that is also somewhat religious, moderate but not deferent are interesting, consistent with earlier work in the field, but warrant future work further exploring the relationship between individual science outlooks and individual levels of religion, science deference and, likely, education.

When considering targeting for these segments, messaging strategy likely plays a larger role than channel strategy. Science deference is an important variable describing Boosters, and is an important consideration when constructing messages for this segment. Unlike their science-deferent brethren, Champions, this segment is a mixed political bag and this should be foremost in mind for messaging.

True to their place on the segmentation spectrum, Boosters consistently rank second highest in reported levels of attention to news stories about science and technology, and news stories about new scientific developments, online, in newspapers and on television (Figure 3.6 and 3.7). Boosters are mainstream media omnivores, paying attention to all mainstream media – ABC/CBS/NBC, CNN and MSNBC – along with Fox News and NPR, albeit at lower rates than their attention to network news or CNN. Although only 12.2 percent of Boosters report using *Twitter* at least weekly (Figure 3.13), 52.2 percent use *Facebook* at least weekly (Figure 3.14) and 44.5 percent use *YouTube* at least weekly (Figure 3.15). As with Cynics, *Twitter* may not be an effective route to reach Boosters, but *Facebook* and *YouTube* may be promising.

Religiosity and conservative ideologies are strong characteristics of Skeptics, which should be kept foremost in mind when messaging for this segment. Another important consideration is that Skeptics have lower than average levels of science knowledge for synthetic biology and nanotechnology (Figure 3.6) and lower levels of education when compared to other segments. While this segment scores the lowest on the media cosmopolitanism index (Figure 3.9), it is also the least likely to avoid certain media personalities, hate certain media personalities or be angered by certain viewpoints in the media (Figure 3.10). Compared to other segments, this group tends not to pay a great deal of attention to specific media outlets, although network news (ABC/CBS/NBC) and CNN attract their attention (Figure 3.11).

Skeptics have one of the lowest rates of *Twitter* use, with 9.6 percent reporting they use the platform at least weekly (Figure 3.13), and *YouTube* use, with 35.6% reporting they use the platform at least weekly (Figure 3.15), but *Facebook* use is relatively robust for this segment. A total of 59 percent of Skeptics report using *Facebook* at least weekly, which could be useful as the primary channel for reaching this segment (Figure 3.14). Specifically targeted *Facebook* communication delivering messaging consistent with their religious and ideological stances and using tools like video and illustration to overcome lower levels of science knowledge and education may be an efficient and effective way to reach this group.

Uncertains

Uncertains are a chimera segment that has something in common with several segments, but one that often sits in the middle without a clear opposite position of another singular segment. Uncertains have levels of religious guidance, economic and social ideologies closest to those seen in Cynics, and levels of deference to science squarely in the middle of all five segments. Looking only at the bases variables, we might expect members this group to fall into either Skeptics or Cynics. A closer look at discriminant variables is enlightening as Uncertains have education and science knowledge levels comparable to what was observed in Boosters, and a racial make-up comparable to that of Champions. Uncertains score fairly high on media cosmopolitanism (Figure 3.9), but also fairly high on media affect (Figure 3.10). They pay moderate levels of attention to all media but are particularly strong users of Fox News along with the Cynics segment (Figure 3.11). It is unknown whether Uncertains are engaged and actively seeking information regarding science, or disengaged and haphazardly encountering information as part of their media routines, and it would be interesting to explore this further and possible examine if this segment is somewhat swayable in its outlook based on the views they encounter in media.

Based on these results, an information-rich, but balanced, messaging strategy will likely be useful for Uncertains. Given their similarities to Cynics, a two-sided message strategy weighing the pro and con of a technology might also be useful for this segment. Channel strategy is a bit challenging for Uncertains. Although this segment uses a wide variety of television channels, there isn't a clear cut single path to reach this group, and thus message distribution runs the risk of being high cost. Unlike other segments for which social networking sites may be a strong channel choice, Uncertains are guaranteed to attend to these. Only 11.1 percent of Uncertains use *Twitter* at least weekly (Figure 3.13), 49.7 percent report using

Facebook at least weekly (Figure 3.14), and 39.1 percent use *YouTube* at least weekly (Figure 3.15). Perhaps the saving grace for Uncertains is that their media habits overlap those of other channels, and thus messaging directed at Cynics through Fox News or Skeptics through network news is also likely to be noticed by members of this group. That the messaging on those channels is optimized for other segments may continue to be a challenge for reaching Uncertains.

Conclusion: Implications of Segmented Media Use

Science communication scholars are just beginning to scratch the surface of how science audiences can be parsed and classified for the purpose of better understanding how individual traits, like religiosity, ideology and deference to science co-occur across large numbers of individuals. This study's goal was to contribute to that effort by creating an efficient and effective means of segmenting American Science Audiences in such a way that produced demographically distinct segments that also displayed distinct media habits. It was successful in that effort.

Using a small number of questions about conservative/liberal economic ideology, personal religiosity and deference to science that could be easily incorporated into a study, this research identified five American Science Audience segments using Ward's Method of agglomerative hierarchical clustering. Using multinomial regression this study was able to identify which bases variables increased the likelihood of individuals being sorted into one segment versus another. After subjecting segments to ANOVA to test discriminant variables, we were able to conclude that the five segments demonstrated strongly significant differences ($p \leq .001$) in racial composition, age, education and science knowledge. Additionally, segments were strongly statistically different ($p \leq .001$) in attention to media across 19 different media variables that were categorized into attention to science in the media, media cosmopolitanism, media affect and generalized media attention, and five different variables related to issue discussion.

Returning once again to our median-ager, we've found that she is living in a media environment in which information about synthetic biology is scant, at best. Although there are many who our outwardly similar to our particular median-ager, her own particular mix of value predispositions – deference to science, religiosity, economic ideology and social ideology – allow us to segment her into a grouping with other like-minded individuals who are demographically similar and share common knowledge levels, media habits, social networking site behaviors and discussion behaviors, among other traits. The next study will determine if these segments are a curious novelty, or if they have potential to help us better understand our median-ager and her fellows.

Chapter 4. Heterogeneity of Networks, American Science Audiences, Attitudes and Behaviors Related to Synthetic Biology

Let's return again to our hypothetical median-age American resident. In the process of uncovering how her attitudes toward synthetic biology are influenced, the first study highlighted the scant amount of synthetic biology news coverage in the United States, which means it isn't likely that she is encountering enough topic-specific information to arrive at an informed opinion about this emerging technology. The second study highlighted how researchers can use a small number of variables to segment our median-ager and her compatriots into groups of like-minded individuals who also share her particular blend of personal predispositions, demographics and media habits. This final study will determine if and how her individual value predispositions and media habits affect three different dependent variables of interest: her individual level of support for synthetic biology, the likelihood that she will seek additional information about synthetic biology or the likelihood that she will discuss synthetic biology with others. This study will then apply American Science Audiences to the same outcomes to determine if personal predispositions and media habits have equal effects on the five segments identified in the previous study.

Discussion Effects

To refer to the introduction to this dissertation: People obtain information in a variety of ways ranging from formal education to media to interaction with one another. Information gleaned from conversation with others can take different forms ranging from light discussion of issues with like-minded friends to all-out confrontation with family at the Thanksgiving table over contentious issues. In each of these situations individuals use relatively sophisticated strategies in combination with personal value predispositions to process socially-obtained information (Huckfeldt & Sprague, 1995).

Although individuals may have natural biases which predispose us to seek out like-minded others, it is our interactions with differently minded others that is often considered a significant pre-condition for change or influence to occur (Huckfeldt & Sprague, 1995; McCleod, Sotirovic, & Hoblert, 1998). In this respect heterogeneous discussion networks, and the frequency of issue-related discussions, may be more important than ever as our modern world allows us to screen out disagreeable information from online news sources, and limit exposure to views different than our own through selective attention to various media channels. Face to face interactions are different. However much she may wish it, our hypothetical median-ager can't block what her salty brother-in-law says after one too many glasses of wine at Mom's house. Although she may rue the day he became family, his dissonant opinions force her to elaborate on new information and/or reexamine her existing stances.

Indeed, for some time communication researchers have found evidence that, for political information at least, discussing issues with others, even a salty brother-in-law, helps resolve inconsistent views (Eliasoph, 1998) and leads to greater levels of issue-related understanding (Eliasoph, 1998; Eveland & Scheufele, 2000). Even the expectation of future discussion, and not just discussion itself, has an effect on individuals as motivation to use news content in later discussion is positively related to elaboration on news content, and elaboration is positively related to knowledge (Eveland, 2004). Further, if our median-ager anticipates engaging in opinion-based discussions she is more likely to seek out topic-relevant persuasive news content – i.e. opinion pieces – than informational news content (Xenos et al., 2011). In other words, if our median-ager believes she will engage in an issue-related conversation at some point in the future, then she may be motivated to use and elaborate on issue-related news content, and the nature of that content – opinion-based or information-based – may be determined in part by the type of conversation she anticipates.

The relationship between discussion and media use is especially relevant to this dissertation. Early work on the topic found that discussion of the news was a more powerful predictor of knowledge than the extent of an individual's news media exposure (Robinson & Levy, 1986) and later research refined that understanding by discovering that discussion plays a strong moderating role for the relationship between media use and current events knowledge, between media use and political participation (Scheufele, 2002) and also moderates the relationships between Internet campaign exposure and political efficacy and Internet campaign exposure and political knowledge (Scheufele & Nisbet, 2004). Additionally these moderating effects occur with computer-mediated interpersonal discussion as well as face-to-face discussion (Scheufele, Hardy, Brossard, & Waismel-Manor, 2996), an important finding for an era in which much of our person-to-person communication occurs via social networking sites or text message.

Discussion Networks

Discussion and debate with differently-minded others is the foundation of a deliberative democracy. The underlying logic is that reasonable, well-informed citizens can arrive at mutually agreed-upon decisions related to contested issues through well-reasoned debate. While the underlying principal may be sound, the actual process of discussion and all of its many aspects, ranging from the composition of one's discussion partners to the ways in which an individual seeks or attends to information in preparation for discussion, is a complicated and multifaceted process.

This study is concerned with the following research question: When confronted with an emerging technology, like synthetic biology, for which an individual has very little knowledge, how does frequency of issue-related discussion, and the degree of heterogeneity within that individual's discussion network affect her tendency to engage in synthetic biology-related information seeking or synthetic biology -related sharing and discussion, and how do those discussion-related variables affect the level of support she expresses toward synthetic biology as an emerging technology? Although there might be one answer for the population as a whole, this dissertation is specifically interested in differences between different American Science Audience segments. Thus this study also asks: does frequency of issue-related discussion and heterogeneity of individual discussion networks have the same effect across all American Science Audience segments for the three dependent variables in this study, or do effects vary across segments?

Put another way, what would our theoretical median ager answer if this study were to ask her the following questions directly? “Are you the type of person that discusses political and scientific issues?” and “Are you the type of person that discusses political and scientific issues with others who are not like me? Or do you tend to discuss those issues with people who look, think and believe in the same ways that you look, think and believe?” While the former question is measures an internal characteristic, the latter questions are proxies for the pressures she might feel when discussing issues with others not like herself (Scheufele, Hardy, Brossard, Waismel-Manor, & Nisbet, 2006), specifically the cognitive dissonance or affect that accompanies discussion with someone(s) whom she knows or suspects disagrees with her. Given the answers to these questions, in what ways does her perception of herself and her perception of the structure of her social world affect her likelihood of seeking issue-related information, discussing an issue, and, ultimately, supporting the issue?

Heterogeneity of Discussion Networks

This study is more concerned with the specific effects of certain types of discussion rather than the effects of discussion in general. The majority of the literature on the effects of heterogeneous discussion networks focuses on political discussions. This review excludes the effects of heterogeneous discussion networks on political participation, for which there is a significant body of work demonstrating varying effects (see Scheufele et al., 2006) as the outcome of political participation is quite different than the outcomes explored in this study. Instead, this review focuses solely on the effects of heterogeneous discussion networks as related to knowledge, information seeking, information processing, and the more abstract concept of support.

Heterogeneous discussion networks are positively related to political knowledge (Kwak, Williams, Wang, & Lee, 2005; Scheufele et al., 2006), an individual's likelihood of seeking out issue-related information and thorough examination of issues (Delli-Carpini, Lomax-Cook, & Jacobs, 2004). Indeed, encountering different viewpoints increases the need to seek information on a wider range of topics (Scheufele et al., 2006) which in turn prompts issue-related newspaper and television news use (Scheufele et al., 2006; Scheufele, Nisbet, Brossard, & Nisbet, 2004). Additionally the anticipation of having conversations with opposing others who hold views different than one's own increases the likelihood that an individual will seek out opinion-related news content, i.e. editorials, rather than objective news stories (Xenos et al., 2011). We might imagine our hypothetical median-ager attending to issue-specific news and opinion pieces to arm herself in preparation for battle with her salty brother-in-law at the Thanksgiving table.

Exposure to dissonant views within one's network is positively related to awareness of the rationales for those dissonant views and increases the likelihood that an individual will interact with a person who holds differently-minded views (Mutz, 2002b). Interestingly, discussion network heterogeneity is also negatively related to confrontational face-to-face interactions (Mutz, 2002a). Despite the negative relationship with confrontational interactions, which may be a necessary part of democracy, the sum of network heterogeneity research could seem to indicate that it is a panacea for difficult democratic deliberations at least as far as encouraging one to seek or attend to issue-related information and elaborate on the views different than one's own. Alas, it is never that straightforward.

A growing body of research has also explored how discussion affects attitude toward emerging technologies. This literature found the multi-dimensional variable frequency of discussion with heterogeneous others is positively correlated with support of emerging technologies, but is not predictive, and individuals with strong value positions tend to stand on their original positions when faced with disagreement (Shih, Scheufele, & Brossard, 2013). In contrast, engaging in discussion with a network of like-minded individuals can lead to the development of extreme attitudes (Binder, Dalrymple, Brossard, & Scheufele, 2009).

Referring back to the literature on political issue discussion, extremity of issue positions had a large and strong relationship with awareness of the rationale for one's own views, and a negative relationship with awareness of rationales for opposing views (Mutz, 2002b).

Frequency of Discussion

Discussion frequency is positively related to elaboration on news content (Eveland, 2004), knowledge (Eveland, 2004; Eveland & Hively, 2009; Eveland & Thomson, 2006; Holbert, Benoit, Hansen, & Wen, 2002; Kwak et al., 2005), issue-salience (Holbert et al., 2002) and political participation (Mutz, 2002a; Scheufele et al., 2004). Cumulatively, there is evidence that discussion might build a more informed and active citizenry (Eveland & Thomson, 2006; Holbert et al., 2002; Kwak et al., 2005).

It becomes more nuanced. Overall discussion frequency is positively associated with both knowledge and participation, but discussion with heterogeneous others is positively related to knowledge, but not political participation; the opposite of which is true for frequency of discussion with homogenous discussion partners where there is a positive relationship to political participation, but not knowledge (Eveland & Hively, 2009). Looking specifically at emerging technologies, both frequency and valance of discussion can affect perceived risks and benefits for an emerging technology (Binder, Scheufele, Brossard, & Gunther, 2011).

Research cited in the literature review failed to find a main effect for the relationship between frequency of discussion with heterogeneous others and support for emerging technologies. However this same study did find a negative relationship between the dependent variable support for stem cell research and the interaction between religiosity and frequency of discussion with heterogeneous others, and a positive effect for the same dependent variable and the interaction between deference to science and frequency of discussion with heterogeneous other (Shih et al., 2013). Further, related research found that frequency and valance of discussion of can affect perceived risks and benefits for an emerging technology (Binder et al., 2011).

Issue-Related Information Seeking

This study conceptualizes synthetic biology-related information seeking and attention to synthetic biology-related information in the news as potential independent variables related to discussion about the topic. Although information seeking is positively associated with issue-related knowledge (Turner, Rimal, Morrison, & Kim, 2006), individuals tend to avoid information when a topic is distressing (Brashers, Goldsmith, & Hsieh, 2002) and when new information potentially conflicts with their belief systems (Babrow, 2001; Brashers et al., 2000) or current state of knowledge (Brashers et al., 2000).

Despite possible cognitive dissonance associated with acquiring new information, education, pre-existing issue-related knowledge and issue salience are positively related to information seeking (Hovick, Liang, & Kahlor, 2014; Niederdeppe, 2008), along with age, income and being a woman (Hovick et al., 2014).

Indeed, the perceptions we hold of our discussion partners can affect the manner in which we acquire and process information in anticipation of discussion. The extent to which an individual perceives that she has issue-related knowledge which is known to those in her discussion network, and the extent to which she believes that her discussion network expects her to share such information is also positively associated with both information seeking and sharing (Yanz, Kahlor, & Griffin, 2014). Additionally, individuals are more motivated to acquire and process information on an issue when they expect relatively strong opposition from discussion partners (Levine & Russo, 1995).

However, looking more closely at the emerging technology literature, there is limited evidence that support for an emerging technology is related to information seeking about that technology, and at least one study found no support for the notion that anticipated discussion related to the emerging technology prompts information seeking (Xenos et al., 2011).

Hypotheses

Based on the literature, this study proposes the following:

H1: Science-media related news use will be positively associated with synthetic biology-related information seeking **(H1a)** synthetic biology-related discussion **(H1b)**, and American Science Audience segments with higher levels of science-related news use will have stronger positive relationships between this variable and both synthetic biology-related information seeking **(H1c)** and synthetic biology-related discussion **(H1d)**.

H2: Issue salience will be positively associated with synthetic biology-related information seeking **(H2a)**, synthetic biology-related discussion **(H2b)**, and support for synthetic biology **(H2C).** American Science Audiences with greater levels of issue-related salience will have stronger positive associations between issue salience and synthetic biology-related information seeking **(H2d)**, synthetic biology-related discussion **(H2e)** and support for synthetic biology **(H2f).**

H3: Knowledge will be positively associated with synthetic biology-related information seeking **(H3a)** and synthetic biology-related discussion **(H3b)**, and American Science Audience segments with greater levels of synthetic biology related knowledge will have stronger positive associations between knowledge and synthetic biology-related information seeking **(H3c)** and synthetic biology-related discussion **(H3d)**.

H4: Individual network heterogeneity will be positively associated with synthetic biology-related information seeking **(H4a)**, and American Science Audience segments with higher levels of individual network heterogeneity will have stronger positive relationships between these two variables **(H4b).**

H5: Frequency of discussion will be related to synthetic biology-related information seeking **(H5a)** and issue-related conversation **(H5b)** and support for synthetic biology **(H5c)**, and American Science Audience segments with that engage in more frequent issue-related discussions will have stronger positive associations between that variable and both synthetic biology-related information seeking **(H5d)**, synthetic biology-related discussion **(H5e)** and support for synthetic biology **(H5f)**.

H6: Individual network heterogeneity will be positively associated with synthetic biology-related discussion **(H6a)**, and American Science Audience segments with higher levels of individual network heterogeneity will have stronger positive relationships between these two variables **(H6b)**

H7: Individual network heterogeneity will be negatively associated with support for synthetic biology **(H7a)**, and American Science Audience segments with higher levels of individual network heterogeneity will have stronger negative relationships between these two variables **(H7b)**.

Because the focus of this research is on the effects of issue-related discussion frequency and individual network heterogeneity we did not hypothesize results for demographic variables or media sentiment as the effects of these variables are beyond the scope of this study. Nevertheless, these are important control variables and results for these variables will be reported in the final analysis.

Data and Sampling

This study used the same data as in the American Science Audience study, a survey created by the Scimep Lab and administered by GfK Knowledge Networks between July 31, 2014 and August 19, 2014. The study was administered online and included participants from a randomly selected national sample of people, the profile of which was described on page 94 of chapter two. The primary purpose of the study was to identify the effects of incivility in online forums on individual perceptions of emerging technologies. To that end, participants were assigned to one of four scientific topics (synthetic biology, nanotechnology, fracking and climate change) and one of eight conditions described in Table 3.2. Only respondent assigned to the synthetic biology condition were used for this study. Additionally, this study was not interested in the effects of the experimental conditions, and thus the conditions were controlled for in the final analysis.

Prior to exposure to the experimental stimulus, participants were first asked a series of questions regarding their online and offline news habits for a variety of topics and media channels, then presented with four different scientific topics and their definitions (nanotechnology, synthetic biology, fracking and climate change) before completing series of questions about their perceived level of knowledge and the degree to which each topic was important to them, personally. Respondents next answered a series of questions testing their actual knowledge as related to the scientific topics along with a set of questions related to their knowledge of civics/politics. A variety of personal predispositions, ranging from individual conflict styles to political ideology and deference to science, were also asked prior to the stimulus. Additionally, respondents answered a lengthy battery of questions regarding their own media use.

Respondents were then exposed to the stimulus, which consisted of a brief neutral article announcing potential hearings related to synthetic biology. The article was accompanied by a set of reader comments. These comments were varied as civil/uncivil, few indicated/many indicated and moderated/unmoderated. After reading the article and its comments, respondents were asked a series of questions about the article itself and the topic it covered. The questions related to the dependent variables in this study were asked post-hoc. If needed, respondents were given the following definition of synthetic biology by 'mousing over' the highlighted text *synthetic biology* during the survey:

> *"Synthetic biology is the use of advanced science and engineering to make or redesign living organisms, such as bacteria. Synthetic biology involves making new genetic code, also known as DNA, which does not already exist in nature."*

A total of 3,166 respondents across all conditions finished the survey for a completion rate of 48 percent. In total, 808 of those respondents were assigned to the synthetic biology condition. Again, because this study is not interested in the effects of the civility, moderation or comment quantity conditions, these were controlled for in the analysis, but reported here for posterity (Table 4.1).

Table 4.1: Survey Conditions

	Indicated Few Comments		Indicated Many Comments	
Moderated Comments	Civil Tone	Uncivil Tone	Civil Tone	Uncivil Tone
Not Moderated Comments	Civil Tone	Uncivil Tone	Civil Tone	Uncivil Tone

Measures

Dependent Variables

Each of the three dependent variables were derived from questions asked post-hoc after the respondents read the article and accompanying comments about synthetic biology. The first dependent variable, synthetic biology-related information seeking, is concerned with how the search for information and attention to information is affected by discussion frequency and individual discussion network heterogeneity. In this conceptualization, seeking and attending to issue-related information could be an antecedent to discussion or occur subsequent to discussion. Additionally this study recognizes that these behaviors may also be conducted to satisfy an individual's internal need to know more about a topic.

Synthetic biology-related information seeking is a two-item measure including the questions "How much do you agree or disagree with the following? I would seek out more information about synthetic biology" and "I would pay closer attention to the topic when I encounter it in the news" (Pearson's r = 0.84).

The second dependent variable, synthetic biology-related discussion, combines the measures "I would share the news article with others," and "I would have conversations with others about the topic presented in the news article and comments," (Pearson's r=0.83). The first indicator in this conceptualization, sharing, is included as recognition that sharing issue-related information is a form of discussion or an attempt to begin discussion.

The third and final dependent variable, support, is not an aspect of conversation but a variable of wide interest in science communication research. It is included in this study in order to determine the extent to which discussion frequency and heterogeneity of individual discussion networks affect support for synthetic biology as an emerging technology. Support measures an internal individual characteristic by combining "Overall, I support the use of synthetic biology," and "Overall, I support federal funding for synthetic biology research," (Pearson's r=0.90).

Independent Variables

Demographics

The analysis included the demographic variables age (Mean=46.73 years; SD=17.44), income (median household income = $50,000-$59,999), gender (female=50.8%) and education (less than high school = 12.4%; high school diploma or GED = 29.6%; some college or associate degree = 29.0%; bachelor's degree=16.4%; master's, professional or doctorate degree = 12.6%).

Value Predispositions

Because this study is interested in the different effects of value positions by segment, it uses each of the bases variables -- individual religious guidance, political ideology and deference to science – as opposed to segment assignment as independent variables Thus, it is able to compare results across segments in order to understand the individual contribution of each variable to overall individual variance within each segment. As with segmentation in the earlier study, religious guidance consisted of a single question ”How much guidance does religion provide in your everyday life?” measured on an 11-point scale, with zero indicating “no guidance at all” and 10 indicating “a great deal of guidance” (Mean=5.43; SD=3.58). Political ideology consisted of two questions measured on a seven point scale, “In terms of economic issues, would you say you are … very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative” and “Now, thinking in terms of social issues, would you say you are … very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative,” (Pearson’s r=0.82; mean=4.18; SD=1.41). Deference to science consisted of two questions measured on an 11-point scale with zero indicating “do not agree at all,” and 10 indicating “agree very much,” “How much do you agree or disagree with the following statements: Scientists know best what is good for the public,” and “Scientists should do what they think is best, even if they have to persuade people that it is right,” (Pearson’s r=0.82; mean=3.91; SD=2.60).

Science-Related Media Use

Science-related media use was a three item variable which measured attention to science in newspapers (Cronbach’s *alpha*=0.93; mean=3.53; SD=3.01), on television (Cronbach’s *alpha*=0.94; mean=3.94; SD=3.03) and online (Cronbach’s *alpha*=0.93; mean=3.03; SD=2.87). These were measured on an 11-point scale where 0 indicated “none” and 10 indicated “a lot” and included the questions, “How much attention do you pay to news stories about the following topics when you read the newspaper, either in print or online/watch television/go online … science and technology … [the] political or ethical implications of emerging technologies … new scientific developments in fields like synthetic biology.”

Social Networking Site Use

Social networking site use was measured as a single question for three separate variables, “How often do you use any of the following, if at all? *Facebook* (Mean=3.65; SD=2.83) *Twitter* (Mean=0.81; SD=1.77) and *YouTube* (Mean=2.73; SD=2.25). Answers ranged from 0 to 7, where 0 indicates never, 1 indicates less than once a month, 2 indicates once a month, 3 indicates two to three times per month, 4 indicates once a week, 5 indicates two to three times a week, 6 indicates daily and 7 indicates multiple times per day.

Media Sentiment

Recent scholarship has highlighted the way individuals tend to consume news from a variety of mediums or sources (A. Anderson, Brossard, & Scheufele, 2010; Taneja, Webster, Malthouse, & Ksiazek, 2012; Yuan, 2011) often in complex patterns (Taneja et al., 2012; Yuan, 2011) that are related to age, education level, science-specific educational achievement, trust in news media and trust in online media (Su, Akin, Brossard, Scheufele, & Xenos, 2015). One study found that science media repertoires, in particular, are diverse, finding that 84 percent of the public relies on a mix of formats to acquire information about science, 8 percent rely on a single format, i.e. newspaper only or online only, and 8 percent do not use media at all to obtain science information (Su et al., 2015). This present study is interested in individuals’ perceptions of the diversity of their own media repertoire, in itself and as compared to those around them. Termed *media cosmopolitanism*, this variable was measured as a scale that included the questions “How much do you agree or disagree with each of the following statements? I use media sources that represent a wide variety of backgrounds and cultures … I tend to have a more diverse media diet than most of my friends.” Because we were also interested in the extent to which individuals perceive that they reserve judgment when using diverse media, a third question was added “I often reserve my judgment until I have had a chance to hear the different opinions represented in the media” (Cronbach’s *alpha* =0.79; mean=4.98; SD=2.53).

A second measure related to selective exposure and media repertoires was included to measure the degree to which individuals avoid certain media personalities. This measure was prompted by results of the American Science Audience segments which revealed clear patterns of use or avoidance of Fox News, Rush Limbaugh, NPR and CNN among individuals in the Champions and Cynics segments. Termed *media affect*, this was measured as a broad, general variable on a scale which included “How much do you agree or disagree with each of the following statements? … There are certain media personalities I avoid because I strongly disagree with their views … There are certain media personalities I have come to hate because of the things they stand for … The viewpoints expressed in certain media make me angry.” Answers for items in both scales ranged from 0 to 10 with the lower end of the scale representing “disagrees strongly” and the higher end of the scale representing “agree strongly” (Cronbach’s *alpha*=0.86; mean=5.22; SD=2.89).

Issue Salience & Knowledge

Although there are different conceptualizations of salience encompassing various facets of the variable, including attention to an issue, relative prominence of an issue and valence or attitude toward an issue (Kiousis, 2004), this dissertation is primarily interested in a more narrow definition that considers salience as the degree to which an issue is relevant, i.e. personally important, to an individual (Carter, 1965) (Sears & Whitney, 1973). To that end, issue salience was measured with a single question, “On a scale of 0 to 10, how important is synthetic biology to you, personally?” Zero indicated “not important at all” and 10 indicating “very important” (Mean=3.51; SD=2.85). Because averages for this variable were not reported in the previous chapter on American Science Audiences, they are provided here: Champions (Mean=4.14; SD=2.97), Boosters (Mean=4.04; SD=2.80), Uncertains (Mean=3.22; SD=2.62), Skeptics (Mean=3.16; SD=2.87) and Cynics (Mean=2.96; SD=2.91).

Science knowledge serves as a mediator for the relationship between media effects and perceptions of science issues (Nisbet et al., 2002). Although the role of knowledge is sometimes small and moderated by other variables, it can have a different effect on those with conservative ideologies, high degrees of religiosity and/or low levels of deference to science (Ho et al., 2008). In this study, synthetic biology knowledge was measured with three questions: “Could you tell us for each of the following statements if you think it is true or false? … Recently, the Obama Administration banned all synthetic biology research (false) … Synthetic biology is the application of artificial intelligence to biological systems (false) … The first biosynthetic insulin went on sale as early as the 1980s (true).” Generally speaking, knowledge for this subject was low with an overall sample mean of 1.03 (SD=1.07). Despite this, 20 percent of Champions answered all three questions correctly, 11.8 percent of Boosters, 11.7 percent of Uncertains, 7.7 percent of Skeptics and 13.4 percent of Cynics did the same.

Discussion Frequency

Issue-related discussion frequency was created as a two-item measure including “How often do you discuss public affairs or public issues with others?” and “How often do you discuss science or science-related issues with others?” (Pearson’s r=0.82). Answers ranged from 0 to 10 with the lower end of the scale indicating “never” and 10 indicating “very often” (Mean=4.24; SD=2.80).

Heterogeneity of Networks

The goal with this measure is to approximate the degree of cross-cutting pressure the respondent believes she may encounter as a result of a heterogeneous discussion network. In other words, this study seeks to measure the degree to which an individual may feel discussion-related pressure as a result of holding views that are different from those of her discussion partners. This is difficult to measure directly, but previous research has found that using a proxy measure of network heterogeneity, specifically the degree to which an individual perceives her discussion network to be heterogeneous relative to sociodemographic variables, is an effective measure of the cross-pressure felt by that individual (Scheufele et al., 2006).

Heterogeneity of individual discussion networks included four questions: “How frequently do you discuss public issues with people who are of a different race or ethnicity than you … people who have different education levels than you … people who are of a different religion than you … people who have different political views than you?" Answers ranged from 0 to 10 with the lower end of the scale indicating "never" and 10 indicating "very often" (Cronbach's *alpha*=0.93; mean=4.42; SD=2.91).

Analysis

The analysis was conducted using ordinary least squares (OLS) regression. Post-stratification demographic weights were applied to the OLS regression to ensure the results were representative of the general United States population. Independent variables were entered in assumed causal order to determine their relative contribution to the overall explanatory power of the model. Because our primary goal did not involve utilizing the experimental conditions, these were entered first. Blocks were entered in the following order:

Block 1: Condition (civility condition, moderation condition, experimental manipulation check)

Block 2: Demographics (age, gender, income, education)

Block 3: Value predispositions (religious guidance, political ideology, deference to science)

Block 4: Science-related media use (attention to science in newspaper, attention to science on television, attention to science online)

Block 5: Social networking site use (*Facebook, Twitter, YouTube*)

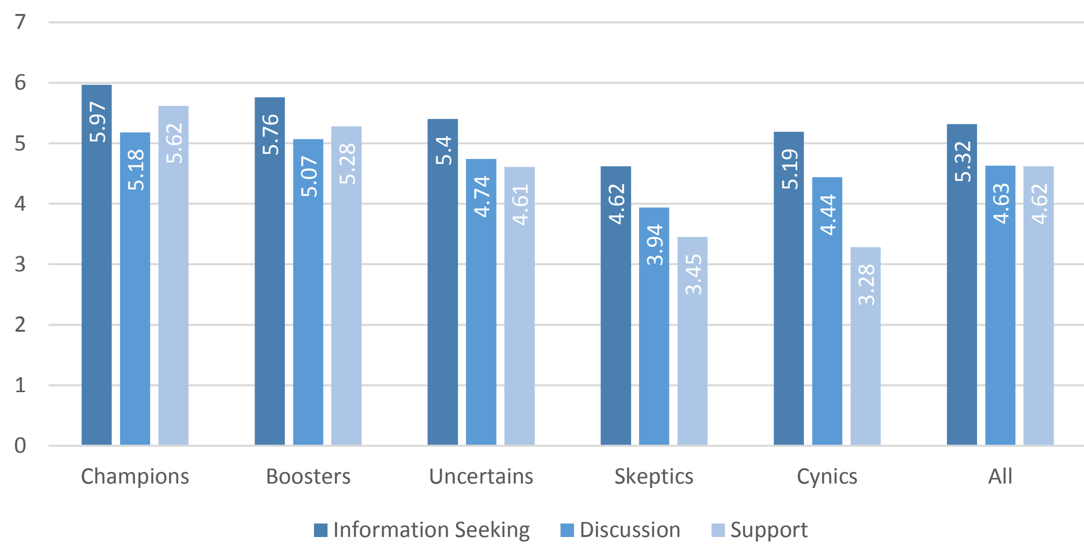
Block 5: Media sentiment (media cosmopolitanism, media affect)

Block 6: Knowledge (synthetic biology knowledge)

Block 7: Heterogeneity of networks (Discussion frequency scale, heterogeneity of individual network scale)

An initial regression using the entire sample was performed for each dependent variable in order to establish effects for the entire sample as a whole. Subsequent regressions for each of the dependent variables were conducted for each American Science Audience by filtering out respondents classified as members of segments other than the one under consideration. In a number of instances, particularly with regards to Champions and Cynics, the segment population was small enough that Type II errors are evident even after adjusting acceptable p-values to $p \leq .10$ at the segment level. This is noted here and also in the limitations section.

Figure 4.1: Mean and standard deviation by American Science Audience segment for dependent variables synthetic biology-related information seeking, synthetic biology-related discussion and support for synthetic biology



	Information Seeking		Discussion		Support	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Champions	5.97	(2.55)	5.18	(2.42)	5.62	(5.27)
Boosters	5.76	(2.62)	5.07	(2.46)	5.28	(2.51)
Uncertains	5.40	(2.78)	4.74	(2.59)	4.61	(2.47)
Skeptics	4.62	(3.37)	3.94	(3.03)	3.45	(2.8)
Cynics	5.19	(3.33)	4.44	(3.19)	3.28	(3.06)
All	5.32	(2.99)	4.63	(2.77)	4.62	(2.78)

Champions n=65; Boosters n=203; Uncertains n=154; Skeptics n=200; Cynics n=74; All n=706; ANOVA p≤.001

Results

Demographics

Considering the full sample, age and education do not have a statistically significant relationship to synthetic biology-related information seeking (Table 4.2), synthetic biology-related discussion (Table 4.3) or support for synthetic biology (Table 4.4). Gender, specifically being female, has a small positive association with synthetic biology-related information seeking (B=0.06; p≤.10) and being male has a small association with support for synthetic biology (B=-0.06; p≤.05) (where male is low). Income has a negative relationship with synthetic biology-related discussion (B=-0.12; p≤.001) but is not related to the other dependent variables.

The demographics of Champions are only occasionally associated with the three dependent variables: There is a negative relationship between education (B=-0.12; p≤.10) and race (B=-0.17; p≤.05) for synthetic biology-related discussion (Table 4.3), and a positive relationship between income and discussion (B=0.14; p≤.10), and a slightly larger positive relationship between education and support for synthetic biology (B=0.14, p≤.05) (Table 4.4) that accounts for 7.8 percent of variance and 10.1 percent of the observed variance for synthetic biology-related discussion and support for synthetic biology, respectively, which are considerable contributions given the models' overall adjusted r-square of 28.8 for synthetic biology-related discussion (Table 4.3) and 21.7 for support of synthetic biology (Table 4.4).

Demographics were more frequently associated with outcomes for Boosters, but had less overall explanatory power. Age was positively associated with synthetic biology-related information seeking (β=0.12; p≤.01) but had no relationship with the other dependent variables (Table 4.2). Gender, specifically being female, was positively associated with both synthetic biology-related information seeking (β =0.12; p≤.001) (Table 4.2) and synthetic biology-related discussion (β =0.08; p≤.05) (Table 4.3) but negatively associated with support (β =-0.09; p≤.05) (Table 4.4). Education was strongly and negatively associated with synthetic biology-related discussion (β =-0.14; p≤.001) (Table 4.3), but was not related to support. Income had no association whatsoever with any of the three dependent variables for Boosters.

For Uncertains, age had no association with the three dependent variables and gender, specifically being female, had a positive association with synthetic biology-related information seeking (β =0.09; p≤.05) (Table 4.2). Income had a negative association with synthetic biology-related information seeking (β =-0.08; p≤.10) (Table 4.2) and synthetic biology-related discussion (β=-0.14; p≤.001) (Table 4.3) and a small, positive association with support (β=0.08; p≤.10) related to support. Education was positively associated with synthetic biology-related information seeking (β =0.07; p≤.10) (Table 4.2) and support (β =0.09; p≤0.10) (Table 4.4), but not synthetic biology-related discussion.

For Skeptics, age had an association with synthetic biology-related information seeking (β =0.09; p≤.05) (Table 4.2), and a small association with support (β=0.06; p≤.10) but no association with discussion. Gender, specifically being female, had a negative association with support (β =-0.12; p≤.001) (Table 4.4), but was not associated with information seeking or discussion. For Skeptics, income was negatively associated with synthetic biology-related information seeking (β =-0.06; p≤.10) (Table 4.2), and synthetic biology-related discussion (β =-

0.13; $p \leq .001$) (Table 4.3), but positively associated with support ($\beta = 0.07$; $p \leq .05$) (Table 4.4). Education was associated with support for synthetic biology for Skeptics as well, ($\beta = 0.07$; $p \leq .10$) (Table 4.4).

As with Champions, demographics had fewer associations for Cynics as compared to the other segments. There were no relationships between demographics and either synthetic biology-related information seeking or support for synthetic biology for this segment. Income had a negative association with synthetic biology-related discussion ($\beta = -0.13$; $p \leq .10$) along with education for this same dependent variable ($\beta = -0.11$; $p \leq .10$) (Table 4.3), but no other demographics had a statistically significant effect.

Table 4.2: OLS Regression predicting synthetic biology-related information seeking (final standardized betas reported)

	Full Sample n=706		Champions n=65		Boosters n=213		Uncertains n=154		Skeptics n=200		Cynics n=74	
Block 1: Condition												
Civility Condition (Uncivil=low)	-.04		.16	*	-.04		-.03		-.04		-.04	
Moderation Condition (Unmoderated=low)	-.04		-.11		.01		.06		-.05		.01	
Read Comments	.11	***	.18	**	.09	*	.10	*	.16	***	.17	*
Incremental R^2	***7.6***	*******	***5.4***	*******	***4.1***	*******	***4.4***	*******	***13.4***	*******	***5.3***	*******
Block 2: Demographics												
Age	.04		-.03		.12	**	.02		.09	*	.02	
Gender (Male=low)	.06	+	.11		.12	***	.09	*	.03		-.02	
Income (continuous scale)	-.03		.05		-.06		-.08	+	-.06	+	-.09	
Race (Non-white=low)	-.07	*	-.14	*	-.01		.02		.02		-.10	
Education (continuous scale)	-.00		-.04		-.06	+	.07	+	.02		-.07	
Incremental R^2	***1.1***		***0.3***		***4.1***	*******	***3.7***	*******	***4.3***	*******	***1.7***	
Block 3: Value Predispositions												
Religious Guidance	.05		.07		.06		.02		.09	**	-.05	
Political Ideology (Lib=low)	.02		.12		-.01		-.08	+	.01		.02	
Deference to Science	.12	***	.01		.14	***	.04		.07	+	-.01	
Incremental R^2	***3.6***	*******	***2.3***		***4.4***	*******	***1.2***		***6.1***	*******	***0.8***	
Block 4: Science-Related Media Use												
Newspaper	.00		.05		.02		.07		.06		.04	
Television	.10	*	.10		.18	**	.10	+	.06		.29	**
Online	.06		.15		-.03		.12	*	-.01		-.01	
Incremental R^2	***14.4***	*******	***17.1***	*******	***12.6***	*******	***16.7***	*******	***12.5***	*******	***23.8***	*******
Block 5: Social Media Use												
Facebook	.07	*	-.02		-.02		-.02		.11	**	-.08	
Twitter	-.08	*	-.20	**	-.01		.00		-.05		-.15	*
YouTube	.01		.14	+	.03		.01		.05		.14	+
Incremental R^2	***0.7***		***3.6***	*******	***0.3***		***0.3***		***2.7***	*******	***4.2***	*******
Block 6: Media Sentiment												
Media Cosmopolitanism	.14	***	.15	+	.13	*	.05		.18	***	.08	
Media Affect	.05		.03		.05		.10	*	-.03		-.05	
Incremental R^2	***3.7***	********	***2.4***	*******	***2.0***	*******	***1.9***	********	***3.1***	********	***1.7***	
Block 7: Knowledge												
Issue Salience	.20	***	.19	*	.23	***	.26	***	.15	***	.26	***
Synthetic Biology Knowledge	.08	*	-.07		.03	+	-.05		-.01		.13	*
Incremental R^2	***3.7***	*******	***3.1***	*******	***4.3***	*******	***5.4***	*******	***1.6***	*******	***8.0***	*******
Block 8: Heterogeneity of Networks												
Discussion Frequency Scale	.09	+	-.05		.03		.09		.22	***	-.05	
Heterogeneity of Discussion Network Scale	.02		.16	+	.02		.00		-.01		.19	*
Incremental R^2	***0.4***		***1.4***		***0.1***		***0.4***		***2.1***	*******	***1.7***	***+***
Adjusted R^2	***33.2***	*******	***29.4***	*******	***29.4***	*******	***30.4***	*******	***43.5***	*******	***38.8***	*******

+=.10; *= .05; **=.01; ***=.001; Final entry betas are reported

Table 4.3: OLS regression predicting synthetic biology-related discussion (final standardized betas reported)

	Full Sample n=706		Champions n=65		Boosters n=213		Uncertains n=154		Skeptics n=200		Cynics n=74	
Block 1: Condition												
Civility Condition (Uncivil=low)	-.03		.16	*	-.05		-.02		-.05		.04	
Moderation Condition (Unmoderated=low)	.00		-.03		.01		.03		.01		-.04	
Read Comments	.05		.08		.01		.01		.14	***	.12	+
Incremental R^2	***3.9***	***	***1.7***		***1.5***	*	***1.1***		***10.0***	***	***2.3***	
Block 2: Demographics												
Age	-.04		.13		-.04		-.02		.03		-.03	
Gender (Male=low)	.03		.06		.08	*	.06		.02		.00	
Income (continuous scale)	-.12	***	.14	+	-.03		-.14	***	-.13	***	-.13	+
Race (Non-white=low)	-.06	+	-.17	*	.00		-.08	+	.02		-.11	
Education (continuous scale)	-.01		-.12	+	-.13	***	-.06		-.05		-.11	+
Incremental R^2	***1.1***		***7.8***	**	***1.7***	*	***3.9***	**	***1.7***	*	***2.1***	
Block 3: Value Predispositions												
Religious Guidance	.08	*	.00		.14	***	.00		.08	*	-.14	*
Political Ideology (Lib=low)	.02		.12	+	-.01		-.03		.01		.09	
Deference to Science	.11	**	-.04		.08	*	.00		.07	+	.08	
Incremental R^2	***3.3***	***	***1.2***		***4.3***	***	***0.9***		***5.4***	***	***3.5***	
Block 4: Science-Related Media Use												
Newspaper	-.09		.05		-.01		.04		.08		.11	
Television	.15	**	.15	+	.13	*	.15	*	-.02		.24	*
Online	.06		.12		.00		.13	*	.01		-.12	
Incremental R^2	***14.5***	***	***17.6***	***	***13.0***	***	***16.3***	***	***12.8***	***	***23.9***	***
Block 5: Social Media Use												
Facebook	*.03*		*.00*		*-.07*	*+*	*-.06*		*.07*	*+*	*-.08*	
Twitter	*.02*		*-.14*	*+*	*.00*		*.10*	*	*-.06*		*-.09*	
YouTube	*-.05*		*.14*	*+*	*-.01*		*-.04*		*.03*		*.07*	
Incremental R^2	***0.1***		***2.1***		***0.3***		***1.4***	*	***1.6***	**	***2.4***	
Block 6: Media Sentiment												
Media Cosmopolitanism	.14	***	.09		.16	**	.01		.18	***	.08	
Media Affect	-.02		-.05		.05		.06		-.08	*	-.02	
Incremental R^2	***3.0***	***	***1.3***		***3.1***	***	***1.0***	*	***3.0***	***	***2.3***	*
Block 7: Knowledge												
Issue Salience	.16	***	.25	***	.20	***	.15	**	.17	***	.22	**
Synthetic Biology Knowledge	.03		-.05		-.04		.00		-.06	+	.14	*
Incremental R^2	***2.4***	***	***4.9***	**	***3.6***	***	***1.9***	**	***2.0***	***	***7.1***	***
Block 8: Heterogeneity of Networks												
Discussion Frequency Scale	.18	***	-.04		.19	***	.15	*	.32	***	-.01	
Heterogeneity of Discussion Network Scale	.05		.13		-.02		.02		-.00		.24	**
Incremental R^2	***2.2***	***	***0.9***		***1.7***	***	***1.3***	*	***4.3***	***	***3.3***	*
Adjusted R^2	***28.3***	***	***28.8***	***	***26.7***	***	***24.0***	***	***38.4***	***	***38.6***	***

+=.10; *= .05; **=.01; ***=.001; Final entry betas are reported

Table 4.4: OLS regression predicting support for synthetic biology (final standardized betas reported)

	Full Sample n=706		Champions n=65		Boosters n=213		Uncertains n=154		Skeptics n=200		Cynics n=74	
Block 1: Condition												
Civility Condition (Uncivil=low)	.02		.15	*	-.02		-.02		.03		-.09	
Moderation Condition (Unmoderated=low)	-.02		.10		.10	*	-.09	+	-.07	+	-.34	***
Read Comments	.08	**	-.04		.13	***	.10	*	.15	***	-.11	
Incremental R^2	***5.2***	*****	***3.8***	***+***	***5.8***	*****	***6.0***	*****	***11.7***	*****	***13.4***	*****
Block 2: Demographics												
Age	.02		.09		-.05		.03		.06	+	-.09	
Gender (Male=low)	-.06	*	-.12		-.09	*	-.02		-.12	***	-.07	
income (continuous scale)	.04		.01		.06		.08	+	.05		.11	
Race (Non-white=low)	-.02		.06		.06		.05		.07	+	-.06	
Education (continuous scale)	.05		.14	*	.00		.09	+	.07	+	.02	
Incremental R^2	***2.8***	*****	***10.1***	*****	***3.4***	*****	***4.9***	*****	***8.3***	*****	***1.9***	
Block 3: Value Predispositions												
Religious Guidance	-.13	***	-.02		-.03		-.07		-.02		-.10	
Political Ideology (Lib=low)	-.12	**	.00		.03		.02		-.01		.06	
Deference to Science	.35	***	.21	**	.14	***	.18	***	.23	***	.28	***
Incremental R^2	***23.6***	*****	***5.1***	***	***2.1***	****	***5.4***	*****	***8.5***	*****	***8.6***	*****
Block 4: Science-Related Media Use												
Newspaper	-.05		.03		-.06		.03		-.19	**	-.02	
Television	.12	*	.22	*	.06		.00		.17	**	.14	
Online	.05		.00		.09	+	.13	*	.03		-.12	
Incremental R^2	***3.9***	*****	***6.1***	****	***3.0***	*****	***6.0***	*****	***4.3***	*****	***2.3***	
Block 5: Social Media Use												
Facebook	*-.05*		*-.04*		*.00*		*-.05*		*.01*		*.08*	
Twitter	*-.04*		*.03*		*-.01*		*.00*		*-.05*		*-.13*	+
YouTube	*-.02*		*.10*		*-.10*	*	*.00*		*.09*	*	*-.14*	
Incremental R^2	***0.5***		***0.6***		***0.4***		***0.3***		***1.2***	***	***3.5***	***+***
Block 6: Media Sentiment												
Media Cosmopolitanism	.05		.04		.14	**	.04		.16	**	.06	
Media Affect	.07	*	-.19	*	.04		-.02		.04		-.06	
Incremental R^2	***0.8***	***	***3.1***	***	***1.4***	****	***0.2***		***2.9***	*****	***0.8***	
Block 7: Knowledge												
Issue Salience	.17	***	.05		.17	***	.20	***	.09	*	.15	+
Synthetic Biology Knowledge	.09	**	.15	*	.03		.07		.08	*	.20	**
Incremental R^2	***2.5***	*****	***2.1***	***+***	***2.0***	*****	***3.7***	*****	***1.3***	*****	***5.3***	****
Block 8: Heterogeneity of Networks												
Discussion Frequency Scale	-.01		-.11		-.07		.04		-.03		.03	
Heterogeneity of Discussion Network Scale	-.08	*	.06		.00		-.02		.07		.06	
Incremental R^2	***0.5***	***+***	***0.4***		***0.3***		***0.0***		***0.2***		***0.4***	
Adjusted R^2	***37.9***	*****	***21.7***	*****	***15.3***	*****	***22.6***	*****	***35.9***	*****	***26.1***	*****

+=.10; *= .05; **=.01; ***=.001; Final entry betas are reported

Value Predispositions

Beginning once again with the full sample, religious guidance is not associated with synthetic biology-related information seeking (Table 4.2), but positively associated with synthetic biology-related discussion (β=0.08; p≤.05)(Table 4.3) and negatively associated with support for synthetic biology (β =-0.13; p≤.001) (Table 4.4). Political ideology is not associated with either synthetic biology-related information seeking or synthetic biology-related discussion, but has a negative association with support which indicates that being liberal is associated with supporting synthetic biology (β =-0.12; p≤.01) (Table 4.4). Deference to science is positively associated with all three of the dependent variables, synthetic biology-related information seeking (β =0.12; p≤.001) (Table 4.2), synthetic biology-related discussion (β =0.11; p≤.01) (Table 4.3) and support (β =0.35; p≤.001) (Table 4.4).

There are no relationships between the variables measuring value predispositions and synthetic biology-related information seeking for Champions. However, there is a relationship between political ideology and synthetic biology-related discussion (β =0.12; p≤.10) (Table 4.3), along with deference to science and support for synthetic biology for this segment (β =0.21; p≤.01) (Table 4.4).

Boosters and Skeptics have some similarities with regards to value predispositions and the three dependent variables, although the strength of each relationship varies. Religious guidance is a significant variable for both segments, positively so for Skeptics relative to synthetic biology information-seeking (β =0.09; p≤.01) (Table 4.2), and significant for both relative to synthetic biology-related discussion. However, the relationship for Boosters is larger and stronger (β =0.14; $p \leq .001$), than the relationship is for Skeptics (β =0.08; $p \leq .05$) (Table 4.3).

These two segments are also similar with regards to deference to science. Although deference to science plays a larger role for Boosters (β=0.14; $p \leq .001$) than Skeptics (β =0.07; $p \leq .10$) with regards to synthetic biology-related information seeking (Table 4.2); there is no discernible difference with regards to deference to science and synthetic biology-related discussion with Boosters scoring only slightly higher (β =0.08; $p \leq .05$) than Skeptics (β =0.07; $p \leq .10$), though the statistical significance of the relationship is stronger for Boosters (Table 4.3). However when considering support for synthetic biology as a dependent variable, deference to science has a much larger association for Skeptics (β =0.23; $p \leq .001$) than Boosters (β =0.14; $p \leq .001$) (Table 4.4). The major point with regards to both religious guidance and deference to science for Boosters and Skeptics is not the way in which patterns reverse themselves, but that both of these segments consistently rely on these two value predispositions with regards to synthetic biology-related information seeking, synthetic biology-related discussion and support, and neither rely on political ideology (Tables 4.2 through 4.4).

For Uncertains, liberal views are negatively, but weakly, related to synthetic biology-related information seeking (β =-0.08; $p \leq .10$) (Table 4.2). Deference to science has a large and relatively strong association with support for synthetic biology (β =0.18; $p \leq .001$) (Table 4.4), suggesting that in the absence of other strong value predispositions, this segment relies heavily on its belief that scientists know best or should do best, despite the fact that other segments demonstrate higher average values for these two deference variables.

There are no relationships between value predispositions and synthetic biology-related information seeking for Cynics, but a negative association between religious guidance and synthetic biology-related discussion for this segment ($\beta = -0.14$; $p \leq .05$) (Table 4.3). Despite the segment's name, there is a relatively large and strong positive association between deference to science and support for synthetic biology for this segment ($\beta = 0.28$; $p \leq .001$) (Table 4.4), which is interesting – and perhaps surprising - as there is very little variation with regards to the low levels of deference to science for this segment.

Science-Related Media Use

The extent to which subjects in this study attended to science in the media mattered a great deal. Science-related media use made substantial contributions toward explaining synthetic biology-related information seeking and synthetic biology-related discussion across all models, and a smaller but significant contribution toward explaining support for synthetic biology. The incremental r-square for the block containing science-related media use explained 14.4 percent of the variance for synthetic biology-related information seeking against an adjusted r-square of 33.2 (Table 4.2) for the full model and 14.5 percent of the variance for synthetic biology-related discussion against an adjusted r-square of 28.3 (Table 4.3), but only 3.9 percent of the variance in support for synthetic biology against an adjusted r-square of 37.9 (Table 4.4). When looking at the full model for the sample as a whole, attention to science on television is the only statistically significant science-related media variable ($\beta = 0.10$; $p \leq .05$) (Table 4.2), it has a large effect for synthetic biology-related discussion ($\beta = 0.15$; $p \leq .01$) and support for synthetic biology ($\beta = 0.12$; $p \leq .05$) (Table 4.3 & Table 4.4).

Attention to science on television, which was associated with all three dependent variables in the models considering the full sample, had a positive association with synthetic biology-related information seeking for Boosters (β =0.18, p≤.01), Uncertains (β =0.10; p≤.10) and Cynics (β =0.29; p≤.01) (Table 4.2). These same segments displayed positive relationships between the variable and synthetic biology-related discussion; Boosters (β =.13; p≤.01), Uncertains (β =0.15; p≤.05) and Cynics (β =0.24; p≤.01). as well as Champions (β =0.15; p≤.10) (Table 4.3). Although the relationship between attention to science on television remains important for Skeptics with regards to support for synthetic biology (β =0.17; p≤.01) and Champions (β =0.22; p≤.10) (Table 4.4), there is no relationship between these variables for Boosters and Cynics.

Attention to science online was positively associated with information seeking for Uncertains (β=0.12; p≤.05) and synthetic biology-related discussion (β=0.13; p≤.05) and support for synthetic biology (β =-0.13; p≤.05) (Tables 4.2 through 4.4). With the exception of Boosters, who demonstrated a small effect for attention to science online and support for synthetic biology (β =0.09; p≤.10) (Table 4.4) no other segments were affected by attention to science online.

Based on these results, H1c and H1d were not supported. Although there was a consistent variation in effects across American Science Audience segments for both of these dependent variables, the effects did not occur as predicted.

Social Networking Sites

As with science-related media use, there were varied effects for social networking site use across segments and dependent variables. For the full sample, attention to Facebook (β=0.07; p≤.05) and attention to *Twitter* (β=-0.08; p≤.05) (Table 4.2) were associated with synthetic biology-related information seeking, albeit in opposite directions. However, there were no other statistically significant effects for social networking site use in the full sample for either synthetic biology-related discussion (Table 4.3) or support for synthetic biology (Table 4.4).

Champions and Cynics both have interesting relationships between social networking site and the three dependent variables. Both segments demonstrated negative associations with *Twitter* use and synthetic biology-related information seeking -- (β=-0.20; p≤.01 for Champions and β=-0.15; p≤.05 for Cynics) but positive relationships between YouTube use and synthetic biology-related information seeking (β=0.14; p≤.10 for both segments). The same pattern holds for Champions and synthetic biology-related discussion where there is a negative association with *Twitter* (β=-0.14; p≤.10) and a positive association with *YouTube* (β=0.14; p≤.05) (Table 4.3) but no association for social networking site use and support for synthetic biology (Table 4.4)

Though Cynics do not have statistically significant relationships between synthetic biology-related discussion and any of social networking site variables (Table 4.3), a negative relationship between *Twitter* use and support for synthetic biology surfaces for this segment (β=-0.13; p≤.10) (Table 4.4).

Other segments have interesting social networking site effects as well. Boosters have a negative relationship between *Facebook* use and synthetic biology-related discussion (β=-0.07; p≤.10) (Table 4.3), along with a negative relationship between *YouTube* use and support for synthetic biology (β=-0.10; p≤.05)(Table 4.4). Uncertains demonstrate a positive relationship between *Twitter* use and synthetic biology-related discussion (β=0.10; p≤.05) (Table 4.3). Skeptics have a positive relationship between *Facebook* use and both synthetic biology-related information seeking (β=0.11; p≤.01) (Table 4.2) as well as discussion (β=0.07; p≤.10), and a relationship between *YouTube* use and support for synthetic biology (β=0.09; p≤.05).

With the exception of a positive relationship between *Twitter* use and synthetic biology-related discussion for Uncertains, it appears there is a trend that when *Twitter* use is statistically significant, it is negatively related to information seeking and discussion. Of course this assertion needs to be approached with caution, as it is important to note that the combination of low sample numbers for segments in combination with sizable standardized betas that fail to attain significance may indicate Type II errors due to sample size. Still, there are consistent negative associations for *Twitter* use across all dependent variables and segments with only one exception – Uncertains and synthetic biology-related discussion (β=0.10; p≤.05) (Table 4.3). It is an interesting result that should be investigated in future work with larger sample sizes to determine if these relatively large and negative standardized betas indicate that relationships exist between these variables.

Media Sentiment

Media cosmopolitanism has a positive association with synthetic biology-related information seeking (β=0.14; $p \leq .001$) (Table 4.2) and synthetic biology-related discussion (β=0.14; $p \leq .001$) (Table 4.3), but not support for synthetic biology, when examining the sample as a whole. In contrast, media affect was only statistically significant as related to support for synthetic biology (β=0.07; $p \leq .05$) when considering the sample as a whole (Table 4.4)

Media cosmopolitanism is also a significant variable for Champions with regards to synthetic biology-related information seeking (β =0.15; $p \leq .10$) (Table 4.2), but not with regards to the other two dependent variables. Media cosmopolitanism is a consistently important variable for Boosters and Skeptics. These segments have positive relationships between the variable and synthetic biology-related information seeking, synthetic biology-related discussion and support for synthetic biology, although the size is somewhat smaller for Boosters (β=0.13; $p \leq .05$; β =0.16; $p \leq .01$; and β =0.14; $p \leq .01$, respectively) than Skeptics (β =0.18; $p \leq .001$; β =0.18; $p \leq .001$; and β =0.16; $p \leq .01$, respectively) (Table 4.2 through Table 4.4). Media cosmopolitanism was wholly unimportant for Uncertains or Cynics (Table 4.2 through 4.4).

Media affect has a small positive association with synthetic biology-related information seeking for Uncertains (β =0.10; $p \leq .05$) (Table 4.2) and a small negative association for Skeptics as related to synthetic biology-related discussion (β =-0.08; $p \leq .05$). The negative association for Champions when predicting support (β =-0.19; $p \leq .05$) (Table 4.4) is interesting within the context with results for media cosmopolitanism, suggesting that this segment’s belief that it uses a wider array of media sources than others matters when seeking information or talking about synthetic biology, but how the segment feels about media is what matters when this segment considers support for synthetic biology. Without inferring too much, it is easy to imagine Champions taking a certain measure of pride in having a diverse media diet even as they hold sources at a certain level of disdain.

Likewise, the negative association for Skeptics between media affect and synthetic biology-relate discussion (β =-0.08; $p \leq .05$) alongside the positive association between media cosmopolitanism and discussion (β =0.18; $p \leq .001$) (Table 4.3) is also interesting. Again, without inferring too much, it is easy to imagine Skeptics taking a certain measure of pride maintaining a diverse media diet despite their disdain for certain media personalities.

Issue Salience and Knowledge

When looking at the sample as a whole, issue salience is positively associated with synthetic biology-related information seeking (β =0.20; $p \leq .001$) (Table 4.2), synthetic biology-related discussion (β =0.16; $p \leq .001$) (Table 4.3) and support (β =0.17; $p \leq .001$) (Table 4.4). Based on these results, H2a, H2b and H2c were supported. Although there were clear variations in issue salience among the segments, the variable was strongly and consistently significant across all segments for all three dependent variables with a single exception; issue salience did not achieve statistical significance for Champions in the model examining support for synthetic biology. Given the likelihood of a type 2 error as a result of the small sample size, this result may not hold in future work. Still, based on these results H2d, H2e and H2f were not supported.

When looking at the sample as whole, synthetic biology knowledge was positively associated with information seeking (β =0.08; $p \leq .05$) (Table 4.2) and support (β =0.09; $p \leq .01$)

(Table 4.4), but not discussion. There was a small and weak relationship between knowledge and synthetic biology-related information seeking for Boosters (β =0.03; p≤.10) (Table 4.2). Knowledge was also an important variable for Skeptics as it has a negative association with synthetic biology-related discussion (β =-0.06; p≤.10) (Table 4.3), but a positive relationship with support (β =0.08; p≤.05). Finally, for Cynics knowledge was positively associated with all three variables, information seeking (β =0.13; p≤.05), discussion (β =0.14; p≤.10) and support (β =0.20; p≤.01) Based on these results, H3a was supported, but H3b,which hypothesized a relationship between knowledge and discussion, H3c, which hypothesized that greater levels of knowledge at the segment level would be associated with information seeking, and H3d, which hypothesized that greater levels of knowledge at the segment level would be associated with discussion, were not sufficiently supported.

Although this study did not make a hypothesis, synthetic biology knowledge is an important variable when considering support for the issue for Champions (β =0.15 p≤.05), Skeptics (β =0.08; p≤.05) and Cynics (β =0.20; p≤.01), but not for Boosters or Uncertains (Table 4.4).

Frequency of Discussion

It should not be a surprise that there is a relationship between discussion frequency, which combined how often individuals discuss science-related issues and political issues with others, and synthetic-biology-related discussions, which asked if respondents would share or discuss information related to the stimulus news article with others. Looking at the sample as a whole, discussion frequency has a positive association with synthetic biology-related discussion

(β =0.18; p≤.001) (Table 4.3), thus H5b was supported. Issue-related discussion frequency was not related to synthetic biology-related information seeking or support for synthetic biology when looking at the full sample at the p≤.05 level (Table 4.4). Therefore H5a and H5c were not supported.

However, the surprise in these results is that the relationships detected in the sample as a whole are not evenly distributed once subjects are divided into segments. Our most science-polarized segments, Champions and Cynics, are good examples of the interesting and varied results at the segment level. For example, there is no relationship between discussion frequency and synthetic biology-related information seeking or synthetic biology-related discussion for either the Champions or Cynics segments. For these segments it doesn't matter how often, if ever at all, issue-related discussions occur when we are considering which variables prompt synthetic biology-related information seeking or synthetic biology-related discussion.

A nearly opposite result was true for Skeptics. For this segment, the frequency with which issue-related discussion occur is critically important in regards to synthetic biology-related information seeking (β =0.22; p≤.001) (Table 4.2) and synthetic biology-related discussions (β =0.32; p≤.001) (Table 4.3). Despite these findings, there was still no association between issue-related discussion frequency and support for synthetic biology.

Although there was no association between issue-related discussion frequency and synthetic biology-related information seeking for Boosters or Uncertains, these segments both have positive associations with regards to this variable and synthetic biology-related discussion, although the size and strength of the relationship between discussion frequency and synthetic biology-related discussion varied (Boosters:β =0.19; p≤.001; Uncertains:β =0.15; p≤.05) (Table 4.3).

Based on this, H5d was somewhat supported, but H5e was not as the opposite of what was predicted was true. Additionally, H5f was also not supported, which is consistent with earlier research indicating that discussion frequency is not predictive of support for emerging technologies (Shih et al., 2013).

Individual Discussion Network Heterogeneity

When considering the sample as a whole, there is no relationship between heterogeneity of discussion networks and synthetic biology-related information seeking or synthetic biology-related discussion (Table 4.2 and Table 4.3), based on this H6a was not supported.

However, the diverse composition of the discussion networks for individuals in these segments matters a great deal, as there is a relationship between heterogeneity of discussion networks and synthetic biology-related information seeking for both Champions (β =0.16; p≤.10) and Cynics (β=0.19; p≤.05), the segments with greatest individual discussion network heterogeneity (Table 4.2). Thus H6b was supported. There is a relatively large and strong relationship between heterogeneity of discussion networks and synthetic biology-related discussion for Cynics (β =0.24; p≤0.001) (Table 4.3).

In other words, it is the diversity of those with whom individuals in these segments discuss issues, and not how often such discussions occur, that is positively associated with

Champions and Cynics intent to engage in synthetic biology-related information seeking for both segments, or synthetic biology-related discussion for Cynics.

Beginning again with the whole sample and looking at our final set of hypotheses concerning individual discussion network heterogeneity and support for synthetic biology, this study finds a small, negative association between individual discussion network heterogeneity and support for synthetic biology (β =-.08; $p \leq .05$) (Table 4.4). Thus H7a is supported. However, there were no effects when American Science Audience segments were considered, therefore H7b is not supported.

Study Limitations

The sample size is the most significant limitation to this study. Although the full sample of 706 respondents is sufficient to make strong conclusions for a generalized population, these individuals were not evenly distributed among the five American Science Audience segments. The most science-polarized segments, Champions and Cynics, contained 65 and 74 respondents, respectively. This seriously raised the possibility of a Type II error, which is evident in a number of the values in a number of regressions for each of the three dependent variables. In particular, the effects of attention to science-related media are likely muted for these segments in this study as the effects of attention to science on television for Champions has a large but statistically insignificant effect on synthetic biology-related information seeking (β =0.10) (Table 4.2). Likewise in the Cynics segment there are large but statistically insignificant effects for attention to science in newspaper (β =0.11) and attention to science online (β =-0.12) as associated with synthetic biology-related discussion, and associations between support for synthetic biology and attention to science on television (β =0.14) and online (β =-0.12) for this segment (Table 4.3 and Table 4.4). The same is true for Cynics and social networking sites, where there are relatively large, but statistically insignificant results for the relationship between the dependent variable synthetic biology-related discussion and Facebook use (β =0.08) and *YouTube* (β =0.14) (Table 4.3). There are other large but statistically insignificant independent variables for these two segments, but those related to media are the most regrettable given the focus of this dissertation. Although this limits the current study, it is possible to correct this limitation in future work which by reverting to the entire sample using the segmentation study results and simultaneously examining all science conditions used in the survey on which this study was based to determine the existence and significance of the results described here.

The overall low levels of knowledge and lack of wide variation in issue salience for synthetic biology are a second limitation. Although the fact that synthetic biology is an unknown science topic with few strong stakeholders makes it easier to strongly claim the effects of demographics, value predispositions and media use on the dependent variables, it has limitations. For example, issue salience was measured pre-manipulation on a scale of 0 to 10, where 0 indicated synthetic biology was not at all important. While there was variation in the results, about 78 percent of the sample answered between 0 and 5, which indicates little issue-related salience and a limit in the variation of the variable. With regards to knowledge, 12 percent of the sample as a whole scored 3 out of 3 of the true/false questions correct, which is roughly equal to what would be expected if respondents guessed randomly. Although issue salience is an important variable for each of the three dependent variables, and knowledge was important in several instances, one wonders how these results would differ if synthetic biology was a well-known science issue with greater overall levels of knowledge and variation in issue salience. This is clear limitation for this study, albeit a minor one, but also an excellent opportunity to achieve better understanding of how knowledge and salience affect issues by tracking these changes over time as issue-related knowledge and salience develop.

The final limitation is the scope of the study. This study examines three dependent variables for a full sample plus five segments, equaling a total of 18 regressions. Given the number of regressions, it was beyond the scope of this study to exhaustively examine anything other than main effects. However, results indicate a number of promising areas where interaction effects could be identified in future studies. To that end, this dissertation includes a subchapter illustrating the future potential for American Science Audience segments to discern the ways in which segments differ. The subchapter focuses on the effects of individual discussion network heterogeneity for the Cynics segment as it relates to synthetic biology-related information seeking and is included as an addendum to this chapter.

Discussion

The first finding for this study is the lackluster performance of issue-related discussion frequency and heterogeneity of individual discussion networks as significant and large predictor variables for synthetic biology-related information seeking, synthetic biology-related discussion and support for synthetic biology. These variables failed more often than they succeeded in their associations with the dependent variables. Issue-related discussion frequency achieved significance in only five of the 18 regressions modeled, and only once for the full sample when synthetic biology-related discussion was the dependent variable. Heterogeneity of discussion networks performed similarly, also achieving significance in only five of the 18 regressions modeled, and only once for the full sample when support of synthetic biology was the dependent variable. If finding a previously undiscovered contributor that consistently predicts the three dependent variables used here had been the goal of this study, then it would have failed miserably. Fortunately, that wasn't the aim. This study sought to shed light on for whom issue-related discussion frequency and heterogeneity of individual networks are statistically significant variables, and under which circumstances these two variables might come into play for affected segments. In that respect, this study succeeds and extends the contribution of previous literature.

The first finding is perhaps the easiest to predict: issue-related discussion frequency has strong positive associations with synthetic biology-related discussion for the full sample ($B=0.18$; $p\leq.001$), Boosters, ($B=0.19$; $p\leq.001$), Uncertains ($B=0.15$; $p\leq.05$) and Skeptics ($B=0.32$; $p\leq.001$) (Table 4.3). This finding is logical: those who discuss issues are more likely to discuss synthetic biology as an issue. The surprise with this finding is that the variable did not have a statistically significant effect for the most polarized science segments, Champions ($B=-0.04$; $p\leq.51$) and Cynics ($B=-0.01$; $p\leq.86$) (Table 4.3), and the alpha levels for these results indicate the final numbers were not the result of a near-miss in significance due to the small segment sizes. While this might be predictable for Cynics, as one could make a case that a segment with low deference to science is not necessarily predisposed to discussing any emerging technology (indeed this segment has the lowest average score for science issue discussion, see Figure 3.12, Chapter 3). Still, the non-significance of issue-related discussion frequency is surprising for Champions as this segment is strongly science deferent and, as evidenced in the American Science Audience segment study, engaged in science issue discussion to a greater extent than the general population.

The second finding is closely related to the first. For Cynics synthetic biology-related discussion is not predicted by issue-related discussion frequency, but individual discussion network heterogeneity, an association that is not significant for any other segment or for the full sample. In other words, it is not how often this segments discusses issues, but the degree to which its member's discussion networks are comprised of people different than themselves that is positively associated for Cynics ($B=0.24$; $p\leq.001$) (Table 4.3) with synthetic biology-related discussion. This observation recurs in the models predicting synthetic biology-related information seeking where Individual discussion network heterogeneity has a positive association for Champions ($B=0.16$; $p\leq.10$) and Cynics ($B=0.19$; $p\leq.05$) (Table 4.2), but no other segments. In other words, quality of discussion partners, and not quantity of discussion, is positively associated with synthetic biology-related discussion and information seeking for these segments. Future work should explore these first two findings, perhaps broadening the field to include the full sample to see if this association is true across the other topics included in the full survey, i.e. fracking, climate change or nanotechnology, or limited solely to synthetic biology-related discussion.

The Special Case of Boosters and Skeptics

The discovery of the Boosters and Skeptics segments in the American Science Audience study, and the extent to which they are sometimes mirror images of one another, bears fruit in this study. Looking at the results of the regressions in Tables 4.2 through 4.4, the number of variables that achieve significance for both segments, and the relatively high explanatory value of the overall models for Skeptics, paints a vivid picture of two segments that rely on a wide range of internal variables in processing or discussing issue-related information relative to this particular emerging technology, and possibly for other technologies and issues, too. Based on the results of the American Science Audience study and the present study, both of these segments, but Skeptics in particular, could be grouped under the broad umbrella of "Science Searchers." In this conceptualization, when members of these segments rely on a wide variety of internal variables when they are actively engaged in seeking information, discussing or deciding to support an issue. The word "when" is critical to this conceptualization. As illustrated in Figure 4.1, Boosters might engage relatively more often in synthetic biology-related information seeking and discussion than Skeptics, since Skeptics have lowest overall averages among American Science Audience segments, but we can explain relatively less of the variance in Booster's tendency to engage in issue-related information seeking or discussion as compared to Skeptics (Figure 4.1; Table 4.2 and Table 4.3). Skeptics may not engage in issue-related information seeking or issue-related discussion all that often, but when they do engage in these activities we have a better understanding of which mental gears are turning as the activities are occurring.

Demographics play a slightly larger and stronger role for Skeptics than Boosters in explaining synthetic biology-related information seeking and discussion (Tables 4.2 and 4.3), and more than double in strength when the dependent variable is support for synthetic biology (Table 4.4). Deference to science plays a role for both segments relative to synthetic biology related information seeking (Table 4.2) and discussion (Table 4.3), but it is relatively larger and/or stronger for Boosters than Skeptics, a pattern that reverses itself when support for synthetic biology is the dependent variable (Table 4.4). Based on incremental r-square values, science-related media use is equally important for Skeptics and Boosters relative to synthetic biology-related information seeking (Table 4.2) and discussion (Table 4.4), but slightly more important for Skeptics when support for synthetic biology is the dependent variable (Table 4.4). Again, using incremental r-square values, social networking sites were more influential for Skeptics than Boosters for all three models (Tables 4.2 through 4.4).

Skeptics are an interesting segment. Although the experimental conditions used in this survey were only included as control variables in this study, the effects of those manipulations were stronger for Skeptics over all segments in each model, with the single exception of Cynics in the model predicting support for synthetic biology. Looking closely at this block, the manipulation check *read comments* is strongly positively significant in each model: synthetic biology-related information seeking ($\beta = 0.16$; $p \leq .001$) (Table 4.2) and discussion ($\beta = 0.14$; $p \leq .10$) (Table 4.3) and support ($\beta = 0.14$; $p \leq .001$) (Table 4.4). Notably, this is the only segment for which *read comments* is significant across all dependent variables. Looking at *read comments* in combination with the relatively high explanatory values for the science-related media use block when synthetic biology-related information seeking and discussion are the dependent variables (incremental r^2=12.5; p≤.001; incremental r^2=12.8; p≤.001, respectively) (Table 4.2 and Table 4.3), along with influence of media cosmopolitanism (β =0.18; p≤.001 for both variables) (Table 4.2 and Table 4.3), discussion frequency (β =0.22; p≤.001; β =0.32; p≤.001, respectively) (Table 4.2 and 4.3) and *Facebook* (β =0.11; p≤.01; β =0.07; p≤.10, respectively) (Table 4.2 through 4.3) one can clearly argue that Skeptics may be voracious in their appetite for information, and active in discussion with others, but ultimately motivated to reason in a particular direction that is consistent with low levels of deference to science. Given that this segment has the second lowest levels of deference to science, but also lower than average levels of religiosity, the tentative conclusion is that if this segment engages in motivated reasoning to arrive at the decision to support synthetic biology – a previously unknown emerging technology – in a way that is consistent with their value predispositions, particularly levels of science deference so low that the variable for this group could be re-named disregard of science rather than deference to science. That isn't to suggest that the motivation is affective, instead reasoning for this group might be driven by accuracy. The relatively stronger role that issue salience plays for this segment when synthetic biology-related information seeking (β =0.15; p≤.001) and discussion (β =0.17; p≤.001) are the dependent variables, in contrast to the lesser role that issue salience plays when support for synthetic biology is the dependent variable (β =0.09; p≤.05) supports the notion that any possible motivated reasoning is driven by accuracy rather than affect. However, although the data builds a case for this conclusion, the conclusion itself is speculative and the occurrence of motivated reasoning for this segment should be investigated further.

While this observation about Skeptics is consistent with existing literature on motivated reasoning, one contribution of this study is a demonstration of how segmentation can be used as a tool to better understand how particular audience groupings process information in these circumstances. In combination with the findings of the American Science Audience segmentation study, findings like this provide guidance to science communicators with a need to reach these particular segments through messaging, while also providing new avenues for researchers to more fully understand the conditions under which certain media effects occur and how these observed effects might be stronger for some audience segments than others.

Extending the Findings: Understanding Cynics and the Interaction between Religious Guidance and Heterogeneous Discussion Networks

There are many instances in which preaching to the choir is an important strategy used to rally support for a science-related issue, but when science communicators are concerned about all the ways in which counteragents can advance an anti-science agenda it becomes crucial to speak to its challengers. To that end, understanding science Cynics is critical. This section extends the findings of the third study to examine the interaction effects of religious guidance and individual discussion network heterogeneity on synthetic biology-related information seeking, synthetic biology-related discussion and support for synthetic biology.

American Science Audience segments are arranged on a continuum for science deference. Cynics, the most religious, conservative and least deferent to science, are a segment of particular interest for their unique characteristics, especially with regards to the strength of the association between science-related media use as a predictor for synthetic biology-related information seeking (incremental r-square=23.8; $p \leq .001$) (Table 4.2) and synthetic biology-related discussion (incremental r-square=23.9; $p \leq .001$) (Table 4.3).

The nearly universally high levels of religious guidance in combination with very low levels of science deference place members of this segment on the far end of the American Science Audiences spectrum. Consider the Cynics segment mean of 8.52 (SD=1.94) for religious guidance as compared to the full sample mean of 5.29 (SD=3.60), and the segment's mean of 0.39 (SD=0.58) for deference to science as compared to the full sample mean of 3.92 (SD=2.59). In fact, science deference levels are so low for this segment that not a single member of Cynics places above the median established by the full sample.

However, it would be wrong to assume extreme views relative to deference to science and strong religious guidance isolate this group in any way. Cynics report higher than average levels of individual network discussion heterogeneity with a mean of 4.80 (SD=3.01) as compared to the full sample mean of 4.38 (SD=2.90). When members of this group discuss issues, they believe they do so with differently-minded discussion partners more often than most.

Given these results, it is interesting to consider the interaction effects of religious guidance and heterogeneous discussion networks. This brief extension of the third study asks the question: What are the interaction effects for religious guidance and heterogeneity of individual discussion networks on synthetic biology-related information seeking, synthetic biology-related discussion and support for synthetic biology for the Cynics segment?

Interaction Term Construction & Analysis

Interaction terms were created by centering the mean for each individual variable on zero, then splitting terms into dichotomous variables using a median split for low and high values before multiplying religious guidance by individual network heterogeneity. Terms were entered into the regression in the following order: Block 1: Condition; Block 2: Demographics; Block 3: Value Predispositions; Block 4: Science-related Media Use; Block 5: SNS Use: Block 6: Media Sentiment; Block 7: Knowledge; Block 8: Heterogeneity of Networks: Block: Interaction.

Results & Discussion

As indicated by ANOVA-based graphing, there are statistically significant interactions between religious guidance and network heterogeneity for synthetic biology-related information seeking and synthetic biology-related discussion (Table 4.5, Figure 4.2 and 4.3). Despite the strong potential for the same interaction to have an effect on support, the term's inclusion in the final model was not statistically significant (Table 4.5, Figure 4.4). Looking at the graphed results, it appears that high levels of religious guidance moderate the effects of high levels of heterogeneous discussion networks as it relates to synthetic biology-related information seeking and discussion (Figures 4.2 and 4.3). In other words, heterogeneous discussion networks are positively related to increased synthetic biology information seeking and discussion. Although effects are positive for those with both high and low levels of religiosity, the increase is somewhat smaller for those with high levels of religious guidance.

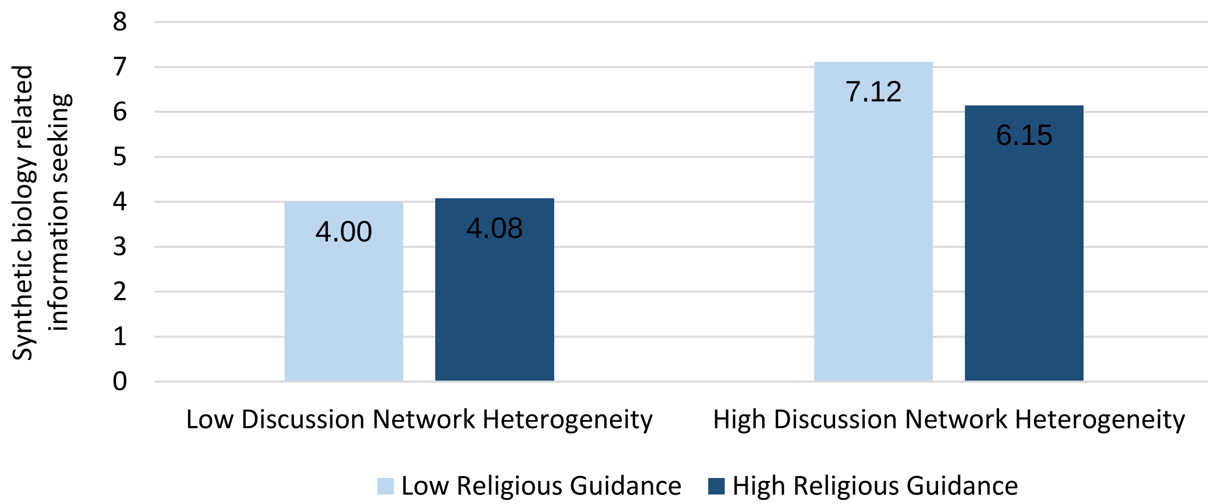
Given the stark difference in the ANOVA results with regards to support for synthetic biology for those in the high network heterogeneity condition, it is surprising that this effect was not statistically significant in the final regression model (Figure 4.4 and Table 4.5). Attempts to build a more explanatory model including other two-way interactions using heterogeneity of networks and religious guidance in combination with other main effect variables failed to find additional significant interaction terms, thus eliminating the possibility of full mediation via another variable for this insignificant interaction term. As part of this exploration, the author created and incorporated a Cynics-specific dichotomous measure of deference to science, where a score of zero was coded as low, and anything higher than zero was coded as high, a 61:39 split for the segment population. This also failed to produce significant interactions. Future work should address this to include more than one of topical conditions in the survey on which this study was based to determine if the lack of significant effects exist broadly across topics or are limited to this model, perhaps as a result of sample size or the lack of strong and wide variation in the dependent variable as compared to other, more developed and polarized science topics.

Table 4.5: American Science Audiences Cynics segment, variables affecting intention to seek information about, discuss or support synthetic biology

	Seek		Discuss		Support	
Block 1: Condition						
Civility Condition (Uncivil=low)	-.04		.0		-.09	
Moderation Condition (Unmoderated=low)	.00		-.03		-.33	***
Read Comments	.17	*	.11		-.12	
Incremental R^2	***5.3***	*******	***2.3***		***13.4***	*********
Block 2: Demographics						
Age	.02		-.02		-.09	
Gender (Male=low)	-.03		-.01		-.07	
Income (continuous scale)	-.08		-.12	+	.11	
Education (continuous scale)	-.07		-.10		.02	***
Incremental R^2	***1.7***		***2.1***		***1.9***	
Block 3: Value Predispositions						
Religious Guidance	.11		.02		-.16	
Political Ideology (Liberal=low)	.00		.05		.05	
Deference to Science	-.02		.07		.28	***
Incremental R^2	***0.8***		***3.5***		***8.6***	*********
Block 4: Science-Related Media Use						
Attention to Science in Newspaper	.05		.14		-.02	
Attention to Science on Television	.28	**	.23	*	.15	
Attention to Science Online	-.02		-.12		-.11	
Incremental R^2	***23.8***	*********	***23.9***	*********	***2.3***	
Block 5: Social Media Use						
Frequency of Facebook Use	-.09		-.09		.08	
Frequency of Twitter Use	-.13	*	-.08		-.14	+
Frequency of YouTube Use	.15	+	.09		-.13	
Incremental R^2	***4.2***	*******	***2.4***		***3.5***	***+***
Block 6: Media Sentiment						
Media Cosmopolitanism	.08		.10		.07	
Media Affect	-.05	**	-.03		-.07	
Incremental R^2	***1.7***		***2.3***	***+***	***0.9***	
Block 7: Knowledge						
Issue Salience	.26	***	.20	**	.14	+
Synthetic Biology Knowledge	.14	*	.13	*	.19	*
Incremental R^2	***8.0***	*********	***6.4***	*********	***5.1***	********
Block 8: Heterogeneity of Networks						
Discussion Frequency Scale	-.05		-.01		.02	
Heterogeneity of Discussion Network Scale	.19	*	.25	**	.07	
Incremental R^2	***1.7***	***+***	***3.3***	*******	***0.3***	
Block 9: Interactions						
Heterogeneity x Religious Guidance	*-.19*		-0.18		.07	
Incremental R^2	**0.9**		**0.8**	*********	**0.1**	
R^2	***48.1***	*********	***47.6***	*********	***36.1***	*********

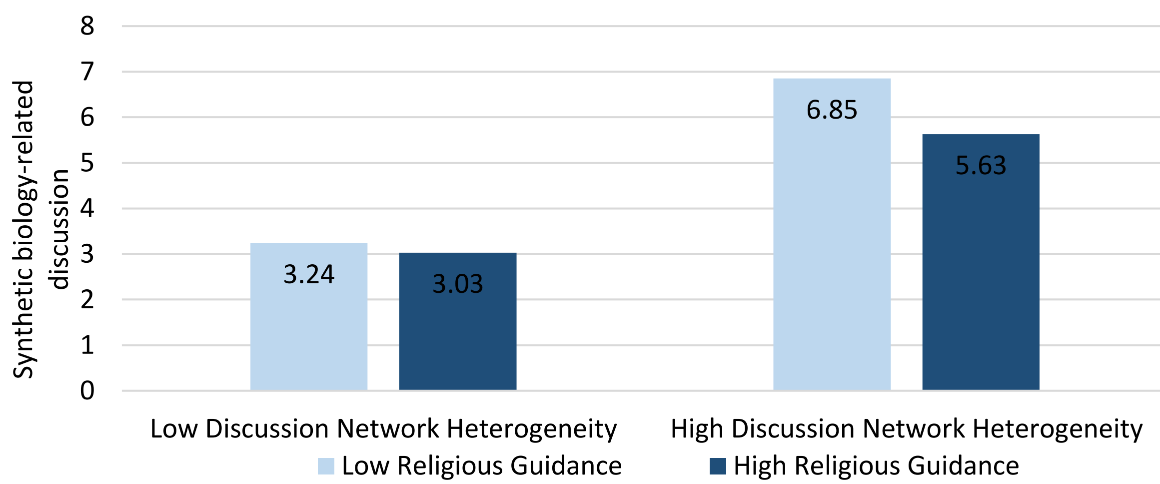
+=.10; *= .05; **=.01; ***=.001; Final entry betas are reported for blocks 1-7; before entry betas reported in block 8.

Figure 4.2: ANOVA depicting synthetic biology related information seeking for the interaction between religious guidance and individual network heterogeneity: Cynics segment of American Science Audience segments



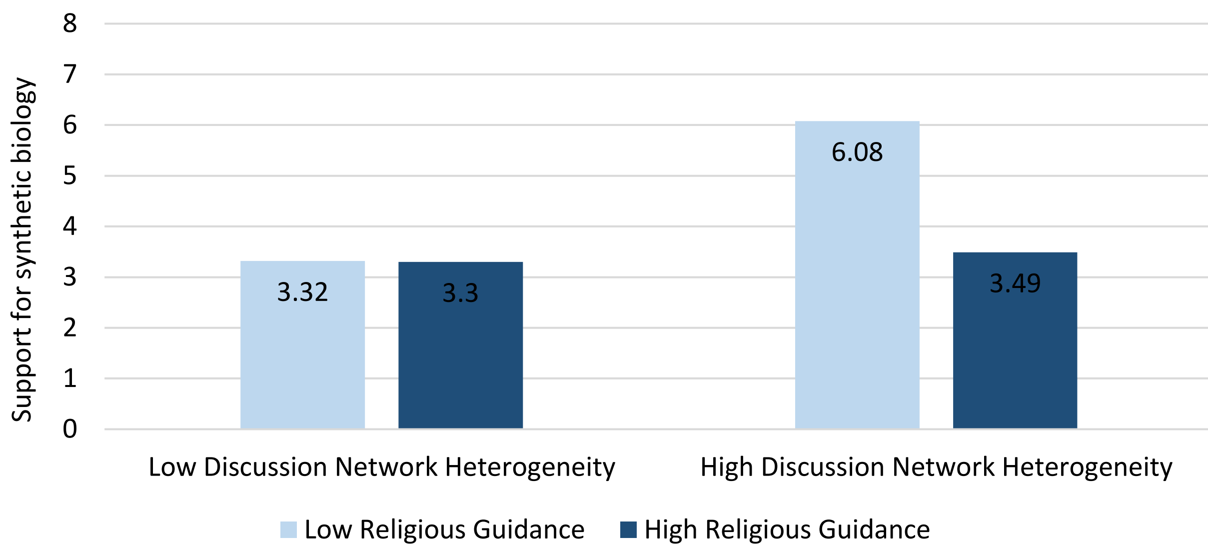
n=74

Figure 4.3: **ANOVA depicting synthetic biology-related discussion for the interaction between religious guidance and individual network heterogeneity: Cynics segment of American Science Audience segments**



n=74

Figure 4.4: **ANOVA depicting support for synthetic biology as the interaction between religious guidance and individual network heterogeneity: Cynics segment of American Science Audience segments**



n=74

Table 4.6: Zero-order correlations for Synthetic biology-related information seeking

	Full Sample n=706	Champions n=65	Boosters n=213	Uncertains n=154	Skeptics n=200	Cynics n=74
Block 1: Condition						
Civility Condition (Uncivil=low)	-.04	.07	.00	-.07	-.03	-.12 +
Moderation Condition (Unmoderated=low)	.00	-.03	.02	.03	-.02	-.01
Read Comments	.27 ***	.20 **	.19 ***	.19 ***	.35 ***	.21
Block 2: Demographics						
Age	.09 *	.03 *	.18 ***	.08 +	.19 ***	.02
Gender (Male=low)	.03	.03	.06 +	.06	-.01	-.01
Income (continuous scale)	.05	.00	.01	-.04	.08 *	-.04
Education (continuous scale)	.07 *	-.06	.00	.14 **	.21 ***	.03
Block 3: Value Predispositions						
Religious Guidance	.05	.09	.13 ***	-.01	.24 ***	-.01
Political Ideology (Liberal=low)	-.09 *	.12 +	-.08 *	-.02	-.13 ***	-.09
Deference to Science	.22 ***	.10	.22 ***	.13 **	.25 ***	.09
Block 4: Science-Related Media Use						
Attention to Science in Newspaper	.40 ***	.29 ***	.35 ***	.37 ***	.48 ***	.42 ***
Attention to Science on Television	.41 ***	.31 ***	.38 ***	.41 ***	.48 ***	.50 ***
Attention to Science Online	.38 ***	.35 ***	.26 ***	.38 ***	.41 ***	.34 ***
Block 5: Media Sentiment						
Media Cosmopolitanism	.43 ***	.36 ***	.34 ***	.30 ***	.52 ***	.39
Media Affect	.26 ***	.12 +	.23 ***	.18 ***	.35 ***	.11
Block 6: Knowledge						
Issue Salience	.43 ***	.33 ***	.35 ***	.43 ***	.40 ***	.40 ***
Synthetic Biology Knowledge	.27 ***	.08	.18 ***	.07 +	.25 ***	.26 ***
Block 7: Heterogeneity of Networks						
Discussion Frequency Scale	.40 ***	.27 ***	.35 ***	.35 ***	.55 ***	.35 ***
Heterogeneity of Discussion Network Scale	.33 ***	.30 ***	.31 ***	.22 ***	.44 ***	.43 ***

+=.10; *= .05; **=.01; ***=.001;

Table 4.7*:* Zero-order correlations for synthetic biology-related discussion

	Full Sample n=706		Champions n=65		Boosters n=213		Uncertains n=154		Skeptics n=200		Cynics n=74	
Block 1: Condition												
Civility Condition (Uncivil=low)	-.04		.10		-.03		-.06		-.03		-.06	
Moderation Condition (Unmoderated=low)	.04		.02		.00		-.02		.02		-.02	
Read Comments	.19	***	.06		.11	**	.09	*	.31	***	.15	*
Block 2: Demographics												
Age	.03		.19	***	.05		.02		.12	**	.07	
Gender (Male=low)	.03		-.04		.03		.02		-.02		.02	
Income (continuous scale)	-.05		.01		-.02		-.07		-.02		-.12	
Education (continuous scale)	.02		-.11		-.07	+	.10	*	.11	**	.03	
Block 3: Value Predispositions												
Religious Guidance	.07	+	.06		.18	***	-.06		.22	***	-.07	
Political Ideology (Liberal=low)	-.05		.15	*	-.07	+	-.01		-.90	*	-.07	
Deference to Science	.18	***	.03		.18	***	.11	*	.21	***	.15	*
Block 4: Science-Related Media Use												
Attention to Science in Newspaper	.35	***	.32	***	.32	***	.36	***	.45	***	.42	***
Attention to Science on Television	.39	***	.34	***	.36	***	.41	***	.41	***	.49	***
Attention to Science Online	.35	***	.31	***	.26	***	.37	***	.40	***	.31	***
Block 5: Media Sentiment												
Media Cosmopolitanism	.37	***	.29	***	.32	***	.27	***	.47	***	.39	***
Media Affect	.17	***	.04		.20	***	.16	***	.26	***	.13	+
Block 6: Knowledge												
Issue Salience	.40	***	.36	***	.33	***	.36	***	.40	***	.36	***
Synthetic Biology Knowledge	.25	***	.06		.10	**	.11	*	.18	***	.21	**
Block 7: Heterogeneity of Networks												
Discussion Frequency Scale	.40	***	.26	***	.37	***	.36	***	.52	***	.38	***
Heterogeneity of Discussion Network Scale	.33	***	.26	***	.31	***	.27	***	.40	***	.50	***

+=.10; *= .05; **=.01; ***=.001;

Table 4.8: Zero-order correlations for support for synthetic biology

	Full Sample n=706		Champions n=65		Boosters n=213		Uncertains n=154		Skeptics n=200		Cynics n=74	
Block 1: Condition												
Civility Condition (Uncivil=low)	.05		.15	*	.02		-.09	+	.07	+	-.24	
Moderation Condition (Unmoderated=low)	-.04		.18	*	.08	*	-.16	***	-.03		-.32	
Read Comments	.23	***	.03		.21	***	.19	***	.33	***	.00	
Block 2: Demographics												
Age	.02		.05		.03		.04		.13	***	.06	
Gender (Male=low)	-.11	***	-.26	***	-.15	***	-.10	*	-.16	***	-.03	
Income (continuous scale)	.14	***	.03		.15	***	.16	***	.20	***	.11	
Education (continuous scale)	.13	***	.19	**	.06		.19	***	.24	***	.07	
Block 3: Value Predispositions												
Religious Guidance	-.27	***	-.08		-.08	*	-.07	***	.07	+	-.14	+
Political Ideology (Liberal=low)	-.30	***	.04		.03		.05		-.14	***	-.06	
Deference to Science	.48	***	.24	***	.13	***	.20	***	.38	***	.24	***
Block 4: Science-Related Media Use												
Attention to Science in Newspaper	.27	***	.27	***	.24	***	.30	***	.29	***	.17	*
Attention to Science on Television	.30	***	.34	***	.24	***	.31	***	.36	***	.19	**
Attention to Science Online	.29	***	.13	***	.25	***	.32	***	.31	***	.19	*
Block 5: Media Sentiment												
Media Cosmopolitanism	.26	***	.20	**	.26	***	.23	***	.40	***	.13	+
Media Affect	.22	***	-.03		.19	***	.11	*	.30	***	.02	
Block 6: Knowledge												
Issue Salience	.33	***	.27	***	.25	***	.38	***	.32	***	.22	**
Synthetic Biology Knowledge	.25	***	.26	***	.15	***	.17	***	.30	***	.18	*
Block 7: Heterogeneity of Networks												
Discussion Frequency Scale	.23	***	.17	*	.21	***	.26	***	.36	***	.22	**
Heterogeneity of Discussion Network Scale	.14	***	.14	*	.18	***	.17	***	.32	***	0.21	**

+=.10; *= .05; **=.01; ***=.001;

Chapter 5. Dissertation Discussion & Conclusions

Summary of Findings

At the outset of this dissertation, I specified three primary goals: 1) greater understanding of the media environment in which communication about emerging technologies occurs, 2) the identification of science-specific audience segmentation that allows for the eventual development of targeted messaging to specific groups of science constituents, and 3) a deeper understanding of how characteristics specific to science audience segments vary in their importance relative to science-related information seeking, discussion and support.

Together the three studies in this dissertation provide evidence that 1) social networking site discourse for an emerging technology issue can set the agenda for newspaper coverage, but also that 2) social networking site discourse in general occurs more frequently among particular segments of the American population, and hardly at all among others, and thus is not a panacea for creating an informed science citizenry in an era of declining science coverage. Additionally, this dissertation finds that 3) segmenting the American public by a small number of variables that could be inexpensively incorporated into surveys – deference to science, liberal/conservative political ideology, liberal/conservative social ideology and religiosity – yields groupings that demonstrate strong and significant differences in a number of variables, including education, race, science knowledge, media use and social networking site habits, among others, and 4) the segments identified in this study can be used to better understand how independent variables such as religiosity, deference to science, media use, issue-related discussion frequency, and individual discussion network heterogeneity vary greatly in strength and significance across segments. Prior to discussing the broader implications of this work, I will summarize the findings of each study.

Key Findings

One of the opportunities in studying emerging technologies in their very earliest stages of development is that news coverage is frequently so scant that it provides an opportunity to study the development of news coverage as a topic begins to garner attention. The first study in this work accomplishes that goal by conducting a census of newspaper coverage of synthetic biology, then graphing newspaper coverage between 2001 and 2014, noting the first use of the term *synthetic biology* in newspapers in 2003, and tracking coverage during the critical 2010 to 2014 period when a number of synthetic biology innovations occurred and caught the attention of the popular press (Figure 2.1). Despite strong upticks in newspaper coverage of synthetic biology during the study period, there are only a relatively small number of articles published on the subject, proportionally more in the United Kingdom than in the United States, when population is taken into consideration. By then graphing the incidence of synthetic biology keyword tweets from 1 January 2010 through 31 December 2014 against newspaper coverage of the topic, and using a combination of vector autoregression (VAR) and Grange-Wald causality testing, the study identifies the multi-directional Granger-cause relationships between synthetic biology keyword tweets and synthetic biology newspaper coverage in both the United

States and the United Kingdom. As a result the first study identifies the role *Twitter* plays in setting the agenda for synthetic biology coverage in the United States while also identifying a more dynamic and equitable distribution of agenda setting effects in the United Kingdom, although the study finds that *Twitter* still plays a critical role in the U.K., too.

Beyond answering research questions about the evolution of synthetic biology newspaper coverage and *Twitter* discourse, the first study in this dissertation also provides a methodological example of how vector autoregression (VAR) time series analysis in combination with Granger Wald causality testing can be used to identify the influence of one media channel on another. Because the method used in this dissertation focuses on a form of causality, albeit not one that rules out extra-model exogenous causes, it is a stronger statistical test of intermedia agenda setting than earlier study methodologies which relied primarily on correlation. If media audiences continue to fragment into ideologically-specific channels, as some suggest, intermedia agenda setting as a research topic could enjoy a renaissance as researchers work to map influence networks from one medium or outlet to another. If so, VAR in combination with Granger Wald causality testing could be a useful tool in better understanding the implications of this media environment.

The second study in this dissertation seeks to improve on audience segmentation by offering a short battery of questions that can be incorporated into survey-based research at minimal cost, but with significant and useful results. As acknowledged in the study itself, and with the exception of work by Maibach et al., segmentation has been under-utilized in some areas of science communication, or often implemented with less-than-optimal rigor (Hine et al., 2014). By relying heavily on science communication theory, making good use of hypothesis testing, and relying on both multinomial logistic regression and extensive post-hoc ANOVA testing of discriminant variables, the American Science Audiences segmentation study succeeds.

The five segments identified in the study, Champions, Boosters, Uncertains, Skeptics and Cynics, displayed unique demographic traits, science-related knowledge levels, media habits, social networking site behaviors and attitudes toward media, among other traits. In addition to the rigorous use of theory to inform segmentation, this study also highlights the potential for audience-centric filters and media-centric filters to affect the media-based reality encountered by different American Science Audience segments.

In addition to identifying the existence of strongly science deferent Champions and their opposite Cynics, the American Science Audience study identified Booster and Skeptics, two segments that are similar in terms of religious guidance and social ideology, and not too far from one another in terms of economic ideologies, but with strong difference in regards to deference to science, where Boosters are strongly deferent and Skeptics significantly less so. Also identified are Uncertains, the Chimera segment, whose members have levels of religious guidance, economic and social ideologies closest to those seen in Cynics, and levels of deference to science squarely in the middle of all five segments.

As noted in the study chapter, the existence of Champions and Cynics is somewhat intuitive. Indeed, the notion that there are strong proponents of science as well as opponents of science who are both somewhat ideologically-driven by deference or disregard for science is likely intuitive for those immersed in the scholarship of science communication. In other words, most scholars would have easily predicted the existence of these segments and their particularly combination of value predispositions. However, the more significant finding is the existence of Boosters, Uncertains and Skeptics, whose various combinations of deference to science, religiosity and political/social ideology place their members in groupings with strongly significant differences relative to demographics, science-related media use, social networking site use, and media sentiment, along with differences in the frequency with which they discuss issues and the degree to which they perceive their discussion networks as heterogeneous.

Although the existence of significantly distinct American Science Audience segments is interesting, it would be an unremarkable curiosity if the segments hadn’t produced statistically significant and insightful results beyond the segmentation study. The third study in this dissertation demonstrates their utility.

The third and final study in this dissertation uses a nationally representative survey to determine how individual characteristics ranging from demographics to value predispositions, science-related media use and social networking site use are associated with synthetic biology-related information seeking, synthetic biology-related discussion and support for synthetic biology. Each of the three dependent variables in this study are examined using a full random sample before testing the effects on each American Science Audience segment. Results of the study are multi-fold. The first contribution of this study is a greater understanding of the limited effects of individual discussion network heterogeneity and issue-related discussion frequency on the dependent variables for the general population. In short, these two variables aren’t spectacular predictors. However when individual American Science Audience segments are considered, there is significant and interesting variation in the effects of both discussion-related variables. The variation is significant enough that their inclusion in the study is worthwhile and provides a measure of insight into how individuals within these segments process information differently. Results of this study would be useful to science communication practitioners interested in crafting segment-specific messages, as well as researchers interested in investigating how individual variables differ in strength and influence across different audience segments.

Indeed, the application of American Science Audience segments produced interesting results in the third study. There was stronger evidence for motivated reasoning in some segments than others. Skeptics, in particular, are an interesting example of this as they had a relatively wide number of main effects related to information– i.e. the comments in the experimental stimulus, science-related media use, issue-related discussion frequency and social networking site use to a lesser extent -- for all three dependent variables in the third study, synthetic biology-related information seeking, discussion and support (Table 4.2, 4.3 and 4.4), as compared to other segments. Yet this segment had the second lowest levels of support for the emerging technology (Mean=3.28; SD=3.06) (Figure 4.1). Despite their heavy reliance on information, Skeptics ultimately arrive at conclusions that are consistent with their relatively low levels of deference to science. This isn’t to say that evidence for motivated reasoning is inscrutable for other segments. For example, Champions also demonstrate clear tendencies toward motivated reasoning, by also relying heavily on information, but ultimately arriving at conclusions that are consistent with high levels of deference to science (Table 4.2, 4.3 and 4.4) (Figure 4.1). However, for Champions this might be clearly predictable when one considers their location at the pro-science pole of science deference, whereas for Skeptics it is a more insightful finding.

The use of American Science Audiences isn't limited solely to understanding how each segment differs, but also expands our understanding of the unique and varied roles that each independent variable across segments. For example, religiosity has a consistent main effect for both the sample as a whole as well as all segments for support for synthetic biology (Table 4.4). When considering the dependent variable synthetic biology-related discussion, it's true that religiosity is also important for the sample as a whole, along with Boosters, Skeptics and Cynics, but not Champions or Uncertains (Table 4.3). In contrast, when considering the dependent variable synthetic biology-related information seeking, religiosity is a significant variable for the sample as a whole, but only Skeptics as a segment (Table 4.2). Further, as highlighted in the extension examining the interaction effects of religiosity and heterogeneity of individual discussion networks for Cynics, religiosity has widely varied effects for different segments.

The point here is not to completely rehash the findings of the third study, but to highlight the ways in which the results of the second study enables the findings of the third study. By using American Science Audience segments, this study was able to both understand how a unique combination of independent variables is important to individual segments, and also compare the effects of a particular independent variable across all identified segments. In combination, the use of American Science Audience segments with traditional OLS regression can advance our understanding of the nuanced ways in which individual variables differently affect unique segments of the population.

The broader implication is that using American Science Audience segments allows communication researchers to move from a one-size-fits-all approach to an approach that is tailored to particular segments of society. Indeed, the results of the third study indicate that there is greater complexity and more variation in the effects of independent variables than previously identified. American Science Audience segments allows us to explore that complexity and make nuanced conclusions.

Issue-related discussion frequency and individual discussion networks performed as generally expected when considering the sample as a whole. I found a small negative relationship between individual discussion network heterogeneity and support for synthetic biology (Table 4.4), but no relationship between the independent variable and synthetic biology-related information seeking or discussion (Tables 4.2 and 4.3)

Similarly, when considering the sample as a whole, there was no relationship between issue-related discussion frequency and synthetic biology-related information seeking (Table 4.2) or support for synthetic biology (Table 4.4), but a strong relationship between this independent variable and synthetic biology-related discussion (Table 4.3), however predictable that may be.

As acknowledged in the chapter discussion, if a re-examination of discussion-related variables on a single, representative sample had been the goal, then this study would have fallen flat. Instead, it was more interested in identifying differences in the effects of these variables across American Science Audiences.

Of course, effects were not distributed evenly across segments. Generally speaking, the findings of this study were consistent with Xenos et. al (2011), which found no support for the notion that anticipated discussion related to emerging technology prompts information seeking. The exception to Xenos is the Skeptics segment. For this segment only, issue-related discussion frequency had a strong and positive main effect ($\beta = .23$; $p \leq .001$) (Table 4.2). Although the third study in this dissertation was qualitatively different than the Xenos et. al. study (2011), I cautiously offer that this exception to the Xenos finding is worth exploring in future work to determine if it is an anomalous finding or an indication of a consistent exception to the rule.

Likewise, when examining the sample as a whole, heterogeneity of individual discussion networks did not have a main effect related to synthetic biology-related information seeking (Table 4.2) or synthetic biology-related discussion (Table 4.3), but demonstrated a negative effect on support for synthetic biology ($\beta = -.08$; $p \leq .05$). However, for Champions and Cynics, the independent variable had a larger, positive relationship with synthetic biology-related information seeking ($\beta = .16$; $p \leq .10$ and $\beta = .19$; $p \leq .05$, respectively), and a large and strong effect for Cynics as related to synthetic biology-related discussion ($\beta = .24$; $p \leq .001$). Again, the point is not to repeat the discussion section of this study's chapter, but to highlight the opportunity to re-examine previous work using American Science Audience segments to identify previously undetected nuances in the effects of well-researched independent variables, and thereby advance the field.

Contributions

The contributions of this dissertation have broader implications for social science research and the field of communication research. The first contribution is the use of Vector Autoregression (VAR) and Granger-Wald causality testing to identify the Granger-cause relationship between synthetic biology-related keyword tweets on the social networking site *Twitter* and synthetic biology-related newspaper coverage, thus establishing strong evidence that *Twitter* has an agenda-setting effect for newspaper coverage of the topic, even as newspaper coverage has an agenda-setting effect for synthetic biology-related keyword tweets. This study helps address issues of influence on news coverage that have been prompted or implied by earlier findings highlighting the decline newspaper coverage of science (Dudo, Dunwoody, & Scheufele, 2011; Mooney & Kirshenbaum, 2009). Additionally, this study complements previous work that provides context for emerging technology studies by mapping the media landscape for issues ranging from stem cells (Nisbet et al., 2003a), nanotechnology (Cacciatore et al., 2012; Dudo, Choi, et al., 2011; Dudo, Dunwoody, et al., 2011), and climate change (Brossard et al., 2004), among others. Future work could repeat variations of this study for other issues, science or otherwise, to determine if social networking sites have an agenda-setting effect for other emerging issues in their early stages.

The second contribution is the novel application of segmentation grounded in theory and supported by rigorous methodology strongly highlights the fact that the effects of value predispositions, science-related media use, issue-related discussion and heterogeneity of individual discussion networks are neither evenly nor haphazardly distributed across individuals, but occur in ways that are unique and identifiable. In addition to finding interesting and useful differences, this second study builds on the foundation laid by Maibach et al. (2011) but provides an inexpensive and more efficient methodological road map for other researchers to utilize in re-creating the segments for application across a wide variety of science issues.

The methodology used in the second study addresses previous criticism that segmentation studies rely on "a preponderance of exploratory and descriptive research designs; a heavy reliance on non-probabilistic sampling methods; relatively small sample sizes; lack of adequate psychometric assessment of the measures employed; and, with few exceptions, rather basic statistical analyses of the collected data," (Foedermayr & Diamantopoulos, 2008), and a limited use of hypothesis tests and/or construction of confidence intervals, instead relying on descriptive statistics (Foedermayr & Diamantopoulos, 2008). With the exception of the Maibach et al. studies (2011), this criticism is also true of a substantial number of attempts to apply segmentation to science issues (Hine et al., 2014). Future work could repeat this study using the same variables for subsequent application to other issues.

Beyond addressing previous criticism of segmentation methodologies, the American Science Audiences study fills a larger need in science communication research. Perhaps because the discipline has had robust success studying specific issues, the existing segmentation scholarship has fallen short of a grand study that uncovers personal predisposition-based mindsets that function across science issues. By using a short battery of five general questions, rather than a lengthy battery of issue-specific questions, American Science Audiences is the first step toward filling that gap in the literature.

The final contribution of this study is in the application of American Science Audience segments to traditional OLS regression to identify strong evidence for motivated reasoning, and identify the different effects of value predispositions, science-related media use, issue-related discussion frequency and heterogeneity of individual discussion networks on American Science Audiences. Again, future work could utilize the findings in this study to identify other areas in which these segments demonstrate different effects.

Why is This Important?

To reiterate the opening to this dissertation: The polarization of certain science topics is resulting in a public in which large numbers of individuals have established attitudes, preferences and behaviors toward science issues, such as climate change, evolution, and genetic modification of foods or vaccinations (Pew Research Center, 2016). In this climate, science communication takes on a new urgency as its proponents are challenged to find ways to effectively cultivate open minds in those who may otherwise be counteragents or generate support among those who are science proponents.

This is not a new challenge. Since long before the days of Servetus’ and Galileo’s trials, science has been controversial. Though it is often the victim of bad policy and negative public opinion, science has sometimes been the victimizer. Indeed those seeking to advance our understanding of the world have sometimes done truly horrific things in the name of science. It’s important for those of us who are pro-science partisans to remember that our opponents in the past haven’t always been wrong. Skepticism, and even outright cynicism, have sometimes been warranted. Consequently, it is important to recognize such a history when we attempt to communicate with audiences whose deference to science is so low that it might accurately be described as disregard for science.

That is the golden nugget in this dissertation. In an era of increasing audience fragmentation in which is it ever more easy to attend solely to ideologically-specific content that does not ruffle our existing worldviews, science communication is challenged to speak to individuals in the language of their pre-existing beliefs and in places online and offline to which they are already attending. While established research provides insight into how independent variables alone and as interaction terms influence our attitudes toward science in a variety of ways, there is little information on how these variables can be used to create rich profiles of audience segments, and how variables that have consistently been important predictors for general populations can be applied to better understand the communication needs and contexts of segmented American Science Audiences.

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