REEVALUATING REGULATION: EXPLORING SHIFTS IN PUBLIC PERCEPTIONS ACROSS DIFFERENT REGULATORY DOMAINS

by

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(Under the Direction of Michael Cacciatore)

ABSTRACT

Relying on data from a nationally representative survey of American adults, this study explores the predictors of public regulatory attitudes on science policies for three science issues at different points of the issue-attention cycle: nuclear power, nanotechnology and synthetic biology. This study views public regulatory attitudes from three perspectives: ensuring safety from existing regulations, slowing down scientific progress, and the need of regulations for academic and commercial research. It aims to provide insights into public regulatory attitudes, including the role factual and perceived knowledge play in shaping public attitudes, how deference and trust in scientific authority can each play different roles in this process, how media consumption on traditional and online media platforms shape regulatory perspectives, and finally, how benefit and risk perceptions operate in this process. The results have the potential to inform how publics arrive at regulatory attitudes towards science policies for different types of science issues.

INDEX WORDS: Science communication, Trust, Deference, Issue attention cycle, Expert knowledge, Regulatory attitude, Regression analysis

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DEDICATION

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CHAPTER 1

INTRODUCTION

There has been a shift in a perspective toward how public shape their opinions regarding science and technology issues during recent years (Nisbet & Scheufele, 2007). Compared to the early scientific opinion formation models that focused on the education of lay audiences which explores the belief that higher levels of knowledge will induce support for science issues (Miller & Kimmel, 2001), more recent science communication work has suggested moving beyond the "deficit model" to understand public attitudes toward science, which explores the idea that it is the deficit of knowledge that affects the public's perceptions of science issues (Sturgis & Allum, 2004). In addition, based on empirical data, it has been found out that there are several heuristic cues influencing and shaping scientific opinion, such as value predispositions and attention to media (Cacciatore, Scheufele, & Corley, 2011; Scheufele & Lewenstein, 2005; Su et al., 2015).

In this study, I examine the relative impacts of value predispositions including political orientation, religiosity, and deference to scientific authority, media consumption, knowledge, trust in scientists, and benefit and risk perception on public regulatory attitudes towards science policy. I focus this work specifically on understanding different impacts of perceived knowledge and factual knowledge, deference and trust in scientists, and scientific and political media consumption in traditional media outlets and online in the formation of public regulatory attitudes toward science. In taking this approach, I explore three perspectives toward science regulations: the role to ensure safety, the possibility of slowing down scientific progress, and the perceived need for more regulations. Specifically, I focus my analysis on nuclear power, nanotechnology and synthetic biology. While a complete overview of these topics is beyond the scope of the present research, a brief overview is necessary for situating my work.

CHAPTER 2

LITERATURE REVIEW

Issue of interest: Nuclear Power

Among the three issues that are discussed in this study, nuclear power is the most established issue, and also American audiences recognize this issue the most with the highest levels of familiarity, and this high familiarity relates to the support of nuclear power, as well. (Van Der Pligt, Eiser, & Spears, 1986).

The nuclear events at Hiroshima and Nagasaki introduced many Americans to the nuclear age, and they increased awareness of nuclear power with the image of mushroom cloud from the exploding atomic bomb (Gamson & Modigliani, 1989). Meanwhile, post-World War II and into the mid-1960s, a dualism concerning nuclear energy emerged, the issue of nuclear power became a choice between atoms for war and atoms for peace (Gamson & Modigliani, 1989). There was limited public opposition toward nuclear power (Gamson & Modigliani, 1989).

In 1970s, antinuclear discourse rose from the Three Mile Island incident and Chernobyl, and the prominent pronuclear discourse toward nuclear energy from the energy crisis rose (Gamson, 1988; Gamson & Modigliani, 1989). In prior studies, there has been a higher level of support from upper-income Americans than lower-income respondents, and more support amongst Republicans and conservatives than amongst Democrats and liberals (Jones, 2009).

Even after the disaster happened in the Fukushima Daiichi plant in 2011, the level of risk perception from conservatives drastically declined compared to the dramatic increase in risk perception among liberals following the disaster (Yeo et al., 2014). In general, predictably, after the Fukushima Daiichi plant disaster in 2011, nuclear energy support from U.S. public declined from 47 percent to 39 percent, and on the other hand, the opposition increased from 42 percent to 52 percent (Pew Resarch Center, 2011).

Issue of interest: Nanotechnology

On the other hand, nanotechnology and synthetic biology are relatively new technologies, and they have significantly lower levels of public awareness (Hart, 2013). In 2008, nearly half (49%) of adults responded that they have never heard anything at all about nanotechnology (Hart, 2008). Nanotechnology is a science diversely applied in the field of science, engineering, and it involves the nanoscale substances, which is 1–100 nanometers in size (Sargent Jr, 2013). The economic and societal promising aspects of nanotechnology have induced governments and companies all over the world to make major investments in the science (Sargent Jr, 2013). In its early stage of development, nanotechnology's broad applications and its technological complexity caused a wide range of public policy discourse. "Maintaining U.S. technological and commercial leadership in nanotechnology poses a variety of technical and policy challenges, including development of technologies that will enable commercial scale manufacturing of nanotechnology materials and products, as well as environmental, health, and safety concerns (Sargent Jr, 2013)." The broad applications of nanotechnology with the unique qualities from nanoscale bring the potential benefits for products and industries that are transformed and created from the existing industries (Vance et al., 2015).

Proponents for nanotechnology perceive that there is no environmental harm in its applications, and it improves the quality of our lives and it will eventually strengthen national security (Sargent Jr, 2013). While there is a growing number of nanotechnology-enabled products in the marketplace (Consumer Reports, 2007) including genetically modified organisms (GMOs), cosmetics (Swiss, 2004), even in cancer therapy through its early diagnosis and personalized therapy and medicine (Misra, Acharya, & Sahoo, 2010), there is also growing concern about the human health and environmental problems associated with the science (Bowman & Fitzharris, 2007; Consumer Reports, 2007; Gordijn, 2006). “Carbon nanotubes have distinctive characteristics, but their needle-like fibre shape has been compared to asbestos, raising concerns that widespread use of carbon nanotubes may lead to mesothelioma, cancer of the lining of the lungs caused by exposure to asbestos (Poland et al., 2008).” In addition, in 2009, it was discovered that seven printing factory workers got lung damages due to exposure to nanoparticles, and two of them subsequently died (Gilbert, 2009). I expect that this incident caused the public to have safety concern and feel more need for nanotechnology regulations. Also, there are widespread ethical, legal and moral issues surrounding nanotechnology because of its ability to control human genetics, and eventually it potentially creates new life (Roco & Bainbridge, 2002).

Issue of interest: Synthetic Biology

Synthetic biology is the application of advanced science and technology to create or re-create living organisms including the production of new genetic code, such as DNA, that have never existed in nature (Hart, 2008). Synthetic biology opened a door for humans to build a new biomolecule to reconnect organisms (Khalil & Collins, 2010), and "these re-engineered organisms will change our lives over the coming years, leading to cheaper drugs, 'green' means to fuel our cars and targeted therapies for attacking 'superbugs' and diseases, such as cancer (Khalil & Collins, 2010)." It has many potential benefits through creating bioengineered microorganisms, and it provides great promise for pharmaceuticals, chemicals, and the medical field for destroying cancer cells (Tucker & Zilinskas, 2006).

On the other hand, like nanotechnology, there are increasing health and ethical concerns for synthetic biology because of the risks from genetically engineered organisms (Serrano, 2007). It increases public risk perceptions that there is a possibility that redesigned organisms are accidentally released (Serrano, 2007). In addition, there is a growing concern for terrorism that synthetic biology could produce engineered agents, and they will function as living sensor web to report to the government, and they will be used as weapons (Ball, 2004).

Prior research has shown that those with high levels of religiosity and lower levels of income and education were more likely to respond that the risks of synthetic biology outweigh the benefits (Hart, 2013). It also has been found that males, liberals, and those with lower levels of religiosity tend to perceive greater benefits from the science (Cacciatore et al., 2011).

Framework for Science Regulations

With the fast-paced nature of technological innovation in the area of emerging technologies, such as nanotechnology and synthetic biology, regulation of these technologies has increasingly become an urgent topic for the policy making community (Corley, Kim, & Scheufele, 2013). When the public's concern about nuclear power safety caused shutdowns for multiple nuclear power plants and a dramatic increase in costs for construction and operation for others, regulation for nuclear power is a matter of considerable debate, as well (Feinstein, 1989). Even considering the extensive scientific and commercial interest in the promising nanotechnology phenomenon, discussion has been limited to debate on the associated regulatory and legal aspects (Bowman & Hodge, 2007). While Forrest (1989) and Fielder and Reynolds (1994) were among the first who speculated on the regulatory challenges that would accompany application in industries of nanotechnology, until recently, there has been rather limited discussion of issues of regulation, and most of the regulation research has been focused on scientists' involvement in regulation instead of public regulatory attitudes.

Targeting leading U.S. scientists, several surveys were conducted recently to better understand their perceptions of nanotechnology regulations. Survey questions were focused on choosing which area of nanotechnology application has the most urgent need for regulation (Corley et al., 2013). Most of the findings concerning emerging technologies' regulations have been focused on the relationship between scientists' benefit and risk perception and their support for regulation (Corley, Scheufele, & Hu, 2009). Less well understood is how the public perceives and processes scientific regulations. Also, there is a need to measure public regulatory attitudes: not solely depending on the fact if they support regulations or not, but how they actually perceive of the purpose of science regulations. Therefore, this study focuses on analyzing different aspects of the public's regulatory attitudes to arrive at a more comprehensive understanding of how publics view the regulatory framework for nanotechnology and other established and emerging technologies.

Materials manufactured at the nanoscale bring a significantly different chemical activity compared to the same materials at a larger size, have significantly different chemical reactivity, electrical conductivity, strength, mobility, solubility, magnetic and optical properties (Swiss, 2004). While nanotechnology provides promising advantages, there is an increasing concern that its regulation does not consider the potential risks and scientific uncertainty associated with the science (Bowman & Fitzharris, 2007). The concern has increased due to the increasing application of consumer products, particularly in the therapeutic and cosmetics sectors.

The usage of engineered nanoparticles has caused a display of unexpected toxicological and ecotoxicological properties, and that links to an apparent risk to health and environmental safety (Bowman & Fitzharris, 2007). Importantly, the FDA announced that they are not currently aware of any safety concerns about nanotechnology-enabled products, but that they are "planning additional studies to examine the effects of select nanoparticles on skin penetration" (FDA, 2009). Meanwhile, consumers continue to buy cosmetics containing nanomaterials without a clear knowledge of the potential risks (Corley et al., 2009). Therefore, beyond the mainstream focus of regulation research on finding out which area of emerging technologies needs more regulation from scientists' perspective (Besley, Kramer, & Priest, 2008; Corley et al., 2009), there is a need of a more comprehensive framework for the public's science policy regulation, and a need to figure out how safety concern can influence public opinion of science regulation.

Political orientations and science regulations

Public opinion on policy issues is group-centric (Nelson & Kinder, 1996), that citizens are susceptible to "visible social groupings" when they shape their political opinion (Converse, 1964). Group-centrism is positioned in citizens' attitudes toward the social groups that they perceive as the primary beneficiaries or victims from the policy issues, and the power of group-centrism explains how issues are framed (Nelson & Kinder, 1996). In a previous research, it has been found out that group-centrism increase when a policy is framed more for a policy's beneficiaries and group-centrism decline when a policy is framed to pay attention to other factors than beneficiaries (Nelson & Kinder, 1996). Therefore, this paper can explore how different wordings in describing regulation policies can influence the public depending on their political orientations.

Political ideology has influenced greatly on both expert and lay audiences for scientific controversies, and especially for science regulations (Pratto, Stallworth, & Conway-Lanz, 1998; Su et al., 2015). Previous research has explained that liberal lay audiences perceive more nanotechnology risks (Kahan, Braman, Slovic, Gastil, & Cohen, 2009; Su et al., 2015). While scientists' political ideology was not significant in predicting the support for more regulations of nanotechnology, higher level of liberalism from the lay audience significantly predicted the need for more regulations in both academic and commercial nanotechnology research (Su et al., 2015). Studies have shown that scientists use their heuristic cues, especially their conservatism to decide if nanotechnology needs more regulations (Corley et al., 2009). This study is meaningful in that it contributes which political orientation of the public influences their perspectives on science regulations, not only for nanotechnology but also for nuclear power and synthetic biology. With this information in mind, I propose my initial set of research questions:

RQ1a: What is the association between respondents' political orientations and their perspective that existing U.S. regulations ensure public safety from (a) nuclear power (b) nanotechnology (c) synthetic biology risks?

RQ1b: What is the association between respondents' political orientations and their perspective that regulating (a) nuclear power (b) nanotechnology (c) synthetic biology will significantly slow down scientific progress?

RQ1c: What is the association between respondents' political orientations and their perspective that academic and commercial (a) nuclear power (b) nanotechnology (c) synthetic biology research should be regulated?

Religiosity and Science Regulations

In shaping public opinion in science issues, religiosity has not only had a simple correlation to public science attitudes, but it also has a relationship with public benefit perceptions (Scheufele, Corley, Shih, Dalrymple, & Ho, 2009). In previous research, publics with higher levels of religiosity was related to more support for regulations for both academic and commercial nanotechnology research (Su et al., 2015).

Religiosity has been found to have a negative correlations with the moral acceptability of science issues like nanotechnology (Scheufele et al., 2009). Interestingly, among respondents who answered that they do not approve nanotechnology under any circumstances, the majority was respondents who do not feel nanotechnology to be morally acceptable (Scheufele et al., 2009). Also, there were less than 10 percent of respondents who approve of nanotechnology as long as the usual levels of government regulation were in effect, when they feel that nanotechnology is morally acceptable (Scheufele et al., 2009). These findings contributed to an idea of how publics form their opinion toward emerging technologies, and it is highly influenced by their personal beliefs, such as religiosity. This study will explore how public religiosity influences regulation regarding safety perception, slowing down the scientific progress, and the support for more regulations for nuclear power, nanotechnology, and synthetic biology. The pattern of religiosity in previous science communication research led me into these research questions:

RQ2a: What is the relationship between the level of religiosity and the perception that existing U.S. regulations ensure public safety from (a) nuclear power (b) nanotechnology (c) synthetic biology risks?

RQ2b: What is the relationship between the level of religiosity and the perception that regulating (a) nuclear power (b) nanotechnology (c) synthetic biology will significantly slow down scientific progress?

RQ2c: What is the relationship between the level of religiosity and the perception that academic and commercial (a) nuclear power (b) nanotechnology (c) synthetic biology research should be regulated?

Deference to scientific authority

To better understand the public's attitude toward science policies and regulation, deference to scientific authority should be considered. Scientists are often considered leading authorities in policy debates with their strong levels of societal trust and their contribution in the discussion of controversies over technologies (Besley & Nisbet, 2013; Scheufele et al., 2007). In the prior science communication research, deference to scientific authority, which was positively correlated with education, has been a central value predisposition shaping support for technologies, it also has been the key predictor of both trust in the sponsors of emerging technologies and generalized reservations about the impacts of science (Brossard & Nisbet, 2007). Deference to scientific authority pre-shapes American public opinion about emerging technologies, and through being cultivated by the nature of the American educational system, deference in primary research has been based on the exceptionalism of science, which is the belief that science should be mostly free from direct regulation and political control (Bimber & Guston, 1995; Brossard & Nisbet, 2007). Through textbooks and lesson plans, science is generally described as a politically neutral, unproblematic institution that systematically and objectively increases knowledge about the nature world (Irwin, 2001). If scientists are perceived as the experts, even when controversies exist for certain science issues, deference to scientific authority is a relatively stable predisposition reinforced through the American educational system. In other words, when science controversies do occur, deference to scientific authority acts as a value predisposition that 'pre-shapes' American perceptions of science in a pro-technology direction. Therefore, this pattern in deference led me into these hypotheses:

H1a: Higher deference to scientific authority will be positively associated to public opinion that existing U.S. regulations ensure public safety from nuclear power risks.

H1b: Higher deference to scientific authority will be positively associated to public opinion that existing U.S. regulations ensure public safety from nanotechnology risks.

H1c: Higher deference to scientific authority will be positively associated to public opinion that existing U.S. regulations ensure public safety from synthetic biology risks.

Trust in Scientists

Prior studies have shown that trust is another key predictor for public opinion and attitudes toward technologies, especially when predicting support for technologies (Anderson, Scheufele, Brossard, & Corley, 2011; Liu & Priest, 2009). Unlike deference that is build by education, trust, as an essential component of all social relationships, is created by tradition (Barber, 1987), and as another heuristic cue, trust acts as social capital to facilitate deference to authorities (Kramer, 1999).

There is a viewpoint that instead of trust influencing public's attitude toward science issues, their attitude builds trust (Poortinga & Pidgeon, 2005), and in this study, it looks into the role of trust in scientists to form public regulatory attitude. Trust in scientists, who are often recognized as the spokespersons for emerging technologies, can serve as a cognitive shortcut for publics to form their own attitudes toward science topics and controversies (Cobb & Macoubrie, 2004; Liu & Priest, 2009). Scientists are often considered leading authorities in policy debates with their strong levels of societal trust and their contribution in the discussion of controversies over technologies (Besley & Nisbet, 2013; Scheufele et al., 2007). It has been shown from prior research that university scientists and religious leaders are two types of trust actors that are related to public attitudes, especially perceived benefits, toward science and technology (Liu & Priest, 2009). Also, in a previous study focusing on nuclear power, it has been found out that people's trust in scientists before Fukushima correlated with the trust in scientists after the Fukushima disaster (Visschers & Siegrist, 2013).

In this study, between scientists and religious leaders, I am focusing on public's trust toward scientists and scientific organizations to see a clearer pattern in public opinion for science regulations. Therefore, this pattern of trust led me into these research questions:

RQ3a: What is the association between respondents' trust in scientists and their perspective that existing U.S. regulations ensure public safety from (a) nuclear power (b) nanotechnology (c) synthetic biology risks?

RQ3b: What is the association between respondents' trust in scientists and their perspective that regulating (a) nuclear power (b) nanotechnology (c) synthetic biology will significantly slow down scientific progress?

RQ3c: What is the association between respondents' trust in scientists and their perspective that academic and commercial (a) nuclear power (b) nanotechnology (c) synthetic biology research should be regulated?

Issue-Attention Cycle

Content analyses in American media for the issue of nanotechnology remain ongoing, but a study of German-language print media found that articles typically reported on the potential benefits of the science as compared to the risks (Gschmeidler & Seiringer, 2012). Due to the media's ability to form public opinion toward emerging technologies, attention to media has been a useful variable to explore when investigating public attitudes toward science issues (Scheufele & Lewenstein, 2005; Su et al., 2015). For the most part, attention to media has been found to correlate positively to public support for science issues (Ho, Scheufele, & Corley, 2010; Lee, Scheufele, & Lewenstein, 2005; Su et al., 2015). Due to the lack of familiarity with many emerging science issues, lay audiences tend to be highly dependent on media consumption to form their opinion on those science issues (Su et al., 2015). According to Downs' (1972) 'issue-attention cycle,' American news media coverage for science issues follows a cyclical pattern with several important stages. First, there is a pre-problem stage when issues just begin, and public's interest and attention is low. In this stage, only a small portion of the overall population, such as experts or special interest groups are likely to be aware of the issue (Downs, 1972;

Shih, Wijaya, & Brossard, 2008). Media coverage in this stage focuses on the potential benefits of the science or technology issues in question. This issue stays in this low-attention stage until a crisis regarding this issue acts as a catalyst pushes the topic into the public consciousness (Nisbet & Huge, 2006). Therefore, in the early stage of the issue-attention cycle, most of the prior research about regulation of emerging technologies has focused on the relation between benefit and regulation, mostly from the scientists' perspective (Bowman & Hodge, 2007; Corley et al., 2013), and focused on economic values due to its potential for applications in the industry and technology transfer (Corley et al., 2009). With the increasing awareness for the issue and the problems regarding this science issue, the public starts to realize the cost for solving these problems. At first, people feel that it is possible to solve these problems, but after some time, they start to realize the cost to solve these problems are more than what they expected, and this is the third stage for a science issue (Shih et al., 2008). With the emergence of new issues, public interest on the existing science issue declines (Nisbet & Huge, 2006).

The different science issues we explore in this study all have emerged into media at different points in time. Nuclear power has already worked through the issue-attention cycle several times, with both a pronuclear movement focusing on nuclear power as a source of alternative energy and an antinuclear movement which rose after several disasters (Gamson & Modigliani, 1989). Antinuclear discourse started through organizations such as the Union of Concerned Scientists saying that nuclear energy is not cost effective, and the issue of nuclear power had the highest levels of media coverage following several major nuclear accidents (Gamson & Modigliani, 1989). Then in the early 1980s, when disarmament became the priority, the antinuclear energy movement disintegrated in the USA (Joppke, 1991). The data that I rely on in this study was collected less than one year after the Fukushima Daiichi nuclear disaster, so this study reflects post-disaster public opinion for nuclear energy.

Based on the familiarity of nanotechnology and synthetic biology, both science issues are positioned in their initial stages of the issue-attention cycle (Ho, Scheufele, & Corley, 2011). Also, prior research has suggested that media coverage for nanotechnology has been a lot more about benefits than risks in traditional media environment (Dudo, Dunwoody, & Scheufele, 2011). When a certain science issue is just emerging, people are more exposed to positive aspects of science from various types of media outlets, and they are more likely to build benefit perceptions toward the topic. This study questions if there is a difference in benefit perception through public's media consumption between an existing science issue and emerging issues. In prior research, scientists with higher levels of benefit perception and lower levels of support for regulation were more likely to have concerns that regulation will slow down scientific progress (Corley et al., 2013). This study will explore how the public benefit perceptions are associated with their concerns for regulations to slow down scientific progress. This led me to the following research questions:

> RQ4a: What is the association between higher media consumption and public concern that regulation for nuclear power will slow down scientific progress?
>
> RQ4b: What is the association between higher media consumption and public concern that regulation for nanotechnology will slow down scientific progress?

RQ4c: What is the association between higher media consumption and public concern that regulation for synthetic biology will slow down scientific progress?

Benefit and Risk Perceptions and Science Regulations

It is an important component for making policy decisions to consider benefits and risks of a new technology (Corley et al., 2009). For nanotechnology, it has been suggested that both public and nanoscientists perceive higher levels of benefits than levels of risks (Besley et al., 2008). For nuclear power, perceived benefits have measured as the acceptance of nuclear power, and it was clear that perceived benefit before Fukushima correlated with perceived benefits after the disaster (Visschers & Siegrist, 2013). Interestingly, after the disaster, people reported higher levels of knowledge about the risks of nuclear power (Visschers & Siegrist, 2013). In 2010, 33% of the American public continued to believe the risks of synthetic biology will be about equal to the benefits (Hart, 2010). When more science regulations can limit the potential benefits, and less restrictive regulations can cause more exposure of uncertain risks to the public (Corley et al., 2009). To better understand the public benefit perception of science issues, I proposed the following research questions:

RQ5a: What is the association between respondents' benefit perception and their perspective that existing U.S. regulations ensure public safety from (a) nuclear power (b) nanotechnology (c) synthetic biology risks?

RQ5b: What is the association between respondents' benefit perception and their perspective that regulating (a) nuclear power (b) nanotechnology (c) synthetic biology will significantly slow down scientific progress?

RQ5c: What is the association between respondents' benefit perception and their perspective that academic and commercial (a) nuclear power (b) nanotechnology (c) synthetic biology research should be regulated?

The last aspect for regulation that I explore in this study is on the perceived need for regulations for both academic and commercial research. To date, public attitudes toward the regulation of recent technologies have not shown a difference between academic and commercial research (Cacciatore et al., 2011). To understand the lay audience opinions of science regulation, perceived benefit and risk perception has been key in prior research (Gerber & Neeley, 2005). This work has suggested that higher risk perceptions leads to support for government intervention; such as regulatory policies to balance their higher perceived risk (Gerber & Neeley, 2005). Previous research about nanotechnology regulations discovered that greater risk perceptions were positively related to higher levels of support for each academic and commercial nanotechnology research (Su et al., 2015). This study will help explain how public risk perception influences their support for not only nanotechnology but also nuclear power and synthetic biology regulations for their academic and commercial research. This led me to the following hypothesis and sets of research questions.

H2: If the public has a higher risk perception, it will positively be related to their support for more regulations for (a) nuclear power, (b) nanotechnology, and (c) synthetic biology commercial and academic research.

RQ6a: What is the association between respondents' risk perception and their perspective that existing U.S. regulations ensure public safety from (a) nuclear power (b) nanotechnology (c) synthetic biology risks?

RQ6b: What is the association between respondents' risk perception and their perspective that regulating (a) nuclear power (b) nanotechnology (c) synthetic biology will significantly slow down scientific progress?

This study is meaningful in a way that it can give a potential direction for science regulations based on an understanding of regulation as a means of ensuring safety, in terms of its impacts on slowing down scientific progress, and by focusing on a host of variables as predictors of these attitudes. Previous research for science regulation has focused on the public and scientist's perception for the need for regulations in commercial and academic research (Su et al., 2015). In addition, current regulatory frameworks for nanotechnology are not able to address nanotechnology research, and it also does not imply the progress of risk evaluation (Corley et al., 2009). Therefore, this study can provide input toward regulatory frameworks by providing not only an assessment of public benefit and risk perception impacts on regulatory attitudes in three specific areas: the role of ensuring safety, the aspect of slowing down the scientific progress, and the need for more regulations for nuclear power, nanotechnology, and synthetic biology.

Perceived Knowledge and Factual Knowledge

There is a long debate concerning the factors influencing public decision-making for policy issues. First of all, there is a theory of human nature known as cognitive misers or at least satisficers, that describes the tendency for a person to collect only as much information about a topic as they think is necessary to reach a decision (Fiske & Taylor, 1991). Since they are facing daily demands consuming their time and attention, instead of being informed of all policy issues, the public looks for short cuts for information processing to reach their social judgments about complex policy debates (Popkin, 1991). "A low information public is likely to rely heavily on their underlying value orientations in combination with a 'convenience sample' of just those interpretations or definitions of an issue most readily available from the mass media (Brossard & Nisbet, 2007)"

The emphasis on low information counters to another widely held belief among many scientists that science literacy, which means understanding the facts in science and having the knowledge, can be the key factor shaping public views about science. Science literacy also relates to the level of support in science. If the public knew more about science, then scientists would be granted greater influence over important policy decisions, and controversies would likely go away (Bodmer, 1985). This perspective has predominantly been driven by the knowledge deficit model, which suggests that low levels of public understanding about science and new technologies in the U.S. may negatively influence levels of support among citizens (Miller, 1998; Scheufele & Lewenstein, 2005).

It is a difficult task to create an appropriate balance of quick and reliable knowledge measures with high validity, so many scholars rely on the use of factual knowledge questions (Ladwig, Dalrymple, Brossard, Scheufele, & Corley, 2012). Similarly, some scholars have argued that measures of 'perceived familiarity', which have also been referred to as 'self-reported knowledge' and 'perceived knowledge', with science topics may reflect a better assessment of an individual's knowledge (Ladwig et al., 2012). So far, previous research focused on only one method of measuring public knowledge for science issues (Cacciatore et al., 2011), and this paper is meaningful in a way that it provides different results when public perceives science issues and when public actually learns more and have knowledge for each issue. This study explores how both the perceived knowledge and factual knowledge predicts public regulatory attitude, and also how both knowledge differently act for more familiar science issue. Therefore, these are the proposed research questions:

RQ7a: What type of relationship does perceived knowledge for (a) nuclear power, (b) nanotechnology, and (c) synthetic biology and public's perception that existing U.S. regulations ensure public safety from (a) nuclear power (b) nanotechnology, and (c) synthetic biology?

RQ7b: What type of relationship does perceived knowledge for (a) nuclear power, (b) nanotechnology, and (c) synthetic biology and public's perception that regulating (a) nuclear power (b) nanotechnology, and (c) synthetic biology will significantly slow down scientific progress?

RQ7c: What type of relationship does perceived knowledge for (a) nuclear power, (b) nanotechnology, and (c) synthetic biology and public's perception that academic and commercial (a) nuclear power (b) nanotechnology, and (c) synthetic biology research should be regulated?

RQ8a: What type of relationship does factual knowledge for (a) nuclear power, (b) nanotechnology, and (c) synthetic biology and public's perception that existing U.S. regulations ensure public safety from (a) nuclear power (b) nanotechnology, and (c) synthetic biology?

RQ8b: What type of relationship does factual knowledge for (a) nuclear power, (b) nanotechnology, and (c) synthetic biology and public's perception that regulating (a) nuclear power (b) nanotechnology, and (c) synthetic biology will significantly slow down scientific progress?

RQ8c: What type of relationship does factual knowledge for (a) nuclear power, (b) nanotechnology, and (c) synthetic biology and public's perception that academic and commercial (a) nuclear power (b) nanotechnology, and (c) synthetic biology research should be regulated?

CHAPTER 3

METHODS

Participants

In order to test these expectations, I relied on data from a nationally representative online survey of U.S. adults aged 18 years and older. The online survey was conducted by GfK Knowledge Networks and relied upon their KnowledgePanel sample. KnowledgePanel members are randomly recruited through probability-based sampling that covers approximately 97% of all U.S. households. To ensure representativeness, households are provided with access to the Internet and hardware where needed. The survey was conducted between December of 2011 and January of 2012. Some 13,131 panelists were randomly drawn from the GfK KnowledgePanel®; 6,425 responded to the invitation, yielding a final stage completion rate of 48.9% percent. The recruitment rate for this study, reported by GfK, was 15.5% and the profile rate was 64.9%, for a cumulative response rate of 4.9% and a final sample size of 2,806. As part of an experiment that was embedded in the data, approximately one-third of respondents were assigned to read a news article about each issue. The articles also differed in terms of how the topic was framed. Rather than run the regression on all 2,806 respondents and risk Type 1 error, I ran the nuclear power regression on those who were assigned to the nuclear power condition, the nanotechnology regression on those assigned to the nanotechnology condition, and so on. Importantly, to control for the experimental manipulations as part of the analysis, these elements are contained in “Block 0” in the regression.

Measures

Dependent Variable 1: Existing U.S. regulations ensure public safety from nuclear power, nanotechnology, and synthetic biology risks

There are three dependent variables to find out public’s regulatory attitude toward nuclear power, nanotechnology, and synthetic biology. The first dependent variable is public’s perspective that existing U.S. regulations ensure public safety from nuclear power, nanotechnology, and synthetic biology risks. This variable was measured with 5-point scale (1=”Strongly disagree,” 5=”Strongly agree”) asking respondents how much they agree with the following statement related to nuclear power: “Existing U.S. regulations ensure public safety from nuclear power risks” (M=3.0; SD=1.1). Same question was used to measure the public’s safety perception toward nanotechnology regulation (M=2.6; SD=.95), as well as for synthetic biology (M=2.6; SD=1.0).

Dependent Variable 2: Regulating nuclear power, nanotechnology, and synthetic biology will significantly slow down scientific progress

The next dependent variable focused on the public’s regulatory attitude is to see if they are concerned that regulations make scientific progress slow down. This was also measured with 5-point scale (1=”Strongly disagree,” 5=”Strongly agree”) asking respondents how much they agree with the following statement for nuclear power: “Regulating nuclear power will significantly slow down scientific progress” (M=2.7;

SD=1.1). The same questions were used to measure public's concern that regulation slows down scientific progress for nanotechnology (*M*=3.0; *SD*=1.0) and synthetic biology (*M*=3.0; *SD*=1.1).

Dependent Variable 3: Academic and Commercial research for nuclear power, nanotechnology, and synthetic biology should be regulated

The last variable concerning public regulatory attitudes focused on the perceived needs for both academic and commercial research for nuclear power, nanotechnology, and synthetic biology. To measure this, we asked a pair of questions examining academic and commercial research for nuclear power, nanotechnology, and synthetic biology. Using a 5-point scale (1="Strongly disagree," 10="Strongly agree"), respondents were asked the following statements: Academic nuclear power research should be regulated (M=3.5; SD=1.1) and Commercial nuclear power research should be regulated (M=3.7; SD=1.1), and these two items were averaged together (*M*=3.6; *SD*=1.0) with *r*=.81). The same questions were asked to respondents for regulating academic research for nanotechnology (*M*=3.3; *SD*=1.1), and commercial nanotechnology research (*M*=3.5; *SD*=1.1), and these items were averaged together (*M*=3.4; *SD*=1.0; *r*=.74). The same items were asked for synthetic biology for regulating its academic research (*M*=3.4; *SD*=1.1) and its commercial research (*M*=3.7; *SD*=1.1), and then these items were averaged together (*M*=3.6; *SD*=1.0; *r*=.77).

Control variables: Demographics

Age, education, gender served as the primary control variables in this analysis. *Age* was measured as a continuous variable (M = 50.6; SD = 15.9). *Education* was an ordinal variable with four categories. The categories ranged from "less than high school" (coded as "1"), "high school" (coded as "2"), "some college" (coded as "3") to "bachelor's degree or higher" (coded as "4") (M = 2.9; SD = .9). *Gender* was a dichotomous variable with male coded as "1" (55.2%) and female coded as "2".

Religiosity, Ideology and Deference to scientific authority

Political ideology was measured for both economic issues (M = 4.4; SD = 1.5) and social issues (M = 4.1; SD = 1.6) with categories ranging from "very liberal" (coded as "1") to "very conservative" (coded as "7"). These two items were then averaged together to create an overall measure of social and economic ideology (M = 4.2; SD = 1.4; r = .77). *Religiosity* was measured by asking respondents, "How much guidance does religion provide in your everyday life?" The measure used a 10-point scale anchored at "No guidance at all" (coded as "1") and "A great deal of guidance" (coded as "10") (M = 6.0; SD = 3.1). *Deference to scientific authority* was measured by asking respondents to report their level of agreement or disagreement ("Strongly disagree" coded as "1" and "Strongly agree" coded as "10") with the following pair of 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." Responses to the two items were then averaged together to create an index (M = 4.0; SD = 2.1; r = .64).

Science media attention and Political media attention

This study included three measures of scientific media consumption, one for each of newspapers, television and online consumption. *Science newspaper attention* assessed by asking respondents to report their levels of attention ("No attention" coded as "1"; "A lot of attention" coded as "5" to the following types of content when reading a newspaper either in print or online form: "Science and Technology", "Specific scientific developments, such as nanotechnology," and "Social and ethical implications of emerging technologies." Responses to these three items were averaged together to form our index of attention to science in newspapers (M = 2.4; SD = 1.0) and displayed high internal consistency (α= .91).

Science television attention was assessed with the same response scale as above by asking respondents to report their levels of attention to the same three content areas when watching either traditional television or online television, through sources such as Hulu or news websites. Once again, responses to the three items were averaged together to form an overall index of attention to science on television (M = 2.7; SD = 1.0) and displayed high internal consistency (α=.93).

Science web attention was measured in the same fashion and across the same content areas noted above by asking respondents to report their levels of attention when they go online (excluding online versions of newspapers or online versions of television shows) for news and information. As with the previous assessments of media attention, responses to the three items were then averaged together to form the index of online science attention (M = 2.1; SD = 1.0) and displayed high internal consistency (α=.94).

Political newspaper attention assessed by asking respondents to report their levels of attention ("No attention" coded as "1"; "A lot of attention" coded as "5" to the following types of content when reading a newspaper either in print or online form: "International Affairs" and "National government and politics". Responses to these two items were averaged together to form our index of attention to politics in newspapers (M = 2.84; SD = 1.13) and showed high internal consistency (α= .91).

Political television attention was assessed with the same response scale as above by asking respondents to report their levels of attention to the same two content areas when watching either traditional television or online television, through sources such as Hulu or news websites. Once again, responses to the three items were averaged together to form an overall index of attention to science on television (M = 3.08; SD = 1.09; α=.91).

Political web attention was measured in the same fashion and across the same content areas noted above by asking respondents to report their levels of attention when they go online (excluding online versions of newspapers or online versions of television shows) for news and information. As with the previous assessments of media attention, responses to the two items were then averaged together to form the index of online science attention (M = 2.41; SD = 1.18; α=.94).

Perceived knowledge and Actual knowledge

Perceived knowledge for nuclear power was measured by asking respondents "How well informed you would say you are about nuclear power." The measure used a 10-point scale anchored at "Not at all informed" (coded as "1") and "Very informed" (coded as “10”) (*M* = 4.37; *SD* = 2.65). *Perceived knowledge for nanotechnology* was also measured by asking respondents same question, but for nanotechnology (*M* = 2.72; *SD* = 2.2). *Perceived knowledge for synthetic biology* was measured with the same item as well, but for synthetic biology *(M* = 2.5; *SD* = 2.0). *Factual knowledge for nuclear power* was measured by asking respondents to report how true or false (“Definitely true” coded as “1”, “Likely true” coded as “2”, “Likely false” coded as “3”, “Definitely false” coded as “4”, and “Don’t know” coded as “9”) they felt the following statements to be: “Less than 10% of the U.S.’s electricity comes from nuclear power plants”, “There are over 90 operating nuclear reactors in the U.S.”, and “Nuclear power plants emit significant amounts of carbon dioxide.” Responses were dichotomized into “1” as correct, and “0” as incorrect, and then responses to the three items were then averaged together to create an index (*M* = .44; *SD* =.31). *Factual knowledge for nanotechnology* was measured by asking respondents, using the same scale noted above, how true or false they felt each of the following statements to be: “Nanotechnology involves materials that are not visible to the naked eye”, “Currently, there are only a few dozen consumer products on the market using nanotechnology”, and “Nanotechnology allows scientists to arrange molecules in ways that do NOT occur in nature.”

Again, answers were dichotomized, correct responses were coded as “1”, and incorrect answers were coded as “0”. Then, responses to these items were averaged together, and then it created an index (M = .52; SD = .32). *Factual knowledge for synthetic biology* was measured with the same process as the factual knowledge variables noted above. Respondents were asked to report how true or false each of the following statements were: “Recently, the Obama Administration banned all synthetic biology research", "Synthetic biology is the application of artificial intelligence to biological systems", and "The iGem competition is a global synthetic biology competition involving undergraduate and high school students." Responses were dichotomized into "1" as correct and "0" as incorrect, and then responses to these items were averaged together to create an index (*M* = .28; *SD* = .30).

Trust in scientists

To measure *trust*, responses were examined for three different types of scientific authority: "university scientists", "regulatory agencies, such as the Environmental Protection Agency (EPA), or the Food and Drug Administration (FDA)", and "Environmental organizations" based on the high correlation with the dependent variables. Trust in each of the above institutions was measured based on a 10-point scale (from "1" coded as "Do not trust their information at all" to "10" coded as "Trust their information very much"). Specifically, respondents were asked: "Now we would like to ask you which of the following sources of information, if any, you trust to tell you the truth about the risks and benefits of technologies and their applications. How much do you trust…?" followed by each of the three scientific institutions noted above. Responses to these three items were averaged together to create an index (*M* = 5.66; *SD* = 1.77) with a Cronbach's alpha of .74.

Benefit and Risk perception

Benefit perception for nuclear power (*M* = 5.0; *SD* = 1.72) was measured using a 7-point scale ("1" coded as "Not at all beneficial" and "7" coded as "Very beneficial"), and the following statement: "How beneficial do you think each of the following is for society as a whole?" where respondents were asked to rate their overall perceptions of benefits for a series of science issues. *Benefit perception for nanotechnology* (*M* = 4.24; *SD* = 1.6) and *Benefit perception for synthetic biology* (*M* = 3.95; *SD* = 1.55) were also measured through the same item. *Risk perception for nuclear power* (*M* = 4.57; *SD* = 1.65) was also measured with a 7-point scale ("1" coded as "Not at all risky" and "7" coded as "Very risky"), using the following statement: "How risky do you think each of the following is for society as a whole?" Respondents were asked to choose their level of risk perception for each science issue. *Risk perception for nanotechnology* (*M* = 3.97; *SD* = 1.51) and *Risk perception for synthetic biology* (*M* = 4.36; *SD* = 1.51) were measured with the same process as the *Risk perception for nuclear power* variable noted above.

Methodology

To test my research questions and hypotheses, I applied hierarchical ordinary least squares (OLS) regression models, entering variables into the regression models in each block according to the assumed causal order. The first block included demographic measures, while the second block contained value predisposition measures. The third block consisted of the media attention measures for both science and politics, followed by measures of perceived and actual knowledge (Block 4) and Trust (Block 5). Block 6 consisted of the each benefit and risk perception for nuclear power, nanotechnology and synthetic biology.

CHAPTER 4

RESULTS

Regression predicting that existing U.S. regulations ensure public safety from nuclear power risks

Table 1 presents the results of the three separate regression models predicting that existing U.S. regulations ensure public safety from nuclear power, nanotechnology, and synthetic biology risks. In these three regressions, for the third block, which is attention to media Before-entry betas allow one to look at the impacts of an independent variable on a dependent variable by entering the variables in that block alone, without the presence of the other independent variables in that block.

[Insert Table 1 about here.]

The first regression predicted the public safety perception concerning existing nuclear power regulation using the following 6 blocks: demographics, value predispositions, scientific and political media consumption, perceived and factual knowledge for nuclear power, trust in scientific authority, and benefit and risk perception for nuclear power. As Table 1 indicates, none of the demographic variables remained significant after all other variables were controlled for. In total, the demographic variables accounted only for 1.4% of the total variance for public's safety perception through existing nuclear power regulation.

The second block of this regression looked at political ideology, religiosity, and deference to scientific authority. In answering RQ1a, there is no significant relationship between respondents' political orientations and their perspective that existing U.S. regulations ensure public safety from a nuclear power risks. Deference to scientific authority remained highly significant, and having a high level of deference to scientific authority positively influenced the public belief that existing U.S. regulations ensure public safety from nuclear power risks. Thus, there is a support for H1a. The second block of the regression contributed 8.9% of the explained variance in the dependent variable.

Next, scientific and political media consumption were entered into the regression. As Table 1 illustrates, political newspaper attention and political television attention were positively related to perceptions of perceived safety from the existing nuclear power regulations. The third block of the regression contributed an additional 1.4% of the explained variance in the dependent variable.

In terms of the main effects of perceived and factual knowledge, and in answering RQ7a and RQ8a, there are not significant relationships for both perceived and factual knowledge for nuclear power and public's belief that existing U.S. regulations ensure public safety from nuclear power risks. Overall, the perceived and factual knowledge block explains a non-significant 0.5% of the variance in safety perception from nuclear power risks through existing regulations.

The fifth block of the regression looked at the influence of trust in scientists on perceived safety from nuclear power risks through existing regulations. As Table 1 illustrates, trust in scientists was positively related to increases in the public safety perception. It partially answers RQ3a that trust in scientists and public's perceived safety is positively related. However, this fifth block of the regression contributes a non-significant 0.6% of the explained variance in the dependent variable.

Finally the last block of the regression included benefit and risk perceptions for nuclear power. Benefit perceptions toward nuclear power were strongly and positively related to the dependent variable that existing regulations ensure public safety from nuclear power. On the other hand, risk perception for nuclear power was negatively influenced the public safety perception concerning existing regulations. The benefit and risk perception block accounted for 11.2% of the explained variance in the dependent variable.

In total, this regression was able to explain 24.5% of the variance in the dependent variable.

Regression predicting that existing U.S. regulations ensure public safety from nanotechnology risks

The second regression predicted public's safety perception through existing nanotechnology regulation using 6 blocks: demographics, value predispositions, scientific and political media consumption, perceived and factual knowledge for nanotechnology, trust in scientific authority, and benefit and risk perception for nanotechnology. As Table 1 indicates, among the demographic variables, age and education remained significant even after all other variables were controlled for, and they were negatively related to the public's perceived safety from nanotechnology risks through existing U.S. regulations. In total, the demographic variables accounted for 0.9% of the total variance of their safety perception.

The second block of this regression looked at the value predispositions: political ideology, religiosity, and scientific deference. In answering RQ1a, there is no significant relationship between respondents' political orientations and their perspective that existing U.S. regulations ensure public safety from a nanotechnology risks. Scientific deference remained strongly and positively related to the public safety perception concerning existing regulations and nanotechnology risks. Therefore, there is a support for H1b. Overall, the value predispositions explains an additional 15.8% of the variance in perceived safety from nanotechnology risks through existing U.S. regulations.

In terms of the main effects of media consumption, attention to science in newspapers, attention to science on television, political newspaper attention, and political television attention were significant and positively related to public safety perception from nanotechnology risks through existing U.S. regulations. This third block of the regression contributed 0.9% of the explained variance in the dependent variable.

The fourth block of the regression examined the influence of perceived and factual knowledge of nanotechnology on the perception of safety. Between two knowledge variables, only factual knowledge remained significant and showed negative influences on perceived safety. In answering both RQ7a and RQ8a, more concretely, there is no significant relationship between perceived knowledge and perceived safety from nanotechnology risks. On the other hand, the more the public learns about nanotechnology – as measured with a set of factual knowledge items – the less they feel that existing U.S. regulations ensure public safety from nanotechnology risks. This fourth block of the regression contributed 0.5% of the explained variance in the dependent variable.

The fifth block of the regression explored the influence of trust in scientists on perceived safety from nanotechnology risks through existing regulations. It partially answers RQ3a that trust in scientists did not significantly impact perceived safety from nanotechnology risks. This fifth block of the regression contributed 0.7% of the explained variance in the dependent variable.

The last block of this regression included benefit and risk perception for nanotechnology. Benefit perceptions for nanotechnology were strongly and positively related to safety perceptions from nanotechnology risks through existing regulations. On the other hand, risk perceptions for nuclear power were negatively related to the public's safety perception through existing regulations. The benefit and risk perception block accounted for 4.5% of the explained variance in the dependent variable.

In total, this regression could explain 24.3% of the variance in perceiving safety from nanotechnology risks through existing regulations.

Regression predicting that existing U.S. regulations ensure public safety from synthetic biology risks

The third regression predicting the public's perceived safety looked at their safety perception from synthetic biology risks through existing U.S. regulations. Among demographic variables, similar to the previous regression, age and education remained significant and negatively related to perceptions of perceived safety into the final model of the regression. The demographic variables accounted for 0.9% of the total variance for perceived safety.

As mentioned, the second block of the regression examined value predisposition variables. In answering RQ1a, the more conservative respondents are, they are more likely to have a perspective that existing U.S. regulations ensure public safety from synthetic biology risks. Similar to two previous regressions, deference to scientific authority remained significantly and positively related to public's safety perception. This supports H1c that higher deference to scientific authority is positively associated to public opinion that existing U.S. regulations ensure public safety from synthetic biology risks. In total, value predisposition variables accounted for 13.7% of the total variance for public's perceived safety toward existing U.S. regulations from synthetic biology risks. About religiosity, among three science issues, only nanotechnology had significant relationships with the second and third dependent variable.

The third block of the regression added media consumption to the model. Unlike the previous two regressions, scientific and political media consumption did not remain significant into the final regression model and did not show any relationship with safety perceptions for synthetic biology risks through existing regulations. This block accounts for 0.6% of the total variance in perceived safety.

The fourth block of the regression examined both perceived and factual knowledge for synthetic biology. Just like the previous regression for nanotechnology, only factual knowledge remained significant and it showed a negative relationship with the dependent variable. To answer RQ8a, the more the public learns about synthetic biology facts, the less they feel that existing U.S. regulations ensure public safety from synthetic biology risks. Overall, the fourth block of this regression contributed 0.8% of the explained variance in the dependent variable.

The fifth block of the regression explored the influence of trust in scientists on perceived safety through existing regulations from synthetic biology risks. It remained highly significant into the final regression model and showed a positive relationship with the dependent variable. It answers RQ3a that higher trust in scientists is associated with a greater likelihood of perceiving that existing U.S. regulations ensure public safety from synthetic biology risks. Overall, this block was able to explain 2.7% of the variance.

The last block of this regression looked at the impact of benefit and risk perception for synthetic biology and their relationship to current regulations. Both benefit and risk perceptions were highly significant, but not surprisingly, in different directions. Specifically, higher the benefit perceptions were associated with a greater likelihood of believing that existing U.S. regulations ensure public safety from synthetic biology risks. On the other hand, higher the risk perceptions were associated with a decreased likelihood of believing that existing U.S. regulations ensure public safety from synthetic biology risks. In total, this last block explains 6.0% of the variance.

In total, this regression was able to explain 25.0% of the variance in perceiving safety from synthetic biology risks through existing regulations.

Regression predicting that regulating nuclear power will significantly slow down scientific progress

Next, I sought to better understand what predicts public perception that regulating nuclear power will significantly slow down scientific progress. As Table 2 indicates, none of the demographic variables remained significant after all other variables were controlled for. Overall, the first block accounted for 0.7% of the variance in the dependent variable.

[Insert Table 2 about here.]

The second block of the regression looked at the role of the value predisposition variables: political orientation, religiosity, and scientific deference. Both political orientation and scientific deference remained significant and showed positive associations with the dependent variable. In answering RQ1b, the more conservative respondents are, they are more likely to have a perception that regulating nuclear power will significantly slow down scientific progress. In total, the second block accounted for an additional 4.9% of the variance in the dependent variable. In answering RQ2b, respondents with higher levels of religiosity less perceive that regulation will significantly slow down scientific progress for nanotechnology.

Next, media consumption in science and politics were entered into the regression. As noted above, rather than reporting the final regression coefficients, I summarize the before-entry betas for each of these regression models for the third block, due to the collinearity between media consumption variables in the third block. As can be seen in Table 2, only science newspaper attention remained significant and showed a negative association with the dependent variable. It answers RQ4b that higher media consumption reduces public concern that regulation for nuclear power will slow down scientific progress. The third block of the regression accounted for an additional 1.2% of the variance in the perception that regulating nuclear power will slow down scientific progress.

In terms of the main effects of the knowledge variables, only perceived knowledge significantly impacted the dependent variable, and it showed a negative relationship. Therefore, to answer RQ5b, we can conclude that perceived knowledge for nuclear power negatively impacts and reduces public perception that regulating nuclear power will significantly slow down scientific progress. In answering RQ6b, there is no significant relationship between factual knowledge for nuclear power and the belief that regulating nuclear power will significantly slow down scientific progress. Overall, the fourth block of the regression accounted for 0.3% of the explained variance in the dependent variable.

Next, in the fifth block, trust in scientists was examined. Trust in scientists remained highly significant into the final regression model and it showed a negative relationship with the dependent variable. In answering RQ3b, higher trust in scientists decreases the belief that regulating nuclear power will significantly slow down scientific progress. Overall, through fifth block, 1.5% could be accounted for from the explained variance in the dependent variable.

Finally, the last block added benefit and risk perceptions for nuclear power to the regression model. Between benefit and risk perceptions, only benefit perceptions remained strongly significant into the final regression model, and was positively related to the dependent variable. In answering RQ5b, it concludes that there is a positive relationship between benefit perceptions toward nuclear power and public concern that regulation will slow down scientific progress. In total, the last block explained 2.6% of the explained variance in the dependent variable.

In total, this regression was able to explain 11.9% of the variance in regulating nuclear power will significantly slow down scientific progress.

Regression predicting that regulating nanotechnology will significantly slow down scientific progress

The next regression examined public concern that regulation will slow down scientific progress for nanotechnology. As table 2 illustrates, none of the demographic variables remained significant into the final model of the regression. In total, the first block of the regression accounted for 1.3% of the variance in public concern that regulating nanotechnology will significantly slow down scientific progress.

Among the value predispositions variables, religiosity and scientific deference remained significant. Religiosity showed a negative relationship with the dependent variable. In detail, the more religious they are, the less they believe that regulating nanotechnology will significantly slow down scientific progress. On the other hand, the higher scientific deference a respondent reports, the more likely they are to believe that regulating nanotechnology will slow down scientific progress. In answering RQ1b, there is no significant relationship between political orientation and public concern that regulating nanotechnology will slow down scientific progress. Overall, 7.6% of the total variance was explained in the dependent variable through this second block of the regression.

Next, to examine the influence of media consumption, attention to science and politics were measured. Both television attention for science and politics remained very strongly significant into the final regression model, with each showing a positive relationship with the dependent variable. Attention to political subjects in newspapers also remained significant into the final model, and showed a positive relationship with the dependent variable. In answering RQ4c, the more respondents consume scientific and political media on television, the more likely they are to report higher concerns that regulation for nanotechnology will slow down scientific progress. Overall, the third block was able to explain 2.2% of the variance in the dependent variable.

The fourth block of the regression looked at the role of perceived and factual knowledge in determining public concern that regulating nanotechnology will slow down scientific progress. None of the knowledge variables remained significant into the final model of the regression. Thus, in answering RQ7b and RQ8b, there is no significant relationship between perceived and factual knowledge for nanotechnology and the public's concern that regulating nanotechnology will significantly slow down scientific progress. This fourth block of the regression contributed 0.8% of the explained variance in the dependent variable.

The fifth block of the regression examined the influence of trust in scientists on the dependent variable. It had a significant negative relationship with the dependent variable. More concretely, and in answering RQ3b, the higher trust in scientists that the public has, the less likely they are to have a concern that regulating nanotechnology will significantly slow down scientific progress. In total, the fifth block accounted for an additional 0.2% of the variance in the dependent variable.

Finally, benefit and risk perceptions for nanotechnology were entered as the last block in the regression model. Only benefit perceptions concerning nanotechnology remained significant into the final regression model and presented a positive relationship with the dependent variable. In answering RQ5b, the higher benefit perceptions the public has, the more likely they are to have higher concerns that regulating nanotechnology will slow down its scientific progress. In total, this block was able to explain 7.7% of the variance in the dependent variable.

In total, 20.7% of the variance could be explained by this regression in regulating nanotechnology will slow down scientific progress.

Regression predicting that regulating synthetic biology will significantly slow down scientific progress

The next regression examined public concern that regulation will significantly slow down scientific progress for the issue of synthetic biology. As Table 2 explains, none of the demographic variables remained significant after all other variables were controlled for. The first block was able to explain 0.7% of the variance in the dependent variable.

Next, the value predispositions variables were entered into the regression. Among political orientation, religiosity, and scientific deference, only scientific deference remained strongly significant into the final model, and it showed a positive relationship with the dependent variable. More concretely, higher deference to scientific authority was associated with a greater belief that regulating synthetic biology will significantly slow down scientific progress. The second block accounted for 6.9% of the variance in the dependent variable.

The third block of the regression examined the influence of media consumption in science and politics. Interestingly, all media consumption variables for science and politics through each of newspapers, television, and online sources remained significant and showed positive relationships with the dependent variable. In answering RQ4b, there is a positive relationship between higher media consumption in science and politics and belief that regulating synthetic biology will slow down scientific progress. Overall, 1.1% of the variance could be explained through the third block.

Next, the roles of perceived and factual knowledge on the dependent variable were examined. Interestingly, only factual knowledge in synthetic biology remained significant into the final model and it showed a negative relationship with the dependent variable. To answer RQ7b and RQ8b, the more the public learns about synthetic biology, the lower their likelihood of reporting that regulating synthetic biology will significantly slow down scientific progress. Overall, the fourth block of the regression could explain 1.5% of the variance.

In the fifth block, like with the previous regressions, the role of trust in scientists was examined. Surprisingly, in answering RQ3b, there was no significant relationship between trust in scientists and the public's perspective that regulating synthetic biology will significantly slow down scientific progress. In total, the fifth block of this regression contributed a very non-significant 0% of the explained variance in the dependent variable.

Finally, in the last block, the influence of benefit and risk perceptions for synthetic biology on the dependent variable was examined. Only benefit perceptions concerning synthetic biology remained significant into the final regression model, and the variable showed a positive relationship with the dependent variable. To answer RQ5b, the higher the benefits one perceives for synthetic biology, the more likely there are to express the concern that regulation will slow down scientific progress. In total, this block for benefit and risk perceptions explained 3.2% of the variance in the dependent variable.

In total, this regression was able to explain 14.0% of the variance in the dependent variable.

Regression predicting that academic and commercial nuclear power research should be regulated

The first regression predicted that academic and commercial nuclear power research should be regulated and included the same 6 blocks as the previous regressions. As Table 3 illustrates, age and education remained significant after all other variables were controlled for. The older respondents are, they are more likely to believe that academic and commercial nuclear power research should be regulated. On the other hand, the less educated they are, the more likely it is that they believe that academic and commercial nuclear power research should be regulated. Overall, the demographic variables accounted for 1.2% of the total variance for the dependent variable.

[Insert Table 3 about here.]

The second block of the regression looked at the role of value predisposition variables in determining the need for more regulation in both academic and commercial nuclear power research. In answering RQ1c, there is no significant relationship between the public's political orientations and their perspective that academic and commercial nuclear power research should be regulated. Deference to scientific authority was negatively related to the dependent variable. Specifically, the more deference the public reports toward scientific authority, the lower their reported need for more regulations for both academic and commercial research. In total, 2.9% of the variance in the dependent variable could be explained through the second block.

Next, media consumption variables were entered into the regression. As mentioned above like previous regressions, I reported before-entry betas for each of these regression models for the third block, due to the collinearity between media consumption variables in the third block. As can be seen in Table 3, science television attention remained significant and showed a positive relationship with the dependent variable. The higher attention the public pays toward television for scientific issues, the more likely they are to believe that academic and commercial nuclear power research should be regulated. This third block of the regression contributed 1.4% of the explained variance in the dependent variable.

The fourth block examined the role of perceived and factual knowledge for nuclear power to the dependent variable. In answering RQ7c and RQ8c, there is no significant relationship between both perceived and factual knowledge of nuclear power and public perception that academic and commercial nuclear power research should be regulated. Overall, the fourth block contributed a non-significant 0.2% of the variance.

Next, in the fifth block, trust in scientists was explored to ascertain its role in the dependent variable. Interestingly, it remained strongly significant into the final regression model and had a positive relationship with the dependent variable. In answering RQ3c, the higher trust in scientists public possesses, the more likely they are to report that academic and commercial nuclear power research should be regulated. In total, trust in scientists explained 3.3% of the total variance in the dependent variable.

Finally, in the last block, the influence of benefit and risk perceptions for nuclear power on the dependent variable was examined. Risk perceptions concerning nuclear power remained strongly significant into the final regression model, and presented a positive relationship with the dependent variable. Thus, H2a is supported. If the public reports a higher risk perception they are also more likely to support the need for more regulations for commercial and academic nuclear power research. The last block was able to explain 8.5% of the total variance in the dependent variable.

In total, 18.1% of the variance in the dependent variable could be explained by this regression.

Regression predicting that academic and commercial nanotechnology research should be regulated

The second regression predicted that academic and commercial nanotechnology research should be regulated. As Table 3 explains, no demographic variables emerged as significant in the final regression model. The first block accounted for 0.6% of the variance in the dependent variable.

Next, to find out the influence of value predispositions on the dependent variables, political orientation, religiosity and deference to scientific authority were entered. Interestingly, all variables in the second block remained significant, and both political orientation and deference to scientific authority presented negative relationships with the dependent variable. In answering RQ1c, the more liberal respondents are, the more likely they are to believe that academic and commercial nanotechnology research should be regulated. Also, higher levels of scientific deference were correlated with the belief that academic and commercial nanotechnology research should be regulated. Also in answering RQ2c, publics with higher level of religiosity supported more regulations for both academic and commercial nanotechnology research. The more religious they are, the greater support for regulations towards academic and commercial nanotechnology research was discovered. The second block explained 0.4% of the variance in the dependent variable.

Next, the role of media consumption for science and politics in determining the need for more regulations on academic and commercial synthetic biology research was examined. Interestingly, for science media attention, only newspaper and television remained significant and showed positive relationships to the dependent variable, and for political media attention, newspaper, television and online attention all remained significant and were related positively to the dependent variable. The third block explained 2.0% of the total variance in the dependent variable.

The fourth block of the regression explored the influence of both perceived and factual knowledge of nanotechnology on the dependent variable. They both remained significant, but interestingly, perceived knowledge showed a negative relationship with the dependent variable, while factual knowledge showed a positive relationship. In answering RQ7c and RQ8c, the higher level of perceived knowledge the public reports having the lower their reported need for regulations for academic and commercial nanotechnology research. On the other hand, the higher their levels of factual knowledge of nanotechnology, the more likely they are to report a greater need for regulation for academic and commercial nanotechnology research. The fourth block explained 2.6% of the variance in the dependent variable.

Next, the role of public's trust in scientists on the dependent variable was entered. It remained strongly significant into the final regression model, and showed a positive relationship with the dependent variable. In answering RQ3c, the higher respondents' trust in scientists is, the more likely they are to have a perspective that academic and commercial synthetic biology research should be regulated. The fifth block was able to explain 2.5% of the variance in the dependent variable.

Finally, the last block of this regression considered the influence of benefit and risk perceptions concerning nanotechnology on the dependent variable. Risk perceptions toward nanotechnology remained strongly significant in the final regression model, and presented a positive relationship with the dependent variable. Therefore, there is a support for H2b, such that if the public has higher risk perceptions, it positively relates to their support for more regulations for nanotechnology commercial and academic research. This final block explained 10.1% of the variance in the dependent variable.

In total, this regression was able to explain 19.3% of the variance in the dependent variable.

Regression predicting that academic and commercial synthetic biology research should be regulated

The third regression predicted that academic and commercial synthetic biology research should be regulated. As Table 3 presents, only age remained significant and had a positive relationship with the dependent variable, which means that older respondents are more likely to have the perspective that academic and commercial synthetic biology research should be regulated. The first block explained 0.9% of the variance in the dependent variable.

The second block explored the role of value predispositions variables. Deference to scientific authority remained strongly significant into the final regression model, and showed a negative relationship with the dependent variable. In answering RQ1c, there was no significant relationship between the public's political orientations and their perspective that academic and commercial synthetic biology research should be regulated. The second block accounted for 3.9% of the variance in the dependent variable.

Next, the role of media consumption of science and politics in determining the public's perception that academic and commercial synthetic biology research should be regulated was examined. Only attention to science newspapers remained significant in the final regression model, and it had a positive relationship with the dependent variable. The third block explained 1.0% of the variance in determining public's perspective on the need for more regulations for academic and commercial synthetic biology research.

The fourth block of this regression examined the role of perceived and factual knowledge of synthetic biology on the dependent variable. In answering RQ7c and RQ8c, there are no significant relationships between either perceived or factual knowledge and public perception that academic and commercial synthetic biology research should be regulated. The fourth block contributed a statistically non-significant 0.1% of the variance.

Next, the role of trust in scientists in determining the need of more regulations on commercial and academic synthetic biology research was examined. Like previous regressions, it remained strongly significant into the final model, and showed a positive relationship with the dependent variable. In answering RQ3c, higher levels of trust in scientists are associated with a greater perception that there is more need for regulation for academic and commercial synthetic biology research. The fifth block of the regression accounted for 2.7% of the variance in the dependent variable.

Finally, the last block of this regression examined the influence of benefit and risk perceptions toward synthetic biology on public perception that academic and commercial synthetic biology research should be regulated. Risk perceptions remained strongly significant into the final regression model, and showed a positive relationship with the dependent variable. Therefore, there is a support for H2c that if the public has higher risk perceptions, they are also more likely to have support for more regulations for synthetic biology commercial and academic research. In total, the final block of the regression explained an additional 11.2% of the variance in the dependent variable.

In total, this regression was able to explain 20.1% of the variance in knowing academic and commercial synthetic biology research should be regulated.

CHAPTER 5

DISCUSSION

Considering the limitations of previous science regulation attitude research, the purpose of this paper was to bring attention to the importance of a more thorough framework for evaluating and understanding science regulations from the perspective of the American public. It has been supported that researchers and scientists play important roles in generating and evaluating policies (Sabatier, 1988). However, recently, when a regulatory framework is being developed, the importance of involving lay audiences has been emphasized for avoiding public backlash, especially for controversial science issues (Priest, Greenhalgh, & Kramer, 2010). The number of citizen scientists, who volunteer to collect and process data for science research, is growing significantly due to the easily available tools for the public to collect the data, and professional scientists realize that the public owns plenty of source for skills, labor, and even finance (Silvertown, 2009).

Thus, as the public role in science keeps increasing, including the public's various concerns and needs for science regulation in this study has an important role in science regulation research. In particular, this study looked at the role of deference to scientific authority, perceived and factual knowledge, trust in scientists, and benefit and risk perceptions for three science issues in determining public opinion toward science regulations.

Indeed, the results indicate that understanding scientific deference is crucial to understand public perceptions of exiting U.S. science regulations. This study also suggests that the position of an issue in the issue-attention cycle, public levels of familiarity with an issue, and their political orientation can each play crucial roles in influencing science regulatory attitudes. Specifically, the more conservative a respondent reported being, the more likely they are to report that regulating nuclear power will significantly slow down scientific progress. Interestingly, for nanotechnology, liberals were more likely to respond that academic and commercial nanotechnology research should be regulated. Additionally, higher levels of political conservatism are associated with a greater belief that existing U.S. regulations ensure public safety from synthetic biology risks. In addition, respondents with higher level of religiosity answered that they do not perceive that regulation will significantly slow down scientific progress for nanotechnology. Also, they supported regulations for both academic and commercial nanotechnology research. These findings show that more religious respondents perceive higher risk perceptions for nanotechnology, likely based on the characteristics of nanotechnology that can potentially be used to create new life based on its ability to control human genetics.

This study is also meaningful in that it explored the role of scientific deference more deeply. The higher the levels of deference to scientific authority the public has, the more likely they are to perceive safety from the existing U.S. regulations from nuclear power, nanotechnology, and synthetic biology risks. Interestingly, higher levels of scientific deference were also positively related to the public opinion that regulation would significantly slow down scientific progress in nuclear power, nanotechnology, and synthetic biology. On the other hand, the public with higher scientific deference was opposed to the need for regulations of both academic and commercial research in nuclear power, nanotechnology, and synthetic biology. These findings imply that the contents of science education in America could encourage the public to have higher benefit perceptions for science issues.

This study also considered various media consumption variables including three different mediated channels, attention to newspapers, television, and online content, for both science and political news. For the first dependent variable, which was to know about whether existing U.S. regulations ensure public safety from risks, attention to political issues in newspapers and on television were positively related to the public's perceived safety from nuclear power risks. Compared to nuclear power, the perceived safety for nanotechnology risks presented positive relationships with the higher consumption in science issues in newspapers and on television, and also in political issues in newspapers and on television.

For the second dependent variable, interestingly, the higher consumption of science in newspapers the public has, the less likely they were to believe that regulating nuclear power will significantly slow down scientific progress. On the other hand, for nanotechnology, television consumption of science news, and both newspaper and television consumption of political news was correlated with a perception that regulating nanotechnology will significantly slow down scientific progress. Synthetic biology was the most susceptible science issue to media consumption effects. Increased attention to newspapers, television, and online for both science and politics resulted in greater likelihood to report that regulating synthetic biology will significantly slow down scientific progress.

For the last dependent variable that academic and commercial research should be regulated for nuclear power, nanotechnology, and synthetic biology, only newspaper and television consumption remained significant. For nuclear power, more television consumption of science issues led to greater belief that academic and commercial nuclear power research should be regulated. Interestingly, for nanotechnology, attention to newspapers and television for both science and politics issues built a perception that academic and commercial nanotechnology research should be regulated. For synthetic biology, only attention in newspapers for science issues led public to perceive more needs for science regulations for academic and commercial synthetic biology research. These findings provide theoretical and conceptual insights to issue-attention cycle, how public senses each issue that are located in different phase in each cycle with different level of contents for benefits and risks. In addition, this paper also suggests the close link between the levels of knowledge for each science issue according to the location in the issue-attention cycle and the public's regulatory attitude.

This study also has a lot of implications in the role of scientific knowledge toward science regulations as well, since this paper is not limited into looking at just one of perceived familiarity and factual knowledge. It examined both perceived and factual knowledge and how they can influence different regulatory attitudes for different science issues. One of the interesting facts from the fourth block was that for both nanotechnology and synthetic biology, the higher level of factual knowledge the public has, less they perceive safety from the existing U.S. regulations from nanotechnology and synthetic biology risks. These findings direct that public support for science issues cannot be enhanced by increasing science literacy based on deficit model. Compared to the existing deficit model that believes a more scientifically literate public has a tendency of having more support of scientific innovations and research programs (Sturgis & Allum, 2004), this study showed that more scientifically literate public has supported more regulations for nanotechnology and synthetic biology.

For the second dependent variable, higher levels of perceived knowledge measured by the respondents themselves made them opposed to the belief that regulating nuclear power will significantly slow down scientific progress. On the other hand, the higher level of factual knowledge the public has, the more likely they are to be opposed to the belief that regulating synthetic biology will significantly slow down scientific progress. More interestingly, in regulating academic and commercial nanotechnology research, when the public has a high level of perceived knowledge, they feel less need for more regulations for academic and commercial nanotechnology research. However, when they report higher levels of factual knowledge for nanotechnology, they support more regulations on academic and commercial nanotechnology research. Compared to previous research about perceived familiarity and factual knowledge, which found that the public with higher information processing are more likely to have higher levels of factual science knowledge (Ladwig et al., 2012), this study is meaningful in finding that higher levels of factual knowledge are associated with higher public risk perceptions. Previous research for science knowledge showed a low correlation coefficient between perceived familiarity with nanotechnology and individual's knowledge about nanotechnology, and it provided a possibility that these two knowledge measures could measure different aspects of public scientific understanding (Ladwig et al., 2012). This study suggests that compared to perceived knowledge, factual knowledge can measure public risk perceptions, and this is meaningful for future studies' knowledge measurements. In addition, these findings can explain a possible way to interpret what type of information the public pays attention to the most from the media and build it into their knowledge, and how the public is able to partake in scientific decision-making.

This study also implies the different roles that deference and trust can present in science regulations. For both nuclear power and synthetic biology, higher trust in scientists led the public to think that existing U.S. regulations ensure public safety from nuclear power and synthetic biology risks. On the other hand, the public with higher level of trust in scientists was less likely to believe that regulating nuclear power and nanotechnology will significantly slow down scientific progress.

Lastly, higher trust in scientists induced audiences to support that academic and commercial nuclear power, nanotechnology, and synthetic biology research should be regulated. This study provides a significantly different pattern between deference to scientific authority and trust in scientists for two regulatory attitudes that regulation will slow down scientific progress and that academic and commercial research need regulations. The reason behind the opposing relationships between the dependent variables and deference and trust in scientists might be based on the theoretical conceptualization of these measures. While deference to scientific authority is built in the early stages of life, it also represents a secured, lasting worldview, while trust in scientists is possible to change depending on events the public encounters. That is, it does not stay as stable as deference and does not function as a core belief (Anderson et al., 2011). This study also suggests that trust in scientists can cause higher risk perceptions, so that the public with higher trust level agreed with the belief that regulation slows down scientific progress and they supported that regulations are needed for academic and commercial research.

Lastly, this study could provide implications for the role of benefit and risk perception in building science regulatory attitudes. The more benefit the public perceives in nuclear power, nanotechnology, and synthetic biology, the more safety they perceive from each science issues' risks through existing U.S. regulations. On the other hand, the more risk perception they perceive, the less safe they feel from the existing U.S. regulations for nuclear power, nanotechnology, and synthetic biology risks. Also, interestingly, with more perceived benefits from these three science issues, they are more likely to believe that regulating nuclear power, nanotechnology, and synthetic biology will significantly slow down scientific progress. Additionally, the more risks they perceive for each issue, they are more likely to support for the more regulations of three issues' academic and commercial research.

Limitations

Like with any research, this study contains several limitations. The first limitation pertains to the measurement of the dependent variables. All 9 dependent variables were ordinal variables measured with 5-point scale. Unfortunately, approximately 80% of respondents fell into the first three categories (Strongly disagree as "1" to Strongly agree as "5) in the first dependent variable for nanotechnology and for synthetic biology and also for the second dependent variable for nuclear power. This may explain why the regression predicting that *Regulating nuclear power will significantly slow down scientific progress* has less of the variance explained than *Regulating nanotechnology* *will significantly slow down scientific progress* and *Regulating synthetic biology will significantly slow down scientific progress.*

Also, *Education* was measured with 4 categories ("Less than high school", "High school", "Some college", "Bachelor's degree or higher"). This breakdown of the variable ranks the level of education so that education level increases as an individual moves up in categories. There were 7.6% of respondents who fell into the first category, and 30.2% of the respondents who fell in to the last category. However, this breakdown did not differentiate bachelor's degree and post-graduate degrees as different categories, and it also considered education level less than high school all the same, too. Unfortunately, this variable cannot tell specifically how respondents with the post-graduate degrees consider science regulations.

The next limitation also concerns the measurement of some key independent variables. In order to arrive at a measurement of scientific and political media consumption, specific media consumption for each science issue was not collected in this data. All scientific media consumption on newspaper, television, and online were measured with the level of attention on 'science and technology', 'specific scientific developments, such as nanotechnology', 'social and ethical implications of emerging technologies'. Also, all political media consumption on newspaper, television, and online measured with the level of attention on 'international affairs' and 'national government and politics'. To see clear relationships between scientific and political media consumption and public regulatory attitude on each science issue, their media consumption for each issue should be considered.

The fourth limitation pertains to the overall design of the study. Even though an experimental manipulation was employed in block 0 for every regression, aspects of this study can be thought as a survey about regulatory attitudes toward science regulations for nuclear power, nanotechnology, and synthetic biology. Therefore, it is difficult to infer any causal relationships between variables.

Also, the date when this data was collected can be another limitation. It was collected right after disaster in Fukushima power plant in 2011. Public opinion for nuclear power could be changed by now compared to the time right after the disaster, and the public might have more familiarity for the emerging technologies investigated here.

Implications

However, despite these limitations this study provides valuable information about public regulatory attitudes toward science issues, and their attitude toward science regulatory policies more generally. Previous studies of science regulations focused on finding out scientists' perceptions of the current policy environment and the area needing more regulations for both academic and commercial research for developing new regulatory policies (Corley et al., 2013). More recently, scientists' and the public's regulatory perceptions have been compared if they support academic and commercial regulation of nanotechnology (Su et al., 2015). So far, previous studies of science regulation have been limited in their focus on only one narrow perspective toward regulations. This study demonstrates the need for a more complete framework when exploring science regulations and general public opinion for science policies. For instance, regulations could be viewed in several ways: as a way of securing safety, as a means of slowing down scientific progress, and in terms of expressed need for more regulations. It is meaningful that this study provides the public regulatory attitudes depending on both deference and trust in scientists, perceived and factual knowledge, and benefit and risk perceptions for issues containing morality and religiosity issues and the issue that had several recent disasters.

Additionally, this study provides some support for the role of issue attention cycle in influencing regulatory attitudes. For science issues that are positioned relatively early in the issue-attention cycle, such as nanotechnology and synthetic biology, relative to more established issues like nuclear power, regulatory attitudes may be more susceptible to media influence concerning public regulatory attitudes. This is theoretically based on the issue-attention cycle that has three different stages defined by different narratives and salience in the cyclical pattern of news. The three stages are the waxing phase, the maintenance phase, and the waning phase (McComas & Shanahan, 1999). When media attention increases, in the early stages of the issue-attention cycle, it is called the waxing phase, and stories in the waxing phase include "consequences" and "implied danger" (McComas & Shanahan, 1999). Due to the increase of media coverage and the higher level of risk contents cause the public to be more susceptible by their attention to the media.

Also, it has an implication in different media effects based on different media platforms that public consumes news. Previous research about media coverage in different media platforms have discussed that online nanotechnology news has a higher level of risk contents than benefit contents (Anderson, Brossard, & Scheufele, 2010), and it was contrasted with traditional news media that they provided positive framing of nanotechnology (Cacciatore et al., 2012). After the Fukushima nuclear power plant disaster, various media organizations' online platforms in the United States, such as The New York Times, showed more creative and visual diagrams than their traditional radiation narrative for explaining "evacuation zones, paths of the plume of radioactivity, the dangers of radiation for workers, and radioactive water problems at the power station" (Friedman, 2011). Due to greater amount of risk media coverage after Fukushima disaster online, and higher level of nanotechnology risk contents online, these studies support these findings that newspaper and television consumption influenced public safety perceptions from nuclear power and nanotechnology risks through existing regulations, which relate to their higher benefit perception of these science issues. From 2004 to 2009, German media coverage in synthetic biology was mostly focused on benefits than risks in both traditional platform and online (Gschmeidler & Seiringer, 2012).

Additionally, this study provides support for both roles of deference to scientific authority and trust in scientists in shaping public opinion toward science regulations. Deference to scientific authority and trust in scientists showed opposite patterns when public perceives regulation as a way of slowing down scientific progress and when they perceive the need for regulations for academic and commercial research.

This study also supports the different effects from perceived and factual knowledge. For emerging science issues with lack of familiarity such as nanotechnology and synthetic biology, only the public level of factual knowledge negatively influenced their safety perception through existing U.S. regulations. More interestingly, this study provided evidence for increasing risk perception for nanotechnology that respondents with high level of perceived knowledge were opposed to more regulations for academic and commercial nanotechnology research, but when they are knowledgeable about the actual facts of nanotechnology, they support more regulations for academic and commercial nanotechnology research.

Finally, this study provides the importance of measuring benefit and risk perception in knowing public opinion on science regulations. Higher benefit perception could influence the viewpoint that existing regulations ensure safety, but respondents with higher risk perception were opposed to having ensured safety from existing regulations. The perspective that regulation will slow down scientific progress was strongly supported by a group with higher benefit perception. On the other hand, a group with higher risk perception perceived the need of more regulations for academic and commercial research. These findings provide insights of public understanding of science, and science policymaking and science education, as well.

Directions for future research

Future research should first examine the role of each science issue more specifically based on their characteristics. For example, among the influence of political orientation on the safety perception through existing regulations, only for synthetic biology, conservative respondents were more likely to believe that existing U.S. regulations ensure public safety from synthetic biology risks. Future research can provide the thought process behind this rationalization, and if this is based on the lack of familiarity of this issue.

Also, in finding out if existing U.S. regulations ensure public safety from nuclear power risks, only traditional political media consumption and remained significant and stayed positive. Future research can discuss more why public shapes their nuclear power opinion based on political media attention, and if this is based on recent nuclear power disasters.

Furthermore, additional research should focus on re-examining the different directions for the impact of perceived and factual knowledge for each science issue. Also, future research can focus on what influences publics with high level of factual knowledge for emerging technologies when they perceive less ensured safety, when they do not believe that science regulations will slow down scientific progress, and when they support for the need for more regulation. This implies the future research direction to find out how publics shape their opinion from when they merely perceive an understanding of an issue to when they actually learn about that issue.

Finally, looking to other variables that may moderate the influence of deference to scientific authority, trust in scientists, media consumption, and benefit and risk perception may prove helpful. Although this study looked at relationships between science regulatory attitude and key independent variables, there may be countless other important variables in moderating the influence of these independent variables. For example, in previous research, elaborative processing influenced public perception of benefits and risks of nanotechnology (Ho, Scheufele, & Corley, 2013). Therefore, the goal of future research should be to discover and test additional variables that moderate the influence of these independent variables, and test the following interaction terms.

TABLES

Table 1. *Main effects for regressions predicting that existing U.S. regulations ensure public safety from nuclear power, nanotechnology and synthetic biology*

	Nuclear Power (N=915)	*Nanotechnology (N=904)*	*Synthetic Biology (N=831)*
Block 1: Demographics			
Age	-.01	-.10**	-.08*
Education	-.02	-.07*	-.07*
Gender	.01	-.02	.03
Block 2: Value Predispositions			
Political Ideology (Cons = high)	.06	.02	.08*
Religiosity	.01	.06	.02
Scientific deference	.15***	.28***	.22***
Block 3: Scientific and Political Media Consumption			
Sci. Newspaper attention	-.01	.08*	-.03
Sci. Television attention	.00	.07*	-.01
Sci. Web attention	.03	.05	-.02
Pol. Newspaper attention	.07*	.08*	-.01
Pol. Television attention	.08*	.10**	-.01
Pol. Web attention	.05	.05	-.05
Block 4: Issue-specific knowledge			
Perceived knowledge	.03	-.03	.01
Factual knowledge	-.03	-.10**	-.10***
Block 5: Trust			
Trust in academic and regulatory groups	.08*	.07	.17***
Block 6: Issue-specific benefit and risk perception			
Benefit perception	.35***	.22***	.18***
Risk perception	-.08*	-.10**	-.17***

Notes: *$p < .05$, **$p < .01$, ***$p < .001$

Cell entries are standardized regression coefficients, except for entries in Block 3, which is before-entry standardized regression coefficients.

Table 2. *Main effects for regressions predicting that regulation will significantly slow down scientific progress for nuclear power, nanotechnology and synthetic biology*

	Nuclear Power (N=915)	*Nanotechnology (N=904)*	*Synthetic Biology (N=831)*
Block 1: Demographics			
Age	-.01	-.06	.04
Education	.01	-.02	.02
Gender	-.05	-.02	.03
Block 2: Value Predispositions			
Political Ideology (Cons = high)	.10**	.06	.04
Religiosity	.03	-.07*	-.07
Scientific deference	.17***	.16***	.15***
Block 3: Scientific and Political Media Consumption			
Sci. Newspaper attention	-.11**	.05	.09*
Sci. Television attention	-.03	.13***	.10**
Sci. Web attention	-.05	.04	.07*
Pol. Newspaper attention	-.07	.09*	.08*
Pol. Television attention	-.01	.12***	.09*
Pol. Web attention	-.02	.05	.07*
Block 4: Issue-specific knowledge			
Perceived knowledge	-.08*	.02	.07
Factual knowledge	.01	.03	-.10**
Block 5: Trust			
Trust in academic and regulatory groups	-.16***	-.11**	-.03
Block 6: Issue-specific benefit and risk			
Benefit perception	.18***	.36***	.22***
Risk perception	-.02	.02	-.01

Notes: *$p < .05$, **$p < .01$, ***$p < .001$

Cell entries are standardized regression coefficients, except for entries in Block 3, which is before-entry standardized regression coefficients.

Table 3. *Main effects for regressions predicting regulatory attitude for nuclear power, nanotechnology and synthetic biology*

	Nuclear Power (N=915)	*Nanotechnology (N=904)*	*Synthetic Biology (N=831)*
Block 1: Demographics			
Age	.08*	.01	.09**
Education	-.09**	-.05	-.01
Gender	-.02	.02	.01
Block 2: Value Predispositions			
Political Ideology (Cons = high)	-.06	-.09*	-.07
Religiosity	.07	.09**	.02
Scientific deference	-.08*	-.14***	-.13***
Block 3: Scientific and Political Media Consumption			
Sci. Newspaper attention	.04	.08*	.10**
Sci. Television attention	.08*	.10**	.06
Sci. Web attention	-.03	.05	.05
Pol. Newspaper attention	.03	.12***	.07
Pol. Television attention	.06	.15***	.03
Pol. Web attention	.00	.08*	.00
Block 4: Issue-specific knowledge			
Perceived knowledge	-.02	-.07*	-.00
Factual knowledge	-.03	.11***	.02
Block 5: Trust			
Trust in academic and regulatory groups	.17***	.19***	.17***
Block 6: Issue-specific benefit and risk			
Benefit perception	-.03	.06	.00
Risk perception	.30***	.36***	.36***

Notes: *$p < .05$, **$p < .01$, ***$p < .001$

Cell entries are standardized regression coefficients, except for entries in Block 3, which is before-entry standardized regression coefficients.

Table 4. *R-squared values for regressions predicting safety for nuclear power, nanotechnology and synthetic biology*

	Nuclear Power	*Nanotechnology*	*Synthetic Biology*
Block 0: Experimental Manipulations			
Inc. R^2 (%)	.5	1.0	.3
Block1: Demographics			
Inc. R^2 (%)	1.4	.9	.9
Block 2: Value Predispositions			
Inc. R^2 (%)	8.9	15.8	13.7
Block 3: Scientific and Political Media Consumption			
Inc. R^2 (%)	1.4	.9	.6
Block 4: Issue-specific knowledge			
Inc. R^2 (%)	.5	.5	.8
Block 5: Trust			
Inc. R^2 (%)	.6	.7	2.7
Block 6: Issue-specific benefit and risk			
Inc. R^2 (%)	11.2	4.5	6.0
Total R^2 (%)	24.5	24.3	25.0

Notes: $*p < .05$, $**p < .01$, $***p < .001$

Table 5. *R-squared values for regressions predicting scientific progress for nuclear power, nanotechnology and synthetic biology*

	Nuclear Power	*Nanotechnology*	*Synthetic Biology*
Block 0: Experimental Manipulations			
Inc. R^2 (%)	.7	.9	.6
Block1: Demographics			
Inc. R^2 (%)	.7	1.3	.7
Block 2: Value Predispositions			
Inc. R^2 (%)	4.9	7.6	6.9
Block 3: Scientific and Political Media Consumption			
Inc. R^2 (%)	1.2	2.2	1.1
Block 4: Issue-specific knowledge			
Inc. R^2 (%)	.3	.8	1.5
Block 5: Trust			
Inc. R^2 (%)	1.5	.2	0
Block 6: Issue-specific benefit and risk			
Inc. R^2 (%)	2.6	7.7	3.2
Total R^2 (%)	11.9	20.7	14.0

Notes: *$p < .05$, **$p < .01$, ***$p < .001$

Table 6. *R-squared values for regressions predicting regulatory attitude for nuclear power, nanotechnology and synthetic biology*

	Nuclear Power	*Nanotechnology*	*Synthetic Biology*
Block 0: Experimental Manipulations			
Inc. R^2 (%)	.6	1.1	.3
Block1: Demographics			
Inc. R^2 (%)	1.2	.6	.9
Block 2: Value Predispositions			
Inc. R^2 (%)	2.9	.4	3.9
Block 3: Scientific and Political Media Consumption			
Inc. R^2 (%)	1.4	2.0	1.0
Block 4: Issue-specific knowledge			
Inc. R^2 (%)	.2	2.6	.1
Block 5: Trust			
Inc. R^2 (%)	3.3	2.5	2.7
Block 6: Issue-specific benefit and risk			
Inc. R^2 (%)	8.5	10.1	11.2
Total R^2 (%)	18.1	19.3	20.1

Notes: $*p < .05$, $**p < .01$, $***p < .001$

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