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Framing Uncertainty: A Case for Purposefully Using Frames in Science Communication

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ABSTRACT: Science communicators must make decisions about frames in order to be ethically responsible communicators. They must first understand how frames affect audiences. For example, different representations of uncertainty result in frames that may distort public perceptions. I propose a typology that organizes factors that influence how frames are used.

KEYWORDS: ethics, frames, framing, uncertainty, science

1. INTRODUCTION

Framing is a process that is based on the idea that how a news report presents an issue affects how audiences understand that issue (Scheufele & Tewksbury, 2007). Framing is essential for centrally organizing ideas, but it can also be used to manipulate audiences and advance an agenda. Messages in the public sphere are inherently framed (Nisbet & Scheufele, 2007), and so science communicators must make decisions about those frames in order to share information in a meaningful and ethically responsible way. Not making decision about a media frame, then, is indeed a decision. The frames around an issue matter more to lay audiences than the technical, scientific details or the consensus of scientists (Nisbet & Mooney, 2007); therefore choosing the frame to use in any science communication effort is an immeasurably important decision. In order to make decisions about frames, scientists and science communicators must understand how different frames affect an audience's interpretation of an issue. One way to explore the effects of framing is to consider the many ways one complex idea, uncertainty, is used as a frame and is incorporated into frames. In this paper, I will argue that uncertainty is represented differently by scientists and journalists. This results in frames that may significantly distort public perceptions of science, especially emerging sciences where there is more uncertainty. Therefore, I propose a typology that can help us organize the factors that influence how particular frames are used.

2. FRAMING

Framing researchers have ambiguously defined "framing" in the past two decades, leading to a recent re-evaluation of the state of framing research (Scheufele & Iyengar, 2011). Framing in this paper incorporates a narrow definition of frames that comes out of psychology research: frames as "informationally equivalent labels" (Scheufele & Iyengar, 2011, p. 2). Equivalence framing means that when the exact same content and information is framed differently, those

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consuming the same information will likely understand the information differently depending on the frame used. Frames are used to help make complex issues more digestible and understandable.

Frames are "considered schemes for both presenting and comprehending news," and so framing effects occur at both the media level—the presentation of the information—and the individual level—the processing of the information (Scheufele, 1999, p. 106). Framing research usually looks at one of the following three processes: frame-building, the process concerning the connection between interest groups and media frames; frame-setting, the process surrounding media frames and audience frames; and individual outcomes of framing, the process between audience frames and the individual effects of framing (Scheufele, 2000). Individual frames include factors that create frames of reference for information to aid in information processing (Scheufele, 1999). Media frames affect the public's attitudes and what topic the public focuses on concerning an issue, and a particular response can actually be "exacerbated or mitigated," depending on the frame surrounding the issue (Price, Tewksbury, & Powers, 1997, p. 501). This paper focuses on media frames, which are created and presented by journalists to present information in a more accessible way (Scheufele, 1999). For a useful discussion on types of frames used in communicating about science, see Nisbet and Scheufele (2007).

3. UNCERTAINTY IN COMMUNICATING CONTROVERSIAL SCIENCE

Science culture does extremely well at managing the message of the science that journalists report, unless the science is emerging and/or controversial (Dunwoody, 1999). In these cases, journalists have a greater role in determining the public's reality of science (Dunwoody, 1999). New and controversial science is laden with uncertainty (Dunwoody, 1999), and how non-scientists interpret that uncertainty in large part depends on how it is framed. Scientifically non-controversial issues that are not free of uncertainty, as uncertainty is inherent in science, are still sometimes presented in an uncertainty frame (intentionally or unintentionally) and in turn create doubt about an issue (Stocking & Holstein, 2009), which can lead to a controversy frame in further reporting and therefore establish a controversy among the public (Nisbet & Scheufele, 2009). The issue of how uncertainty is framed is complicated, in part because uncertainty itself is convoluted: uncertainty is a factor of scientific research, is stated implicitly and explicitly in science reporting, and is a social construction. Before discussing how and when uncertainty acts as a frame and is incorporated into frames, I must first conceptualize uncertainty.

3.1 Conceptualization of Uncertainty

Uncertainty is closely related to several other concepts, including risk, ambiguity, indeterminacy, and ignorance, and the relationship of uncertainty to each of them is significant to the conceptualization. Ambiguity, risk, and uncertainty have been conceptualized and differentiated extensively in economic and psychological theory in the modeling of decision-making preferences (Bach, Hulme, Penny, & Dolan, 2011; Camerer & Weber, 1992; Ellsberg, 1961; Knight, 1921; von Neumann & Morgenstern, 1944). In this vast area of research, risk is considered to be first-order uncertainty about the probability of an undesirable outcome and ambiguity is considered second-order uncertainty (Ellsberg, 1961; Knight, 1921; von Neumann

& Morgenstern, 1944). In other words, risk (first-order uncertainty) is a known probability (von Neumann & Morgenstern, 1944), and ambiguity (second-order uncertainty) is uncertainty about a probability (Ellsberg, 1961; Knight, 1921). Some researchers consider risk to be an objectively known probability, while uncertainty is considered and treated as a subjectively known probability (Camerer & Weber, 1992). More expanded definitions of ambiguity include the caveat that the uncertainty about a probability exists because of missing information that could be known (Camerer & Weber, 1992). People tend to make ambiguous-averse decisions; however, recent research comparing the decision-making process at the neurological level of second-order uncertainty and ambiguity suggests that there are differences between them, despite ambiguity being so frequently defined simply as second-order uncertainty (Bach et al., 2011). The implications of the neurological differences in responses heighten the importance of the potentially-knowable missing information, as well as bring into play the decision makers' beliefs about the availability and accessibility of the missing information (Bach et al., 2011).

Several phenomena, including the dependence of the source of uncertainty and how options are framed (gain versus loss), explain how people make decisions in risky and uncertain (here, meaning ambiguous) scenarios (Tversky & Kahneman, 1992). People are more willing to bet on an uncertain event in their area of expertise than on a risky event outside their area of expertise, which is contrary to what individuals prefer when choosing between uncertain and risky events that are both outside their expert area (Tversky & Kahneman, 1992). The source that is in their area of expertise is deemed more credible, and therefore people are more willing to accept uncertainty. Presenting a probability in a gain frame leads to a different preference than providing an equivalent probability framed as a loss (Tversky & Kahneman, 1992). Actually, research supports that "people can spend a lifetime in a competitive environment without acquiring a general ability to avoid framing effects" (Tversky & Kahneman, 1992, p. 317). What is the effect, then, of these equivalence frames on people with less than a lifetime of experience in the environment in question? Before exploring this question and more about framing effects (particularly in uncertain circumstances), I will explain some of the less technical aspects of uncertainty: lay definitions that scientists and journalists use to describe uncertainty and make it accessible to the public.

3.2 Scientists and Uncertainty

Uncertainty is pervasive in science, and means something different to scientists than it does to journalists. To scientists, uncertainty often means an error range, which is a structural component of quantitative research. Uncertainty is inherent in the scientific process because a major purpose of many scientific endeavors is to venture into and explain the unknown (Zehr, 1999). During the scientific process, a scientist builds off a foundation of certain knowledge until a gap or uncertainty in that knowledge is reached (Zehr, 1999, 2000). The purpose of the scientific endeavor is to fill in, even in the slightest bit, that gap, to remove some of the uncertainty (Zehr, 1999, 2000). That uncertainty exists in science is not new and is not debatable (Zehr, 1999). Scientists manage uncertainty in different ways, including pointing out uncertainties in another's work to bolster their credibility and reporting uncertainty with a rhetoric intended to lead the audience in a particular way, toward a certain idea or a certain construct of knowledge (Zehr, 1999, 2000).

Uncertainty in science, and science in general, is often interpreted much differently in the public sphere than in the scientific community (Zehr, 1999). This is due in part to the diversity of the public audience and the tendency for scientists to misunderstand lay audiences and therefore not communicate ideas clearly and effectively (Zehr, 1999). Also, in the public realm, there are often many scientific voices giving input on a single topic (Zehr, 1999). For example, depending on how an issue is reported in the public sphere, discrepancies between outcomes of multiple scientific studies due to methodological differences could be interpreted by the public as a lack of consensus in a situation where a consensus does in fact exist (Zehr, 1999). This interpretation may even been intentionally promoted, as scientific uncertainty may be managed to reach certain goals. For example, global warming skeptics took the advice of Frank Luntz to frame global warming as an issue of scientific uncertainty, which was a precursor to the conflict frame used by journalists when reporting the issue (Nisbet & Scheufele, 2009).

According to Shackley and Wynne (1996), "Indeterminacy can be loosely said to apply to situations in which not all the parameters of the system and their interactions are fully known, whereas ignorance refers to situations in which it is not known what is not known," (p. 283). These unknowns, indeterminacy and ignorance, that exist in science are often "transformed" into uncertainty when reported to the public in order to make issues more manageable, since scientific indeterminacy and ignorance are difficult concepts for scientists to convey without losing credibility (Zehr, 1999, p. 11). Conversely, uncertainty is often interpreted by the public as ignorance (Somerville & Hassol, 2011). The transformation of indeterminacy and ignorance into uncertainty may be related to the public's misinterpretation of uncertainty as ignorance.

3.3 Uncertainty, Media and the Public Sphere

Journalists often either inflate uncertainty (making the science seem more uncertain than it really is) or downplay uncertainty (making the science seem more certain than it really is) (Stocking, 1999). One way that journalists inflate uncertainty is by describing new research that contradicts past research without providing context for the change (Stocking, 1999). Other times, journalists give scientists with minority views equal weight as scientists with majority views, without adequately describing or explaining the state of scientific consensus on the issue (Stocking, 1999). In the same vein, journalists often give non-scientists the same amount of attention and importance as scientists (Stocking, 1999).

Journalists may downplay uncertainty by eliminating "scientists' carefully chosen tentative wording, and by losing these caveats the information is skewed and presented as more certain and conclusive than it really is" (Stocking, 1999, p. 27). Also, stories with a single source or without any context of previous research mean that the subject at hand is presented as more definitive and certain than it is in reality (Stocking, 1999). There is often a "product over process" approach to science journalism that aids, too, in the downplaying of uncertainty (Stocking, 1999, p. 27). Finally, and most notably for this investigation, when science is framed by journalists as a triumphant quest, uncertainty is erroneously framed as "reducible and resolvable" (Stocking, 1999, p. 27).

Uncertainty has been extensively researched as a social construction (Einsiedel & Thorne, 1999; Shackley & Wynne, 1996). According to this research, representations of certainty do not reflect a given reality or an objective state, but are constructed (Shackley &

Wynne, 1996). The many dimensions of uncertainty overlap with each other, and "uncertainty is manifested by individuals in a number of different ways, for different reasons, and with varying outcomes" (Einsiedel & Thorne, 1999, p. 44). How various actors in society frame uncertainty affects its construction. For the purposes of this paper, however, considering uncertainty as a social construction is operationally not useful.

Though it is natural to assume that journalists without science training tend to mishandle uncertainty because of their lack of training, Stocking (1999) argues that journalists' misrepresentations of uncertainty are due more to media routines and/or organizational level features than to individual factors such as any particular journalists' education and ignorance. Some of the aforementioned ways by which journalists inaccurately report uncertainty are inextricably linked to media routines and journalistic norms. Most notably, journalists value providing balanced sides to an argument, and therefore often give equal weight to dissenting scientists' views and views of the scientific majority (Stocking, 1999). In exceptional science reporting, however, journalists report on the scientific consensus, and if dissenting views are presented, they are put into context of the situation (Rowan, 1999).

One individual factor has been cited to have a stronger correlation with acceptable science stories than education: experience (Stocking, 1999). Perhaps new journalists covering a science story rely on journalistic norms such as balance as a substitute for proficiency in the topic they are covering, therefore inadvertently inflating the uncertainty around an issue. Given the importance of experience in the accurate reporting, it is unfortunate that recent research indicates that journalists with science training (re: experience) are decreasing in numbers (Dudo, Dunwoody, & Scheufele, 2011).

The number of science stories is decreasing, potentially reflecting a decrease in science coverage in general that seems to be related to the increasingly small cohort of science writers (Dudo et al., 2011). In their analysis of news coverage of nanotechnology over twenty years, Dudo et al. (2011) found that the 1% of reporters covering nanotechnology news authored 15% of the stories analyzed. That is, seven authors—five working for one organization, The New York Times—covered 280+ of more than 1,900 stories (Dudo et al., 2011). Three of the most prolific authors have either left the science beat or the newspaper (Dudo et al., 2011). If the trends in authorship of nanotechnology news reflect trends in other areas of science, the overall decrease in experienced science writers may mean that it is becoming increasingly likely that uncertainty will continue to be promoted. There are some journalistic norms, however, that instead promote certainty.

Some media routines and organizational factors affect the overstatement of uncertainty; other media routines and organizational factors help inflate the certainty of an issue. Because the general public (in the United States) generally trusts scientists, when science stories are covered without alarm-raising cues from special interest organizations (religious groups, environmental organization, political factions, etc.) they are often covered in a business-related sense, in an economic-development frame or a social progress frame (Nisbet & Scheufele, 2007), or in the frame of science as a triumphant quest. The nature of these frames is to downplay or eliminate uncertainty, so when economic and scientific promise are focused on early in the issue cycle, as has happened with coverage of plant biotechnology and nanotechnology in the United States, the matter in question seems more definitive and certain (Nisbet & Scheufele, 2007). Sometimes, too, stockholders, owners, or advertising will pressure a media organization to promote the business aspects of a scientific issue, and therefore any uncertainty claims that may compromise the business interests are downplayed or eliminated

(Stocking, 1999). The relationship among journalism, science, and uncertainty is complicated by and intensified by the potential emergence of post-normal science.

4. POST-NORMAL SCIENCE

Uncertainty is more than a social construction, and it is more than an inherent aspect of the scientific process. As decision stakes and uncertainty in scientific problems become higher, society is entering, according to Funtowicz and Ravetz (1992), post-normal science: a new realm where these high stakes and high uncertainty are part of the definition, of the foundation, of science. Post-normal science is beyond the scope of applied science and professional consultancy, and takes over where these other problem-solving strategies fail in their ability to offer solutions (Funtowicz & Ravetz, 1992). Post-normal science adds "onto their [applied science and professional consultancy's] practice which bridges the gap between scientific expertise and a concerned public," (Funtowicz & Ravetz, 1992, p. 253).

Post-normal science is a democratization of science; instead of scientists being the only investigators in the process of science, post-normal scientists include an "extended peer community [collecting] extended facts, to include anecdotal evidence and statistics gathered by a community," (Funtowicz & Ravetz, 1992, p. 254). The emergence of post-normal science and the existence of uncertainty as a social construction are not mutually exclusive ideas. Because science is moving in this post-normal direction—in the direction of more uncertainty, the direction of higher stakes, and the need for more public involvement in the decision-making process than ever before—the need to understand how uncertainty is communicated and interpreted reaches a new height. The emergence of post-normal science, and therefore of high uncertainty as a norm, intensifies the need to accurately convey uncertainty; distorting uncertainty is therefore distorting reality, and is a disservice to everyone involved in all aspects of the issue. Furthering understanding of how uncertainty is incorporated into or used as a frame helps to explain part of the social construct, and may eventually help inform how the uncertainty that is guaranteed to surround the issues emerging into a world of post-normal science will be interpreted.

This paper in part responds to calls from literature to investigate news story variables that affect readers' perceptions of uncertainty, including framing (Corbett & Durfee, 2004). To the public, uncertainty is in large part a social construction (Einsiedel & Thorne, 1999; Shackley & Wynne, 1996); how uncertainty is incorporated into and used in frames of science news stories is one component of that construction. The implications of how the media deals with uncertainty may be long-lasting; frames surrounding issues early in their media emergence may dictate the focus of public discourse, as demonstrated by global climate change being presented and perceived in an uncertainty frame. Rogers (1999) suggests that two issues in particular—global climate change and AIDS—exemplify how uncertainty is handled in the media based on certain properties. Global climate change and AIDS "lie at opposite ends of a spectrum that situates an immediate, personal issue [AIDS], at one end, and a more long-term, seemingly remote issue [global climate change], at the other" (Rogers, 1999, p. 184). How uncertainty surrounding these issues is incorporated into media frames is most certainly related to the immediacy and level of personal involvement in an issue, as Rogers (199) suggests; further, this description can be extrapolated to other issues.

5. TYPOLOGY OF ISSUES

I have created a dynamic four-cell typology of how uncertainty will relate to the frame of an issue based on the key characteristics of the issue, level of involvement, and the time frame of outcomes (Figure 1).

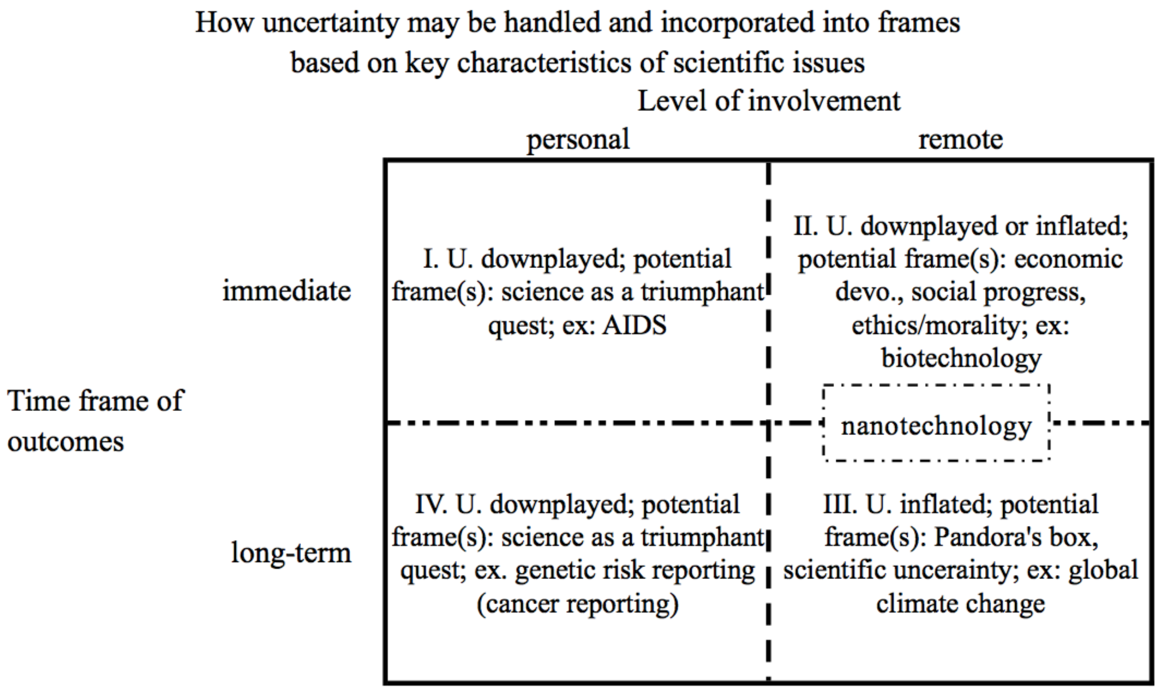

Fig. 1. A typology of scientific issues describing how uncertainty may be handled and incorporated into frames based on key characteristics. How uncertainty may be misrepresented is first, followed by potential frames and then issues that fit the typology. The cells are arbitrarily numbered for ease of referencing. “U.” = “uncertainty.”

This typology can serve as a guide for science communicators as they make decisions about framing controversial issues in this era of increasingly complex science and technologies with undetermined ethical, social, and legal implications. The typologies are not static; issues themselves go through an “attention cycle” in public discourse, and changes in public perception of an issue driven by the media frame may change based on current events and emerging scientific knowledge. I next describe characteristics of each cell, and then case studies of scientific issues that fit each typology in more detail, followed by a more thorough description of the dynamic nature of this breakdown of typologies and associated limitations.

5.1 Type I. Personal and Immediate Scientific Issues (AIDS and HIV crisis)

When issues hit close to home for individuals, the uncertainty surrounding them will naturally likely also be personal. When journalists cover stories of such a personal nature and immediate consequences, they have to consider and “accommodate public sensitivities” (Nelkin, 1995, p. 105). These issues, then, are often framed as a triumphant quest for certainty (Stocking, 1999), and within that frame uncertainty is downplayed/and or eliminated precisely because the uncertainties are so personal, coupled with the norm that journalists strive to be sensitive to the public when covering such cases. Uncertainty in this frame is presented as reducible and resolvable, despite that uncertainty is inherent in the scientific process and will likely never be reduced (Stocking, 1999). News coverage of AIDS downplays or eliminates uncertainty by placing AIDS in the frame of "science as a triumphant quest" (Rogers, 1999).

Acquired immune deficiency syndrome (AIDS) is the final stage of HIV disease (Dugdale, 2012). Since the beginning of the epidemic, the World Health Organization estimates that more than twenty-five million people have died from AIDS (Dugdale, 2012). As of 2008, more than thirty-three million people are living with AIDS (Dugdale, 2012). AIDS is the sixth leading cause of death among people aged 25-44 in the United States (Dugdale, 2012).

Coverage of AIDS was considered the story of the decade in 1988 (Rogers, 1999). AIDS had only been discovered in the United States' population seven years earlier, in 1981, and in that time frame AIDS became a salient topic in the media (Rogers, 1999). Since the '80s, AIDS is covered in terms of scientific breakthroughs and discoveries. In the media, AIDS was (and is) "framed as a disease whose origins and means of transmission are well-understood" (Rogers, 1999, p. 195). The uncertainties associated with AIDS—mostly revolving around effects of new/emerging drug treatment, financial aspects of treatment (who pays for what), and the prospect of a vaccine—generally do not make it to any story in the media (Rogers, 1999). Uncertainty in this context, then, is downplayed and ignored, which may facilitate the perception that the science is more certain than it really is.

5.2 Type II. Remote, Immediate Scientific Issues (Biotechnology)

Uncertainty surrounding issues that have potentially immediate applications and repercussions but that are operate outside the scope of the public eye (either in laboratories or production outside of the U.S., so the associated risks are not surrounding and visible to the American public) tends to be downplayed. This is related to the idea stated previously that unless given cues otherwise, the public in the U.S. tends to trust the scientific institution, and business- and progress-related frames are employed (Nisbet & Scheufele, 2007). For example, certain biotechnological applications are framed in business-related frames; however, other applications of biotechnology tend to be framed in such a way that the scientific uncertainty is inflated.

Biotechnology includes both human genetic engineering—like stem cell research—and plant genetic engineering, for example, genetically engineered foods. The issues have been framed very differently, partly because of the negative attention given to stem cell research by interest groups, politicians, and religious figures, and the absence of similar attention regarding plant bioengineering (Nisbet & Scheufele, 2007). Stem cell research has been framed in such a way to either downplay, eliminate, or inflate uncertainty from the discussion. Stem cell research has gone through a science event- and policy-driven cycle of media attention, from the beginning of gene therapy and bone marrow research fifty years ago being mostly an administrative decision without much media attention, to the discovery of embryonic stem cells reaching the level of being a frequent topic of debate among presidential candidates in the late 1990s (Nisbet, Brossard, & Kroepsch, 2003). Embryonic stem cell research is the most controversial, and because ethics and morality come strongly into play, interest groups and political figures have been vocally against it. When stem cell research advocates are framing the issue, they tend to downplay the uncertainty and frame it in business-related terms; when adversaries are framing the issue, they tend to employ a "morality/ethics" frame, in which scientific uncertainty is a non-issue, or a "conflict/strategy" frame, in which scientific uncertainty is inflated (Nisbet et al., 2003; Nisbet & Scheufele, 2007).

Genetically engineered foods, on the other hand, have not gained the attention from special interest groups that stem cell research has and so have tended to be framed in business- and progress-related ways, within which uncertainty has been drastically downplayed (Nisbet & Scheufele, 2007). This is in part due to the trust that the public in the U.S. places in the regulatory framework surrounding food safety, as well as to the tendency for Americans to defer to scientific authority when not given cues otherwise (Brossard & Nisbet, 2006; Nisbet & Scheufele, 2007; Pelletier, 2005). Also potentially contributing to the downplaying or ignoring of scientific uncertainty is that information released and regulations put in place by government organizations concerning genetically engineered foods have been, according to some researchers, more certain than is accurate (Pelletier, 2005).

5.3 Type III. Remote, Long-Term Scientific Issues (Global Climate Change)

When issues are remote and the repercussions are not immediate, scientific uncertainty may be inflated. This is especially if the long-term impacts of the issue are difficult to comprehend, as in the case of global climate change.

The debate surrounding anthropogenic global climate change in the United States in recent years has been political, not scientific. The majority of scientists agree that global climate change is occurring and that humans have been a root cause of the accelerated change (Le Treut et al., 2007). The International Panel for Climate Change (IPCC) has been issuing reports for decades on this issue, and though the details change, as happens in the scientific process, each new report does not change the overall conclusions that the climate is changing and humans are significantly contributing to the warming (Le Treut et al., 2007). Despite the scientific consensus concerning the state of the earth's climate, the public in the United States is incredibly divided (Leiserowitz, Maibach, Roser-Renouf, & Smith, 2011). In a recent assessment of the public's attitude toward global climate change, a quarter of the population on the United States was doubtful or dismissive that global climate change was even occurring (Leiserowitz et al., 2011). This disconnect between the perception of this scientific issue and the issue's scientific reality can be in part explained by the frames used in the public discourse surrounding global climate change, including frames of Pandora's box, public accountability, morality and ethics, economic development and, most notably for this paper, scientific uncertainty (Nisbet & Scheufele, 2009).

A combination of intentional and unintentional factors surrounding the reporting of global climate change lent themselves to an uncertainty frame around the issue. Republicans were advised to frame arguments against climate change partly around scientific uncertainty, inflating the perception of uncertainty and discrediting scientists (Nisbet & Scheufele, 2009)—an obviously intentional endeavor to inflate the uncertainty of the issue. A less intentional but perhaps comparably effective inflation of the uncertainty occurs when climate scientists use their common vocabulary consisting of likelihood terms such as likely, very likely, etc. (Somerville & Hassol, 2011).

5.4 Type IV. Personal, Long-Term Scientific Issues (Genetic Risk Assessment)

Issues that have lasting and long-term impacts and that hit close to home for individuals tend to downplay uncertainty. Health-related issues, particularly related to genetic risks, such as predisposition for cancer and other diseases, vary in how uncertainty is presented in relation to the frame used.

In recent years, genetic research has advanced incredibly quickly. With this advancement has been an upsurge in reporting on genetic risks (Cappella, Mittermaier, Weiner, Humphreys, & Falcone, 2007). Genetic risk information about cancer has been shown to be reported mostly deterministically, meaning the majority of articles report definitively that a certain gene (or genes) cause cancer, even though the relationship between genes and cancer reality is much more complicated (Cappella et al., 2007). This may be that reporting of non-cancer research in the frame of "science as a triumphant quest," looking for and finding the root cause of a problem. Within this frame, the uncertainty is downplayed.

5.5 Dynamic Nature of Typology Breakdown

The issues presented in Figure 1 are not static; the lines between types are dashed to represent the dynamic nature of the breakdown. The breakdown of "time frame of outcomes" is not so simple because of scientific unknowns. Issues may also move among cells depending on where the issue is in terms of the issue-attention cycle.

For example, the issue of nanotechnology is on the line. In the U.S., nanotechnology is currently predominantly framed in terms of "social progress" and "economic development," in which scientific uncertainty is largely left out of the discussion (Nisbet & Scheufele, 2007). Nanotechnology is "on the line" between immediate and long-term effects in Figure 1 for multiple reasons: first, a frame shift is on the horizon, as indicated by headlines in the late 2000s alluding to the "darker side" of nanotechnology (Nisbet & Scheufele, 2007); second, scientists and the public are both concerned, in different ways, about risks related to nanotechnology, nanoscientists, more so about long-term health and environmental risks and the public more so about privacy and economic-related risks (Scheufele et al., 2007). The focus of the American public's concerns may soon shift even more quickly from reporting nanotechnology in business-related frames to frames that, at best, accurately convey scientific uncertainty, or to frames at the other extreme, such as "ethics/morality" (that ask, is what we are doing even right to do?) to frames that inflate and exploit, like "scientific uncertainty" itself, or "Pandora's box." Part of this shift is related to where the issue is in the attention-cycle of the public.

5.6 Issue-Attention Cycle

Many issues that at some point are perceived as "crises" in the U.S. go through an "issue-attention cycle" as described by Downs (1972). This dynamic cycle consists of five stages: pre-problem, alarmed discovery and euphoric enthusiasm, realizing the cost of significant progress, gradual decline of intense public interest, and the post-problem stage (Downs, 1972, pp. 39–40). Issues with certain characteristics are particularly susceptible to the issue-attention cycle, including those that affect a minority (by numbers), those in which "the suffering caused by the problem are generated by social arrangements that provide significant benefits to a majority or power minority of the situation," and those in which the problem has "no intrinsically exciting qualities" (Downs, 1972, p. 41).

Not all issues go through an issue-attention cycle; however, for those that do, where the attention is on the issue may affect how people respond to different frames. Conversely, how and when different frames are employed during different parts of the attention cycle may affect the intensity of attention (Nisbet & Huge, 2006). For example, the early (pre-problem) framing of plant biotechnology by proponents of the technology likely contributed to the general lack of concern shown by the American public as the issue progressed through the attention cycle (Nisbet & Huge, 2006).

6. CONCLUSION

There are several limitations to this study. First, it is difficult to account for individual values, which is significant because a person's existing value system will influence how that individual processes information surrounding uncertainty. For example, if an individual firmly believes in creationism/intelligent design, then any news surrounding evolution (another example of an issue with scientific consensus and political and social dissent) will be perceived as much less certain than it really is. Any debate surrounding the validity of evolution questions and inflates the uncertainty of the issue, considering the theory, in the scientific meaning of the word, of evolution is solidly supported. Evolution is pervasive throughout much of science, and is also rejected by many people because of their religious beliefs. Accounting for the many applications of and responses to evolution is challenging, and this four-cell typology may miss the nuance of this issue and others like it. Also, regardless of how well a particular issue fits a typology that describes or predicts how the media deals with uncertainty surrounding that issue, if actors in a societal system are using uncertainty instrumentally to achieve certain goals, or when scientific integrity is compromised, then the parameters are moot. For example, scientific uncertainty was an integral component of much of the controversy over autism being linked to vaccines, but this was initiated from a fraudulent study.

Despite these limitations, this typology could help researchers understand how uncertainty may be dealt with in media frames by comparing some basic characteristics of emerging scientific research to some of the issues outlined in this paper. As exemplified by the widespread acceptance of plant biotechnology in the U.S. being largely due to the early framing strategies that downplayed uncertainty, framing significantly impacts public response. An uncertainty frame may really be equivalent to an ignorance frame, due to the public's interpretation of scientific uncertainty. Because the public interprets uncertainty as ignorance (Somerville & Hassol, 2011), the acknowledgement of uncertainty is the equivalent of the declaration of ignorance (Corbett & Durfee, 2004). An ignorance frame surrounding uncertainty is often the result of scientists acknowledging the existence of uncertainty (Corbett & Durfee, 2004). Future research of how uncertainty is incorporated into frames could include a more detailed breakdown of characteristics of issues, perhaps, for example, distinguishing among types of impact (health, environmental, etc.) and scale of impact. This theoretical exploration may further journalists' understanding of uncertainty in science news; being aware of how uncertainty may be used or exist in accordance with certain frames may promote more accurate reporting of scientific uncertainty.

If scientists do not make a decision about how to frame their research, it does not mean their research will not be framed; it means that someone else will frame it (Nisbet & Scheufele, 2007). Exploring how complex ideas like uncertainty in science exist with frames could be a part of a graduate training in communication for scientists, which is a step that Nisbet and Scheufele (2009) propose as a direction forward for science communication. Considering the dual-use potential for frames, learning about framing is inextricably tied to an ethical discussion. Dahlstrom and Ho (2012) pose several questions related to the ethical use of narratives that, with slight modifications, I suggest are central to questions related to the ethical use of frames. The questions for narratives asked by Dahlstrom and Ho (2012) are "(a) What is the underlying purpose of using narrative: comprehension or persuasion? (b) What are the appropriate levels of accuracy to maintain? and (c) Should narrative be used at all?" (p. 610). By the equivalence frame definition, choosing among different frames means choosing different ways of presenting the same information, making question (b) above moot when applied to frames (Scheufele & Iyengar, 2011). However, asking "what is the underlying purpose of using this frame: comprehension or persuasion?" and "should this frame be used at all?" are questions central to any ethically sound science communication effort.

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