Testing Public (Un)Certainty of Science: Media Representations of Global Warming

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Testing Public (Un)Certainty of Science

Media Representations of Global Warming

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*This exploratory study examines whether readers' assessments of the certainty of scientific findings depend on characteristics of news stories. An experimental design tested whether adding controversy and/or context to a news story about global warming influenced readers' perceptions of its certainty. Respondents (*N *= 209) were randomly assigned to read one treatment and answer a questionnaire. Overall, there was a significant difference in readers' assessment of the certainty of global warming across treatments (*F *= 12.59, p = .00). The context treatment produced the highest level of certainty about global warming and differed significantly from the control treatment (with neither context nor controversy) and from the controversy treatment. Control and controversy treatments resulted in the lowest levels of certainty. There was an interaction effect between treatment and environmental ideology upon certainty (*F *= 1.64, p = .03) and a correlation between environmental ideology and prior certainty about global warming (*r *= .35, p = .01), suggesting that those with proenvironmental ideology were less swayed by the treatments.*

Keywords: *science communication; scientific uncertainty; global warming; climate change; environment; mass media*

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Public understanding of science and technology is critical for a society increasingly affected by scientific developments and policies influenced by scientific expertise (Miller 1986; Nelkin 1995). For most citizens, knowledge about science comes largely through mass media, not through scientific publications or direct involvement in science. As Nelkin stated, the public understands science "less through direct experience or past education than through the filter of journalistic language and imagery" (1995, 2).

This is especially true for unobtrusive or "invisible" issues where a person lacks real-world experiential conditions that could help shape opinion and understanding, such as global climate change. Even if a person lives through the hottest summer on record, record drought, or severe forest fires (weather events that occurred in the United States in 1988 and 2002), it is the media that attempt to connect such events to scientific evidence. Bell (1994) found that the media were the sole source of information on climate change for New Zealanders, and Wilson (1995) reported that the media (especially television) were the primary information source in the United States.

For the phenomenon of global climate change (often referred to by journalists and the general public as global warming),[1] communication research has focused on media portrayals, public opinion and understanding, and how both scientists and journalists construct scientific certainty and/or ignorance. However, research is lacking that directly tests audience responses to journalistic discourse of global warming—in particular, the media's portrayal of its (un)certainty. That is the goal of this exploratory research.

Literature Review

Media Coverage of Science, Global Warming

Like news coverage generally, media reporting of science is tied to classic definitions of news and is often event driven, using the occasion of a scientific meeting or publication in a major scientific journal to spur attention to an issue. According to Wilkins (1993, 74), science coverage emphasizes discoveries and "firsts in science," is tied to discrete events, and emphasizes an elite group of scientists. Often missing in science stories are the contexts (social, economic, political, and historical), as well as information about how science and the scientific process are conducted (Nelkin 1995).

Other elements also play a role in bringing science news to the public through the mass media. Scholars have demonstrated that some scientists have used the media to advance their own careers or agendas (Dickson 1984; Nelkin 1995) or to popularize certain areas of science such as medicine

(Logan 1991). For the topic of breast cancer, Corbett and Mori (1999) identified two-way relationships between the amount of media attention, number of scientific journal publications, and medical research dollars. As Mazur and Lee (1993) found in a study of news content, human drama and other components of a "good story" play a part in bringing science topics to the news. They discovered that widespread media coverage of several environmental issues—ozone holes, global warming, rainforest destruction, and species extinction—was the result of the interplay of prominent news sources, extraneous events, attention by prominent national news media, and human drama, not primarily the scientific discoveries involved. Greenberg and others (1989) similarly found that television news coverage was more influenced by a story's dramatic value than the inherent risk, while McComas and Shanahan (1999) concluded that media narratives on climate change were driven by dramatic considerations.

Some past research has focused specifically on media coverage of climate change, including the role of reporters and story construction. For example, in a study of print coverage from 1987 to 1990, Wilkins (1993) found underlying values of progress, innocence, and an institutionalization of knowledge in scientific and governmental bodies. She argued that these values reflect a dominant frame that emphasizes technological "fixes" for global warming rather than human behavior change. Trumbo (1995) conducted a longitudinal analysis of climate change coverage and discovered that reporting first peaked in 1988 and declined in the early 1990s; Ungar (1995) attributed this decline to the topic's lack of dramatic crisis. Coverage resurfaced on news pages beginning in late 1997 (Wilson 2000).

In early reporting on global warming, scientists were the primary sources of information, but later, politicians and interest groups (both industry and environmental) entered the discourse (Trumbo 1996). Wilkins (1993) reported that even by 1990, the balance of sources cited in global warming stories had shifted from scientists to politicians and interest groups. Williams (2001) analyzed media coverage from 1976 to 1998 and found a similar shift in the discussion from one dominated by science to one in the policy and industry arenas. He concluded that this shift may have contributed to the confusion—by reporters and, by extension, the public—regarding the certainty of climate change.

In a study of reporters' knowledge of global climate change, Wilson (2000) found that many reporters were confused about the basic science involved and the scientific certainty of the greenhouse effect. Reporters who primarily used scientists as sources and who worked the science or environment beat full-time had the most accurate climate change knowledge. Wilson

concluded that reporters were confused about climate change; they exaggerated the debate and underplayed the consensus.

Bell (1994) identified several different types of inaccuracies in climate change reporting: scientific or technical inaccuracies, misquotations, significant omissions, exaggerations, and distortions of emphasis. This study was consistent with an earlier one by Tankard and Ryan (1974) that documented that science reporting overall had greater numbers of errors and inaccuracies than did general news reporting.

Public Understanding of Global Warming

General public awareness of global warming has increased dramatically during the past two decades. In 1981, only 38 percent of the public had heard of global warming, which increased to 40 percent by 1987, to 86 percent by 1990 (polls reported by Trumbo 1995), and to near saturation levels of 88 percent in 1997 (Stamm, Clark, and Eblacas 2000). When respondents in surveys were asked if they believed global warming was real, however, lower percentages were reported. A survey by the National Science Foundation in 2001 found that 77 percent of adults believed that global warming was real, a percentage that increased according to level of education (Public belief in global warming 2001). A Gallup poll in March 2002 found that 61 percent of respondents believed that the phenomenon was occurring, up from 48 percent in 1997 (Gallup polls on environmental issues 2002).

Obviously, having heard of climate change is not the same as understanding the phenomenon, possessing accurate knowledge about it, or being certain about it. On these dimensions, the research has found much lower levels.

In a survey of adults in metropolitan areas, for example, Stamm, Clark, and Eblacas (2000) found that people were aware in a general sense of global warming but had a limited understanding of its particular causes, possible consequences, and solutions. Among the 512 respondents, the researchers found widespread misconceptions and uncertainty. The good news, they reported, was that both mass media and interpersonal communication appeared to make a positive contribution to understanding, although it also helped perpetuate some popular misconceptions and uncertainties.

Other research has documented the fluctuations in concern and apprehension. Ungar (1992) noted that public anxiety peaked in hot, dry summers (as did media attention). Williams (2001) also discovered that public interest in global warming has fluctuated over time.

Krosnick, Holbrook, and Visser (2000) conducted national surveys before and after the debate surrounding the 1997 Kyoto Protocol and found that the discussion attracted people's attention and strengthened existing

beliefs and attitudes. However, it produced almost no changes in public opinion about climate change.

In a large survey of Americans, Bord, O'Connor, and Fisher (2000) attempted to assess the importance of actual knowledge about global warming in explaining people's intentions to do something about it; they reasoned that an intent to behave responsibly requires a concrete knowledge of causes. They found that knowing what causes climate change and what does not was indeed the most powerful predictor of stated intentions to take voluntary actions. The researchers also noted several patterns regarding public sentiment: "public concern, particularly for the future; beliefs in specific negative outcomes such as ocean level rise, more frequent storms, and possible water shortages; and general agreement that this is a serious or potentially serious problem" (p. 205). In earlier work, these same scholars (Bord, O'Connor, and Fisher 1998) concluded that global warming is poorly understood by the public and is not a salient issue for them.

These studies demonstrate that although general awareness of climate change is relatively high, public understanding, knowledge, interest, and certainty about the phenomenon is lower and variable. As Gallup noted, less than two-thirds of people believe that climate change is occurring (Gallup polls on environmental issues 2002). Research thus far on news reporting of climate change has reached similar conclusions: media attention ebbs and flows, many journalists lack accurate climate change knowledge, reporting contains inaccuracies and distortions, and journalists tend to underplay the scientific consensus. It is logical to conclude that there must be some connection between media coverage of climate change and public misconceptions of it, particularly because this is an issue largely communicated to the public through the media.

Ungar (2000) hypothesized that as an issue, global climate change lacks the currency and day-to-day relevance necessary to motivate individuals to obtain information. He argued that there is an "attention economy" in which scientific claims must compete, and when "entry costs" are high, individuals need to be motivated to undertake scientific literacy. When it came to understanding the ozone hole, people could easily understand the metaphor of dangerous rays penetrating an ozone shield and could personally and immediately apply the pragmatic advice about sunscreen and exposure. Although individuals may be motivated to learn about global warming as good citizens, Ungar said the issue is presented as future oriented and lacks "social utility of knowledge" or is not information that is in demand in particular social situations.

Obviously, the media play a role in the public's perception of global warming as an issue. In particular, we are interested in how media coverage

has communicated one of the key components of climate change as a scientific and political issue—its certainty.

The Communication and Perception of Certainty

A growing number of scholars have begun to focus not just on certainty and knowledge but also on ignorance, particularly as it relates to science (Smithson 1993). Broadly defined, ignorance can include an absence of knowledge, uncertainty, incompleteness, bias, error, and irrelevance (Stocking and Holstein 1993). While a key goal of the scientific process is to whittle away at ignorance study by study, built into scientific practice are a variety of legitimated uncertainties, such as interpretive claims, site or subject selection, and acceptable levels of statistical error. Some have argued that assessments of certainty and scientific "fact" originate in the social world (Pinch 1981) and that representations of certainty do not reflect a given reality or state of objective knowledge but are constructed in particular situations and with certain effects (Shackley and Wynne 1996; Stocking and Holstein 1993). For matters of controversial science, various scientific factions may actually use uncertainty as a rhetorical tool (Dunwoody 1999). As Einsiedel and Thorne (1999) maintained, "Uncertainty is a social construction, one that is negotiated among actors in a social system that includes various publics. Seen in this light, uncertainty is manifested by individuals in a number of different ways, for different reasons, and with varying outcomes" (p. 44).

When journalists report scientific work, they have the discretion to pass along the caveats and uncertainty claims presented by the scientist or to exclude such claims. As noted by Shackley and Wynne (1996), when the consequences of science have significance for a range of policy actors, "the scientific community no longer has full autonomy to decide whether and how scientific uncertainty is presented to outsiders" (p. 278), such as the press.

In the case of global warming, the media have more often than not overplayed the level of uncertainty about global climate change. This has been the conclusion not only of academics but also of Pulitzer Prize–winning journalist Ross Gelbspan. In his book *The Heat Is On* (1998), Gelbspan demonstrated that the manufacture of doubt and uncertainty regarding the science of climate change was a deliberate, well-financed tactic by oil and coal companies and conservative politicians in an attempt to undermine public confidence in science and thereby defer action against global warming.

After analyzing popular press articles about global warming from 1986 to 1995, Zehr (2000) concluded several things about the portrayal of scientific uncertainty. First, scientific uncertainty was a salient theme in the newspaper articles. Second, Zehr maintained that scientific uncertainty was constructed

through representations of controversy, new research topics, and the increasing scope of the problem. Third, scientific uncertainty was managed by the media in such a way that science remained an authoritative knowledge provider. Zehr concluded that the rhetorical boundaries between scientists and the public reinforced a "misinformed public" identity (p. 98). Zehr suggested that further research was needed to investigate how the media communicate scientific uncertainty (and how it is received by the public).

Researchers have suggested a variety of other factors that affect uncertainty, such as omitting scientific caveats, using single-source stories, giving equal weight to fringe and nonscientists as much as scientists, focusing on novel research and drama, and popularizing science (Dearing 1995; Stocking 1999). Rogers (1999) asked focus-group participants to read or view news stories about AIDS and global warming and discuss story characteristics that inhibited their understanding. Participants mentioned insufficient information, lack of context, story structure, visuals, and story framing.

Two of the factors identified in these studies seem to have gained particular notice from researchers for their ability to convey uncertainty in science stories: the use of controversy and the lack of context.

Scientific uncertainty can be heightened in news stories by interjecting or emphasizing controversy or disagreement among scientists. Not only does conflict fulfill traditional news values and add drama, but also it may provide journalists with a pretext of objectivity by presenting multiple sides. Zehr (2000) argued that "controversies tend to make dramatic reading and often are important to public concerns. On occasion, journalists may develop controversy where none previously existed, or sustain it by soliciting opposing arguments by expert scientists" (p. 86). This practice has been interpreted as a way to construct journalistic objectivity and to create drama in one's account (Stocking and Holstein 1993).

When sources offer conflicting claims, reporters use one of two strategies: try to be objective or try to balance the story (Dunwoody 1999). The result of the routine media practice of quoting conflicting sides may be to treat the various scientists and the sides they represent as having equal weight, even though the majority of evidence or opinion may fall clearly to one side (Stocking 1999) or one side may consist of industry-supported or otherwise fringe scientists (Wilkins 1993). Dearing (1995) noted in his analysis of media reporting on "maverick science" that the journalistic function of balance functioned to make the fringe claims more credible. As Stocking (1999) concluded:

> Sometimes, particularly in science addressing contentious public issues, journalists have been found to pit scientist against scientist, with little or no

> discussion of the reason for disagreements, and often without mention of the relative degree of scientific acceptance of the differing views. The resulting accounts of science give equal, but unequally deserving, weight to "dueling experts," thus making the science appear more controversial and more uncertain than the bulk of scientists believe it to be. (P. 29)

Media coverage can send the message to readers and viewers that the science is uncertain without ever mentioning the word *uncertainty* in stories. All that may be necessary to deliver that perception are competing scientific views without any sense of how the evidence lines up (Dunwoody 1999). The message of the traditional balanced account may be, "Well, who knows what's really true?" even when a story reports on a controversy in which both science and society have agreed that truth lies more firmly on one side than on the other. Wilson (2000) speculated that journalists have done just this in the coverage of climate change, accentuating the scientific debate by creating "an ersatz balance" (p. 11) and underplaying the consensus that exists.

Another factor that may influence the certainty with which scientific results are treated in media stories is the lack of context (Dearing 1995; Rogers 1999). When a new study departs from or extends prior research, or represents a flip-flop that appears to contradict prior findings (Stocking 1999), journalists need to provide historical context within the body of scientific knowledge. Tankard and Ryan (1974) cited "continuity of research with earlier work ignored" (p. 221) as a primary problem in science reporting. Wilkins (1987) noted that news coverage of events are often stripped of their social, economic, and political context.

Although scholars have pointed to controversy and a lack of context for heightening uncertainty surrounding uncertain science, do these factors actually affect uncertainty in the minds of readers? So far as we know, no one has tested or isolated these factors and tied them directly to audience perceptions of uncertainty. As Van Dommelen (2002) concluded, a pragmatic and fundamental methodology for understanding scientific (un)certainty in different practical contexts needs to be put in place. While the current research into uncertain science and the media presentation of it has provided a rich background, crucial missing links are tests of factors that might contribute to or inhibit perceptions of uncertainty in the minds of readers.

If we extend the findings of media content studies to media audience perceptions, we would expect controversy in a global warming story to decrease certainty about global warming, while context in a global warming story should increase certainty. As an initial test of these largely unexplored factors, we hypothesized the following relationships of controversy and context to readers' perceptions of scientific (un)certainty about global climate change.

Hypothesis 1: The readers of newspaper stories that include context will be more certain of scientific claims (contained in the story) than those who read the article with controversy only.

Hypothesis 2: The readers of newspaper stories with both context and controversy will have more certainty than readers of stories with only controversy and less certainty than readers of stories with only context.

One final factor to isolate and explore is the relationship between environmental ideology and perceptions of uncertainty regarding global warming. Bord, O'Connor, and Fisher (2000) surveyed 1,218 Americans to investigate what drove their behaviors and intentions to address global warming with personal actions. They reported that "general pro-environment beliefs and perceptions" helped explain behavioral intentions (p. 205). Other researchers also have found measures of environmental ideology related to proenvironmental stances or intentions (Beedell and Rehman 2000; Corbett 2002; Grob 1995; Trumbo and O'Keefe 2000). It is reasonable to assume that individuals who identify themselves as having a stronger proenvironmental ideology will have a stronger prior certainty about global warming. However, we would expect that when these individuals are asked to rate the certainty portrayed within a particular news story about global warming, they also will be affected by the treatments and rate uncertainty accordingly.

Hypothesis 3: The stronger the individuals' environmental ideology, the stronger their prior certainty about the existence of global warming.

Methods

Operationalization

This exploratory study was designed to test readers on the actual effects of textual variations in news stories that have long been discussed in the literature. Experimental design enabled us to manipulate two key factors identified in past research as affecting individuals' assessments of scientific certainty: the inclusion of controversy and context. In addition to these singular tests, the experiment allowed us to test the effects of both controversy and context and neither controversy nor context (regarded as the control group) on scientific certainty.

The four treatment stories (see Appendices A, B, C, and D) were developed from actual scientific studies that were reported in the media about three months prior: a scientific journal published a study by scientists who found that a portion of the Antarctic ice sheet was thickening. We reasoned that a

genuine, recent scientific finding provided a more desirable foundation for our experiment than an entirely fabricated one. Because this particular study suggested uncertainty about global warming (since thickening ice would be counterintuitive to global warming), it provided a chance to test whether the addition of scientific context (more studies have found melting than thickening) would be able to mitigate this uncertainty.

Information for the controversy and context treatments was gathered from other recent news articles about studies conducted on the Antarctic ice sheet and was integrated into the news article about the ice-thickening study to be as realistic as possible. Controversy was operationalized according to journalistic standards and involved a paragraph that presented scientists who disagreed with the journal article findings. (Although the nature of the disagreement was scientifically realistic—criticism of methods and conflicting findings from other studies—the names and affiliations of the disagreeing scientists were fabricated.) Context was operationalized by the inclusion of a scientifically accurate paragraph that put the journal article findings in context with a wider body of research, including previous studies that had found Antarctic ice to be thinning. Facts for the "context" paragraph were obtained from other scientific studies of global warming and from recent, widely publicized conclusions made at worldwide gatherings by climate change scientists. The controversy and context treatment included both of these paragraphs.

All of the treatments were designed to resemble an actual newspaper story in layout and text format. The affiliation of the reporter was listed as Associated Press. Each story treatment had approximately the same amount of text. Because the controversy and context treatments involved an additional paragraph, story length was equalized in shorter story treatments by including so-called boilerplate material about the ice sheet and simple facts related to its size and formation. This material was obtained from news stories and from government Web sites.

Administration

The surveys were administered to two undergraduate communication classes at the University of Utah on March 13 and 14, 2002. This convenience sample was considered to be appropriate for three reasons. First, belief in global warming increased with level of education in a National Science Foundation survey (Public belief in global warming 2002), a variable that we were able to control with this sample. Second, because we could find no prior tests of readers' perception of scientific uncertainty based on news story construction, this study is exploratory and a convenience sample is considered

acceptable. Third, participants in research experiments are typically convenience rather than probability samples since the primary goal of this type of research design is to isolate and test the effect of the treatment.

Each student received a clasped envelope with the consent form taped on top. After a brief oral introduction of the study, students were asked to read and sign the consent form before opening the packet, reading the news story, and answering the short survey. Treatments were randomly distributed in each class. Of the 209 participants, 54 students received the controversy treatment, 51 students received the context treatment, 51 students received the controversy-and-context treatment, and 53 received the control treatment (neither controversy nor context). To maintain anonymity, consent forms were collected separately from completed surveys.

Responses of the two undergraduate communication classes did not significantly differ ($F = .004$, $p = .95$) for any of the hypothesized variables.

The survey consisted of 19 questions, four of which generated demographic information. All other response choices were presented as six-point Likert-type scales.

Two questions tested the dependent variable of scientific certainty:

"According to this news story, global warming is a scientific certainty."
"In this article, scientists are unsure whether global climate change is occurring." (scaling reversed)

These two questions scaled together sufficiently (Cronbach's $\alpha = .71$) and were combined into one dependent variable, which provides a stronger single measure of scientific uncertainty than the two single measures. (As explained previously, because neither journalists nor the general public make a clear distinction between global warming and global climate change, we chose to use one question referring to each.)

Respondents' environmental ideology was operationalized with four questions used repeatedly in the General Social Survey that have demonstrated validity as tests of environmental opinions and attitudes (scaled, Cronbach's $\alpha = .61$):

"When humans interfere with nature, it very rarely produces bad consequences." (scaling reversed)
"Economic growth should be given priority even if the environment suffers to some extent." (scaling reversed)
"Would you say that the amount of money we spend as a nation on the environment is too little, too much, or about the right amount?" (scaling ordered)
"The balance of nature is delicate."

For Hypothesis 3, one question at the end of the survey assessed prior certainty:

> "Before you read this article today, how sure were you that global climate change was taking place?"

Obviously, this question is not an ideal measure of prior certainty because respondents were asked to recall preexisting attitudes after reading the news story, not before. A more accurate assessment would have been a measure of prior certainty a week or more before the experiment. However, we included the measure in this exploratory study to see what it might suggest for future tests of this hypothesis and the overall relationship to scientific certainty.

Results

Figure 1 presents the results of the first two hypotheses. The treatments differed significantly in terms of perceptions of certainty (One-way ANOVA, $F = 12.59$, $p = .00$). The means are in the expected direction: Context produced the highest level of certainty regarding global warming in the story, and controversy produced less certainty. Readers of the control treatment (lacking both controversy and context) were least certain about global warming. As predicted in Hypothesis 1, readers of newspaper stories that included context were more certain of global warming than those who read stories with controversy or stories with neither context nor controversy (control).

Because the ANOVA test evaluates means collectively, post hoc tests were run to determine which pairs of means differed significantly from one another. The average certainty rating by readers of the context treatment was 4.1 (6 being the most certain), which differed significantly (Bonferroni post hoc comparison test, $p = .00$) from readers of the controversy treatment, which was 3.1. Readers of the context treatment also rated certainty significantly higher ($p = .00$) than readers of the control treatment ($M = 2.7$). The context treatment mean did not differ significantly from the combined controversy-context treatment mean.

Hypothesis 2 predicted that readers of newspaper stories with both context and controversy would perceive global warming as more certain than those who read controversy alone and less certain than context alone. While the means are in the expected positions, the differences between these pairs were not significant. The controversy and context treatment differed significantly from the control treatment (Bonferroni post hoc comparison test, $p = .00$).

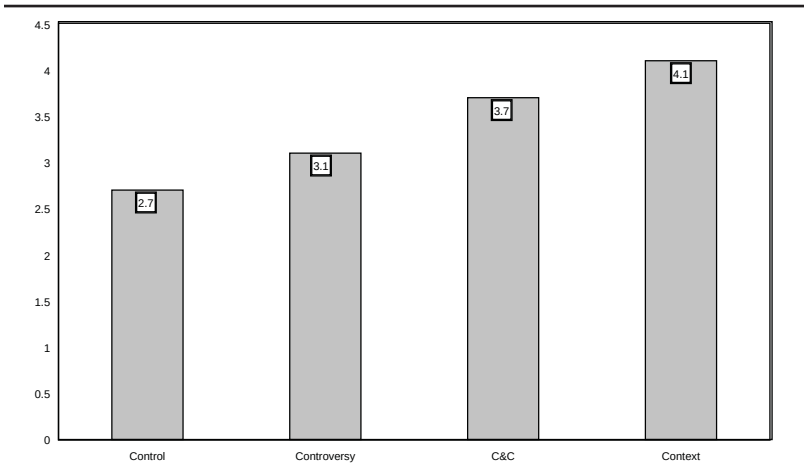

Figure 1: Certainty about Global Warming by Treatments
NOTE: For a one-way ANOVA, $F = 12.59$ and $p = .03$. On a six-point Likert-type scale of certainty, 1 = *very uncertain* and 6 = *very certain*. For Bonferroni post hoc comparisons, the means of A and C, A and D, and B and C are significantly different at the $p < .001$ level.

Tests of the third hypothesis found a significant, positive correlation between environmental ideology and prior certainty about global warming ($r = .35$, $p = .01$). There was, however, a slight interaction effect between treatment and environmental ideology upon certainty as portrayed in the news stories ($F = 1.64$, $p = .03$), suggesting that environmental ideology (and perhaps existing knowledge) mitigated in some way the effect of the treatments on some readers' perceptions of certainty. However, environmental ideology did not have a main effect on the dependent variable of certainty expressed within the news story, which suggests that respondents were able to differentiate to a certain degree between their prior certainty about global warming and certainty as portrayed in the treatments.

No other interaction or main effects on uncertainty were discovered for political ideology, environmental activism, age, gender, newspaper readership, or number of hours worked per week.

Discussion

While researchers have inferred from content studies of media coverage the ways in which uncertainty is constructed and conveyed by scientists and journalists, an important piece of the puzzle is whether these uncertainties are apparent to readers. This research was an initial attempt to test whether

simple, common elements in news stories—controversy and context—influenced readers' perceptions of scientific certainty about global warming. In this experiment, the inclusion of context increased readers' perceptions of certainty, while the inclusion of controversy reduced perceptions of certainty.

The media's attraction to controversy, no matter the source or topic, is unlikely to wane. It is heartening, however, that the simple inclusion of scientific context may help mitigate the uncertainty stirred by scientific controversy.

The slight interaction effect between news-story treatment and environmental ideology upon certainty suggests that those with proenvironmental ideology perhaps possessed greater existing knowledge about global warming and were therefore more certain at the outset. While this is reasonable to assume, environmental ideology did not have a direct effect on uncertainty. Ideology nevertheless may play a role in how a reader interprets scientific uncertainty in relation to environmental issues such as climate change.

While we hesitate to overstep the bounds of what these small, experimental data are able to tell us, it is nevertheless important to discuss these findings in light of the concepts that they attempted to test: context, controversy, and scientific uncertainty. Our aim is not to make grand conclusions but rather to put these findings into a broader context for future research directions and counsel for science communicators and journalists.

Context is obviously important for assessing any complex issue—scientific, political, or social. But in many ways, journalistic news routines work against the inclusion of context. For example, the actual news story that formed the basis of our treatments most likely was the result of publicity sent to the media by the scientific journal where the study appeared. It would be unlikely that a reporter would spend much extra time (particularly if there were no full-time science or environmental reporter on staff) to educate himself or herself to be able to put this one study in context. As Wilson (2000) pointed out, many journalists—even members of the Society of Environmental Journalists whom he surveyed—lack sufficient background knowledge of global climate change. Wilson found that reporters were confused, exaggerated the debate, and underplayed the consensus around global climate change, making it unlikely that they could accurately convey scientific context if it was not supplied to them.

The long-standing journalistic tradition of bringing in opposing sides is an attempt to provide balance and objectivity. However, it is problematic to introduce dissent into an area where science largely agrees, particularly for readers unable to evaluate where the balance of evidence lies. Wilson (2000) argued that "by creating an ersatz balance to the climate change story, the

scientific debate [rather than the scientific consensus] has been accentuated" (p. 11). He suggested a modification of the journalistic tenet to find balance: "quality reporting on climate change needs to portray the scientific consensus and dissent accurately" (p. 11).

Uncertainty is a certain feature of life; people are immersed in and negotiate uncertainty daily. As Henry Pollack argued in his book *Uncertain Science . . . Uncertain World* (2003), "The uncertainties that scientists face are really not so different from the uncertainties we encounter in daily life. . . . Ironically, people who are not scientists often equate science with certainty, rather than uncertainty" (p. 6).

Pollack (2003) concluded that when scientists acknowledge that they do not know *everything* (i.e., that uncertainties remain), there is an unfortunate tendency of both media and the public to interpret this as not knowing *anything* about the subject. In the face of such uncertainty, there has been a willingness to entertain quack or pseudoscience and to consider the status quo preferable.

Uncertainty does not impede science; instead, it propels it forward (Pollack 2003). The key in the public communication of science in general and global warming in particular, therefore, is not to deny the uncertainty (or the controversies that inevitably arise from it) but to place the uncertain finding in the proper and objective context of the scientific process. As Pollack pointed out, this is difficult when there are "sowers of uncertainty" who mount not-so-subtle assaults on science when they do not like what science is telling them, such as the petroleum and coal industries' comments about the causes and consequences of global climate change (Pollack 2003, 13; see also Gelbspan 1998).

Pollack's (2003) perspective on accommodating uncertainty, both ordinary and scientific, may prove useful for science communicators and journalists alike: "Because uncertainty never disappears, decisions about the future, big and small, must always be made in the absence of certainty. Waiting until uncertainty is eliminated before making decisions is an implicit endorsement of the status quo, and often an excuse for maintaining it" (p. 3).

Experimental research, like many other types of empirical research, represents a snapshot, and as such, it is replete with limitations and shortcomings. Similarly, the picture presented of science by the news media is a snapshot. In contrast, the process of science can be described as a long movie. It should not be surprising, then, that the public has struggled to put the "movie" together from its exposure to "science snapshots" from the media. Does this spell doom to an accurate public understanding of the phenomenon of global climate change, given the highly contested and politically charged nature of the debate? On a hopeful note, perhaps not: "Enough snapshots strung

together can begin to look like a movie to the public. Eventually, through repetition, these large-scale environmental concepts can become embedded in the public awareness" (Pollack 2003, 31).

As mentioned at the outset, the convenience sample ($N = 209$) used for this experiment was deemed appropriate to control for the demonstrated effects of education on beliefs about global warming and because we could find no prior tests of readers' perceptions of scientific uncertainty based on news-story construction. While the one-shot nature of experimental research may be considered one of the weaknesses of the method, the controlled conditions may be considered a strength. Additional tests of this study design will no doubt improve generalizability. But this experiment provided a much-needed bridge between the journalistic construction of scientific uncertainty and audience perceptions of it.

Future research could expand on the tests of context and controversy presented here, as well as provide tests of other news-story variables that may affect readers' perceptions of uncertainty, such as single-source stories, the use of visuals, story structure and framing, and giving equal weight to fringe and nonscientists as much as scientists. Because little focus has been given to news consumers' assessments of scientific uncertainty, additional methodologies such as Rogers' focus groups (1999) would provide important details as to how readers arrived at their assessments.

It also would be interesting to question readers about their motivations for gaining or ignoring information about global warming. It may be that readers, regardless of the certainty expressed in an individual story, feel as Zehr (2000) hypothesized, that the issue lacks salience and simply does not fit into their conversational needs or desire for pragmatic, day-to-day information. If that is the case, it may be that continued, traditional media coverage, even if the "snapshot" stories collectively began to resemble a "movie," still may be insufficient to captivate the public's attention to the complex scientific phenomenon of global climate change.

We would like to suggest that global warming needs a more salient metaphor that emphasizes its seriousness, immediacy, and scientific credibility. In the United States, when talk-show hosts and television reporters ask people on the street what they think about global warming, a typical response is that a few degrees warmer might not be so bad. Obviously, media coverage has not communicated the graveness of the phenomenon and the negative consequences for daily life. It ultimately may be up to scientists, science communicators, and journalists to find ways to communicate the salience and seriousness of global climate change to a general public that will be increasingly affected by it.

Appendix A:
Control Treatment

Please read this as you would any news article.

West Antarctic Ice Sheet Thickening, Scientists Say

by John Middleton
Associated Press

A study published today in the journal *Science* has found that parts of the ice sheet in Antarctica, the frozen continent that straddles the South Pole, are getting thicker rather than thinner. Using satellite-based radar technology, the study found that instead of losing about 21 billion tons of ice a year, west Antarctica is accumulating nearly 27 billion tons of ice a year. These new findings cast doubt on the speed with which global warming might be felt in the reaches of the southern hemisphere.

Conducting the research were Dr. Ian Tulland of NASA's Jet Propulsion Laboratory and Dr. Stanley Barton of the University of California, Santa Cruz. Their flow measurements for the Ross ice streams indicate that movement of some of the ice streams has slowed or halted, allowing the ice to thicken. The scientists say their study could indicate a reversal of a long-term trend in glacier shrinkage.

"The ice sheet has been retreating for the last few thousand years, but we think the end of this retreat has come," said Tulland.

The glaciers studied by the scientists sit on bedrock located below sea level, and act as drainage channels—or frozen rivers of ice—for a portion of the ice sheet. The weight of the Antarctic ice is so great that in many areas it actually pushed the land below sea level.

Glaciers form when snow accumulates over tens to hundreds of years. The snow eventually becomes so thick that it collapses under its own weight and forms dense glacial ice. When enough ice is compacted, it succumbs to gravity and begins to flow downhill or spread across flat lands. A glacier may take upwards of 2,000 years to either form or melt and disappear, which while a long time for humans, is a blink of an eye in the world of glaciation where time is measured in tens of thousands of years.

The Antarctic icecap contains over 7 million cubic miles of ice—about 90% of the world's ice and 68% of its fresh water. The ice averages one and a half miles in thickness, with the thickest glacier being almost three miles thick. The glaciers in the mountainous western region get the worst blizzards and some of the coldest temperatures on the planet.

The West Antarctic ice sheet is the world's only remaining marine ice sheet, meaning that the ice sheet is anchored to bedrock below sea level and with margins that are floating. Marine ice sheets are important because their existence and future behavior depend not only on atmospheric conditions and ice movement, but also on sea-level changes.

The Tulland-Barton study of the West Antarctic ice sheet was featured at the latest meeting of the American Geophysical Union in San Francisco, a gathering of scientists across the U. S. but attended by scientists worldwide.

Now turn the page and answer the survey questions.

Appendix B:
Controversy Treatment

Please read this as you would any news article.

West Antarctic Ice Sheet Thickening, Scientists Say

by John Middleton
Associated Press

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"The ice sheet has been retreating for the last few thousand years, but we think the end of this retreat has come," said Tulland.

However, not all scientists agree with the ice-thickening assessment. Dr. Lee Weaver, a chief scientist with the National Oceanic and Atmospheric Administration (NOAA), said, "The preponderance of scientific data simply does not support their hypothesis." Weaver has found instances of rapid ice thinning in Antarctica, a likely result of temperatures that have been rising sharply over the past 50 years on the continent due to global warming. Weaver called Tulland and Barton's research noteworthy, but expressed concern over their use of a relatively unproven computer modeling program.

Over the past two decades, Weaver and Oxford University climatologist Arthur Hutchins have been monitoring temperatures and glacial ice using multiple data modeling programs. "There is enough water in the West Antarctic ice sheet to gradually raise sea levels a staggering 20 feet, so any changes in glacial ice are of great concern," Weaver said.

The glaciers studied by the scientists sit on bedrock located below sea level, and act as drainage channels—or frozen rivers of ice—for a portion of the ice sheet. The weight of the Antarctic ice is so great that in many areas it actually pushed the land below sea level.

Glaciers form when snow accumulates over tens to hundreds of years. The snow eventually becomes so thick that it collapses under its own weight and forms dense glacial ice. When enough ice is compacted, it succumbs to gravity and begins to flow downhill or spread across flat lands. A glacier may take upwards of 2,000 years to either form or melt and disappear, which while a long time for humans, is a blink of an eye in the world of glaciation where time is measured in tens of thousands of years.

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Appendix C:
Context Treatment

Please read this as you would any news article.

West Antarctic Ice Sheet Thickening, Scientists Say

by John Middleton
Associated Press

A study published today in the journal *Science* has found that parts of the ice sheet in Antarctica, the frozen continent that straddles the South Pole, are getting thicker rather than thinner. Using satellite-based radar technology, the study found that instead of losing about 21 billion tons of ice a year, west Antarctica is accumulating nearly 27 billion tons of ice a year. These new findings cast doubt on the speed with which global warming might be felt in the reaches of the southern hemisphere.

Conducting the research were Dr. Ian Tulland of NASA's Jet Propulsion Laboratory and Dr. Stanley Barton of the University of California, Santa Cruz. Their flow measurements for the Ross ice streams indicate that movement of some of the ice streams has slowed or halted, allowing the ice to thicken. The scientists say their study could indicate a reversal of a long-term trend in glacier shrinkage.

"The ice sheet has been retreating for the last few thousand years, but we think the end of this retreat has come," said Tulland.

Although the world's scientists agree that the Earth's surface has warmed significantly, especially over the last several decades, there is a far more complicated picture of Antarctica's weather and how global warming will materialize here. A 1991 study indicated that ice was thickening in parts of the continent, and another study found a cooling trend since the mid-1980s in Antarctica's harsh desert valleys. However, other recent studies have noted a dramatic shrinkage in the continent's three largest glaciers, losing as much as 150 feet of thickness in the last decade. While such individual research results seem contradictory, they cast doubt only on where and how soon global climate effects might be evident. At a major international meeting last fall, scientists agreed that global warming is occurring and that human actions are contributing to the warming.

The glaciers studied by the scientists sit on bedrock located below sea level, and act as drainage channels—or frozen rivers of ice—for a portion of the ice sheet. The weight of the Antarctic ice is so great that in many areas it actually pushed the land below sea level.

Glaciers form when snow accumulates over tens to hundreds of years. The snow eventually becomes so thick that it collapses under its own weight and forms dense glacial ice. When enough ice is compacted, it succumbs to gravity and begins to flow downhill or spread across flat lands. A glacier may take upwards of 2,000 years to either form or melt and disappear, which while a long time for humans, is a blink of an eye in the world of glaciation where time is measured in tens of thousands of years.

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Now turn the page and answer the survey questions.

Appendix D:
Controversy and Context Treatment

Please read this as you would any news article.

West Antarctic Ice Sheet Thickening, Scientists Say

by John Middleton
Associated Press

A study published today in the journal *Science* has found that parts of the ice sheet in Antarctica, the frozen continent that straddles the South Pole, are getting thicker rather than thinner. Using satellite-based radar technology, the study found that instead of losing about 21 billion tons of ice a year, west Antarctica is accumulating nearly 27 billion tons of ice a year. These new findings cast doubt on the speed with which global warming might be felt in the reaches of the southern hemisphere.

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Now turn the page and answer the survey questions.

Note

1. Although some have argued (Wilson 2000) that *global climate change* is a scientifically more accurate description of the phenomenon than *global warming*, the distinction is far less clear to journalists and the general public. The terms have also been subject to political spin by those who believe that *global climate change* has less fear appeal to the public than *global warming*. Here, we simply use both terms rather interchangeably to remain more true to the actual usage by the general public.

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