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Communicating Uncertain Science to the Public: How Amount and Source of Uncertainty Impact Fatalism, Backlash, and Overload

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Abstract

Public dissemination of scientific research often focuses on the finding (e.g., nanobombs kill lung cancer) rather than the uncertainty/limitations (e.g., in mice). Adults ($N = 880$) participated in an experiment where they read a manipulated news report about cancer research (a) that contained either low or high uncertainty (b) that was attributed to the scientists responsible for the research (disclosure condition) or an unaffiliated scientist (dueling condition). Compared to the dueling condition, the disclosure condition triggered less prevention-focused cancer fatalism and nutritional backlash.

Keywords

uncertainty; cancer; fatalism; nutritional backlash; cancer information overload

1. INTRODUCTION

The information age is defined by greater access to an ever growing pool of information. Yet, this increased access has not alleviated fundamental problems in communication such as how to present complex information to the public[(1)]. From a scientific standpoint, communicators continue to struggle with uncertainty. Whether and how to present uncertain science to the public is a critical question that remains largely unaddressed.[(2–9)]

At least two conflicting forces complicate this issue. First, scientific discourse is lexically complex, a problem that may be increasing over time[(10)]. Second, and partly due to the first problem, researchers have discovered that public communication of science is frequently

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simplified in ways that could be problematic.[11, 12] Notably, uncertainties are removed from scientific messages as they move from the lab to the public.[13] That is, public communication of science is generally devoid of caveats, limitations, or other forms of discourse-based uncertainty.[15,16,17]

The frequency of this critique is tempered by the fact that researchers have rarely tested whether removing/including uncertainty in the dissemination of scientific research impacts public understanding or perception. Jensen found that including uncertainty in news coverage of cancer research significantly improved the trustworthiness of both scientists and journalists connected to the articles.[6] In a follow-up study, Jensen and colleagues found that uncertain news coverage invoked less cancer fatalism and nutritional backlash.[7] Though limited, available experimental evidence suggests that the public may respond positively to uncertainty in public dissemination of scientific research.

The present study continues this line of research by investigating how variations in the amount (low vs. high) and source of uncertainty impacts public perceptions of cancer research. Theoretically, this research engages the central tension between uncertainty reduction theory (URT)[18] and uncertainty management theory (UMT).[2] The former holds that uncertainty is an aversive motivational feature of communication that audiences want to reduce or eliminate whereas the latter posits that uncertainty is not always aversive but a resource utilized to decipher information in line with goals. To date, experimental research in the communication of science has supported UMT; however, a limitation of past research is that both Jensen[6] and Jensen et al.[7] utilized college student samples. College students can serve as a good proxy for the general public,[19] but students also differ along several key dimensions (e.g., education, income, age) that could influence their response to uncertainty. This is a key omission, as communicators are averse to uncertainty primarily because it is perceived to be a barrier to comprehension. Put another way, college students may benefit from increased uncertainty, however, that is not the target population of concern. To address this limitation, the present study examines whether variations in the amount (low vs. high) and source of uncertainty impacts public perceptions of fatalism and backlash in an adult sample. Cancer research is utilized as a stimuli to replicate past research and because it is frequently used as an exemplar by researchers studying the communication of uncertainty.[4, 7, 9, 20, 21]

2. LITERATURE REVIEW

2.1. Uncertainty and Public Dissemination of Cancer Research

As a key source of information, news media have the power to influence behavior. Consumption of cancer news coverage, for instance, has been linked to increased screening,[22,23] health information-seeking,[24] participation in clinical trials,[25] and more informed treatment decisions.[26, 27] More generally, survey research suggests that people do acquire information about cancer from the media,[28] although there is some concern that individuals with higher education, knowledge, or community involvement reap greater knowledge gains[7, 29, 30].

News media are relied upon and positioned to induce change, but past research has identified several problematic reporting practices. News media frequently report atypical examples or consistently report issues in a biased manner[(31)]. For example, content analyses have revealed that cancer news coverage is heavily slanted toward treatment[(32, 33)] and that some cancers are depicted disproportionately to their real-world incidence.[(34)] Of particular interest to the present study, past research has demonstrated that media reporting of science routinely removes uncertainties. In fact, content analyses suggest that 36–40% of science news stories overstate the findings by omitting key conditional statements,[(16, 17, 35–37)] such as whether the sample was representative of the target population.

Uncertainty is central to science and pervades almost all scientific activities. Popper argued that the scientific community distinguished itself by embracing the limitations of existing knowledge, a philosophy that is generally accepted as the dominant paradigm of modern scientific inquiry.[(38)] Though scientists often try to thread uncertainty into their discourse (e.g., a limitations section), it has been observed that this information is systematically removed as scientific discovery is prepared for public consumption[(14, 39, 40)]. Specifically, news coverage of science often omits caveats and limitations (stated in the original research report) because this material has been removed, initially by scientists and then by public relations professionals and journalists.[(12, 16, 17)] For example, Lai and Lane found that 43% of front page newspaper stories about science were based on preliminary evidence.[(35)] Of those stories, only 18% were described as preliminary or mentioned limitations of the research.

The systematic removal of scientific uncertainty is common, but little experimental work has examined whether the presence of scientific uncertainty affects public perceptions. Existing work has focused primarily on public reaction to dueling or disclosure formats.[(41)] In disclosure stories, scientists question their own research (e.g., “Dr. Albright noted several limitations of her research …”), whereas a dueling structure offers multiple perspectives of an issue in the confines of a single message (e.g., “Dr. Heskin, a researcher unaffiliated with the study, argued that Dr. Albright’s research was limited in several ways …”). For example, Corbett and Durfee conducted an experiment where they manipulated dueling and context in a single news story about global warming.[(42)] Dueling was manipulated by inserting an outside expert into the story who pointed out limitations in the research. Context, on the other hand, was manipulated by including a paragraph that described the larger research trends relevant to the article. They found that additional context increased readers’ perceptions of the certainty of global warming whereas the presence of dueling experts had the opposite effect.

Jensen[(6)] examined how variations of dueling coverage impacted news consumer perceptions of scientists’ and journalists’ credibility. In a lab experiment using news coverage of cancer research as stimuli, they attributed uncertainty to either the scientists responsible for the research (i.e., the disclosure condition) or scientists unaffiliated with the research (i.e., the dueling condition). Participants exposed to the disclosure condition were found to rate scientists’ and journalists’ as more trustworthy. A follow-up study, using the same stimuli, revealed that increased uncertainty reduced fatalistic beliefs about cancer and negative backlash against nutritional recommendations. Moreover, participants exposed to dueling coverage had significantly greater trust in medical professions, a finding that suggests news consumers make meaningful distinctions between scientists and those involved in healthcare.[1]

2.2. Cancer Fatalism, Nutritional Backlash, & Cancer Information Overload

The present study examines whether the amount and source of uncertainty in news coverage of cancer research impacts three outcomes: cancer fatalism, nutritional backlash, and cancer information overload. A description of all three outcomes as well as why each might be triggered by the absence/presentation of scientific uncertainty follows.

2.2.1. Cancer Fatalism—Fatalism is a disposition defined by feelings of angst and nihilism.[43] Fatalistic individuals view events as meaningless, a situation that leads to feelings of despair. Cancer fatalism is a specific type of fatalism wherein a person believes that there is nothing he or she can do to prevent or treat cancer[43] That is, actions taken to prevent or treat cancer are viewed as meaningless. Past research has found that cancer fatalism is positively related to self-efficacy, though the exact nature of this relationship is unclear. For example, it is possible that cancer fatalism shapes self-efficacy, vice versa, or that that they mutually influence one another.[44] Conceptually, fatalism focuses on the relative meaning of an action or event whereas self-efficacy encompasses whether an individual believes they are capable of an action. In other words, a person might believe that it is possible to eat 5 cups of fruit a day (high self-efficacy) but meaningless in terms of cancer prevention (high cancer fatalism). These nihilistic feelings explain why cancer fatalism seems to be negatively related to intentions to screen for cancer[45] and adherence to cancer prevention recommendations.[46]

Most relevant to the present study, researchers have proposed that one cause of cancer fatalism is news consumption,[47] including stories where uncertainty has been systematically removed.[21, 48] Removing uncertainty creates a situation where new research seems to frequently contradict existing research, and it may overwhelm news consumers by cultivating the idea that all research findings are equal.[13] Both of these situations could trigger fatalistic thinking, primarily as a coping mechanism for handling information overload.[6]

Jensen and colleagues found that uncertain news articles provoked significantly less cancer fatalism than certain articles.[6] This effect replicated across four different news articles and it did not vary by source attribution (i.e., disclosure vs. dueling). Concerning the main effect for cancer fatalism, it has recently been revealed that fatalism may have two underlying dimensions: prevention- and treatment-focused cancer fatalism.[49] Prevention-focused cancer fatalism (henceforth, prevention fatalism) is the belief that nothing can stop cancer from occurring whereas treatment-focused cancer fatalism (henceforth, treatment fatalism) is the belief that nothing can reduce cancer mortality. This distinction suggests that it may be meaningful to examine the impact of uncertainty on prevention fatalism and treatment fatalism separately, especially since U.S. adults appear to be less fatalistic about the latter.[49]

2.2.2. Nutritional Backlash—Nutritional backlash refers to “a broad gamut of negative feelings about dietary recommendations” including “skepticism, anger, guilt, worry, fear, and helplessness”.[50] Nutrition researchers have observed that nutritional backlash relates to unhealthy diet and poor nutrition behaviors.[50] It has been suggested that nutritional backlash could be a response to sensationalized media coverage.[50] More specifically, Jensen proposed that nutritional backlash could be a reaction to simplified news coverage, perhaps because news audiences feel overwhelmed by countless nutrition recommendations that all sound the same.[6]

In a test of this idea, Jensen and colleagues found that college students exposed to uncertain news articles about cancer exhibited marginally less nutritionally backlash ($p = .056$) than those exposed to certain articles.[7] Interestingly, the effect did not vary by source attribution or story type. Concerning the latter, uncertain articles about nutrition and cancer yielded the same effect as those without nutritional content.

2.2.3. Cancer Information Overload—Cancer information overload is a perception of the cancer information environment.[49] Past research has found high levels of dispositional cancer information overload in the U.S.[46] Researchers have theorized that dispositional cancer information could be cultivated by several factors, including normative practices in the reporting of cancer research.[49] For example, the systematic removal of scientific uncertainties, and conflict framing, could cultivate dispositional cancer information overload. The information overload model posits that exposure to these normative reporting practices triggers state-based cancer information overload which, over time, cultivates dispositional overload.[7] No study to date has examined whether normative features of cancer news coverage trigger state-based overload.

2.3. Hypotheses

Developed to study initial interactions, uncertainty reduction theory (URT) posits that uncertainty is an anxiety inducing feature of a situation, and that humans actively seek to reduce it.[18] Alternatively, uncertainty management theory (UMT) posits that uncertainty can trigger a multitude of responses – including anxiety, anger, comfort, pleasure – and that humans actively and passively seek to manage it.[2] Though URT was not intended to describe situations beyond initial interaction, it has been applied to a wide variety of situations and – fairly or not – serves as a foil for UMT.[51] In a sense, UMT reframes the situation to (a) do humans ever embrace uncertainty, (b) what are the features of those situations, and (c) what is the purpose and effect of doing so? Identifying communication situations where uncertainty is embraced not only supports the core postulate of UMT, but is also serves to further explicate the theoretical framework.[51] In the case of news coverage of cancer research, past work has found support for key postulate of UMT in the inclusion of scientific uncertainty triggered less negative affect in the form of cancer fatalism and (marginally) nutritional backlash.[7] The authors argued, though did not examine, that the inclusion of scientific uncertainty would also reduce state-based cancer information overload.

H1: Higher scientific uncertainty in news coverage of research will trigger less prevention fatalism (H1a), treatment fatalism (H1b), nutritional backlash (H1c), and state-based cancer information overload (H1d).

Past work has focused on the both the amount and source of scientific uncertainty. In terms of source attribution, researchers have compared the relative impact of disclosure and dueling models of communication. UMT posits that disclosure of uncertainty can be viewed as a form of information seeking, and that it could trigger positive reciprocation and affect from others.[(2)] Burrell and Koper[(52)] argued that self-disclosure of uncertainty is a type of powerless language that may hinder or enhance communication depending on the context. Jensen[(6)] found that self-disclosure of uncertainty seemed to enhance communicator credibility relative to a conflict driven, dueling modeling of communication, however a follow-up study failed to find a positive impact on other outcomes, including cancer fatalism and nutritional backlash. Relatedly, risk communication has typically endorsed the disclosure of uncertainty,[(53)]though some studies have found that such practices can trigger negative responses from the public.[(54)] Taken as a whole, it still seems logical to hypothesize that disclosure of scientific uncertainty will trigger less negative response than dueling models of communication.

H2: Compared to dueling models of communication, disclosure of scientific uncertainty will trigger less prevention fatalism (H2a), treatment fatalism (H2b), nutritional backlash (H2c), and state-based cancer information overload (H2d).

In addition to the two hypotheses outlined above, the current study considers the moderating impact of education and article type. Other studies that are most relevant work to this study utilized college student samples which may not represent the public at large.[(6,7)] Notably, college students are atypical from an education standpoint, and this could be problematic. After all, communicators systematically reduce uncertainty in a message to increase readability and thus comprehension. The purpose of this strategy is to make the message more accessible to populations with less education and/or skill deficits. Whether it achieves that goal is still unknown, but what is clear is that college student samples cannot adequately demonstrate whether variations in the amount and source of uncertainty impact lower education populations. To that end, the current study examines whether education moderates how individuals process uncertainty.

RQ1: Does education moderate how people process the amount (RQ1a) and source of uncertainty (RQ1b) in news coverage of research?

Past research has treated news articles as a random factor[(6,7)] rather than examining specific questions about the content. However, recent research has revealed that cancer fatalism differs for prevention and treatment.[(49)] Thus, it is reasonable to examine whether news articles about prevention and treatment research trigger different responses.

RQ2: Does article type (prevention vs. treatment) moderate how people process the amount (RQ2a) and source of uncertainty (RQ2b) in news coverage of research?

3. METHODOLOGY

3.1. Procedure

All individuals in a 2 (uncertain condition: low uncertainty vs. high uncertainty) × 2 (source condition: disclosure vs. dueling) × 4 (news story condition: nanobombs, lung cancer, Mediterranean diet, and lycopene pills) between-participants experiment were randomly assigned to one of 16 conditions. Participants read a version of one of four newspaper stories and then responded to a battery of questions. The news story condition represented two prevention stories and two treatment stories, so it was recoded into a dichotomous variable. Given the role that education may play in interpreting scientific uncertainty, education was also included in the analysis as a dichotomized variable (0 = 12th grade education or less, 1 = more than 12th grade education). Thus, for analytical purposes, the final design was a 2 (uncertainty condition) × 2 (source condition) × 2 (article type condition) × 2 (education condition). Participants were paid $10 for completing the study. A University IRB approved all aspects of this study.

3.2. Participants

Adults (*N* = 880) were recruited from one of seven shopping malls located in the Midwest. At each location, managers allowed the research team to set-up a table and twelve chairs in one of the main intersections of the mall. A team of 3–5 researchers recruited mall shoppers from 9 am – 9 pm over a period of seven days. Participants were recruited verbally and using six large canvas signs (with the name of the University supporting the research). When participants approached the research team they were randomly assigned to one of six different studies (one of which was the present protocol).

More females (64.1%) participated than males (33.9%). Participants ranged from 18 – 84 years of age, with a mean age of 35.92 years (*SD* = 16.03). The participants were predominantly Caucasian: 83.2% Caucasian, 11.7% African American, 3.1% Hispanic, Latino, or Spanish Origin, 1.0% Asian or Pacific Islander, 1.8% American Indian or Native American, and 2.3% described themselves as "other" (participants could check more than one category). From an education standpoint, approximately 45.6% had a high school degree or less. The mean household income was $51,769.46 (*SD* = $42,954.35).

3.3 Stimulus Materials

Stimulus materials were taken from Jensen.[(6)] All versions of the manipulated articles are included in Appendix A. In that study, the author used a search term and a random number generator to select several cancer news articles from the Lexis Nexis database. Four of those articles were utilized in the current study, namely the articles on nanobombs, lung cancer treatment, Mediterranean diet, and lycopene pills. The first two articles (nanobombs, lung cancer treatment) address research on cancer treatments whereas the latter two (Mediterranean diet, lycopene pills) address research on cancer prevention. Accordingly, a factor was created that compared treatment and prevention articles (labeled article type).

The articles were manipulated in two ways. First, the amount of uncertainty in the article was varied to create two conditions: low uncertainty and high uncertainty. Hyland argued that uncertainty could be lexical (e.g., single words or phrases like *may, could, might*) or discourse-based (i.e., entire sentences describing limitations of a study).[15] Scientists seem to be more concerned about the latter[55], thus, the present study added or subtracted discourse-based uncertainty from the manipulations. The low uncertainty condition was constructed by adding a single sentence conveying scientific uncertainty, a stock phrase stating that "it was too early to make definitive claims and that more research needed to be done." This was thought to be an appropriate realization because researchers have noted that even news coverage of science that is certain occasionally includes single statements about the need for more research.[56] The high uncertainty condition, on the other hand, was designed to mirror the actual scientific uncertainty desired by the primary researchers (in each of the news articles). That is, high uncertainty coverage was defined as the level of scientific uncertainty the researchers wanted to convey. The level of scientific uncertainty desired by the researchers was assessed by examining the discussion section of the research report(s) on which the news articles were based. The scientific uncertainty contained in the original article was crafted into an additional paragraph and added to the high uncertainty versions of the news articles.

Second, the source of the uncertainty was manipulated. The uncertainty was either attributed to the scientist(s) responsible for the research (the disclosure condition) or to a contrived scientist unaffiliated with the project (the dueling condition).

3.4. Manipulation Check

There is debate about the utility and function of manipulation checks.[57] That said, the uncertainty manipulation is relatively subtle and some readers may wonder whether participants perceived it. Following exposure to the stimuli, participants answered three questions using 5-point scales (*strongly disagree – strongly agree*): "There are many limitations that need to be addressed before this research is done," "The researchers acknowledge the limitations of their work," and "The reporter did a good job identifying the limitations of the research." These three variables are henceforth referred to as limitations, researchers acknowledged, and reporter good job. Three ANOVAs were carried out for the three manipulation check variables with uncertainty, source, and article type as fixed factors. Consistent with the manipulation, there were significant main effects for uncertainty for limitations, $F(1, 858) = 7.35$, $p = .007$, researchers acknowledged, $F(1, 862) = 16.44$, $p < .001$, and reporter good job, $F(1, 862) = 19.39$, $p < .001$. Compared to those reading low uncertainty articles, those in the high uncertainty condition were more likely to agree that the research had many limitations ($M = 3.25$, $SD = 1.07$ vs $M = 3.45$, $SD = 1.07$), that the researchers acknowledged those limitations ($M = 3.21$, $SD = 1.04$ vs $M = 3.49$, $SD = .98$), and that the reporter did a good job identifying the limitations ($M = 3.14$, $SD = 1.09$ vs $M = 3.45$, $SD = 1.01$).

3.5. Measures

3.5.1. Cancer fatalism—The Powe fatalism inventory (henceforth, "PFI") is a 15-item questionnaire used to assess cancer fatalism.[43] Five response options (*strongly disagree, disagree, neutral, agree, strongly agree*) were provided for each item, scored 1–5 respectively (i.e., higher scores equate to greater fatalism). Sample items include, "I believe that if someone is meant to have cancer it doesn't matter what they eat, they will get cancer anyway," "I believe if someone gets cancer it was meant to be," and "I believe cancer kills most people who get it." Cancer fatalism was originally explicated as "the belief that death is inevitable when cancer is present,"[43] however, an examination of the PFI suggests that several of the items target cancer prevention rather than cancer treatment. Consistent with this idea, a factor analysis of the inventory found two underlying dimensions: prevention-focused and treatment-focused cancer fatalism.[49] Cancer fatalism about prevention consisted of 7 items that all conveyed the idea that there was nothing that could be done to stop cancer from occurring (Cronbach's $\alpha = .91$; $M = 2.45$, $SD = .90$). Cancer fatalism about treatment consisted of 6 items that conveyed the idea that there death from cancer was inevitable (Cronbach's $\alpha = .80$; $M = 2.05$, $SD = .71$). Two items did not load on either factor above .40 and were omitted.

3.5.2. Nutritional backlash—The nutritional backlash scale is an 11-item scale that measures negative feelings (e.g., skepticism, worry, guilt, fear, anger, and helplessness) about dietary recommendations.[50] Four response options (*1=strongly disagree* to *4=strongly agree*) were provided for each item (i.e., higher scores equate to greater backlash). Sample items include, "I am annoyed when there are no healthful food choices at a restaurant," and "Scientists really don't know whether a low-fat diet is good for you." In the present study, the nutritional backlash scale had acceptable reliability (Cronbach's $\alpha = .77$; $M = 2.20$, $SD = .50$).

3.5.3. State-based cancer information overload—Researchers have yet to develop a validated measure of state-based cancer information overload. To that end, half of the participants ($n = 477$) responded to 6 newly created items designed to capture state-based overload, including, "The cancer news article left me feeling overloaded," "I feel overwhelmed by the cancer information in the news article," "I don't know what I am supposed to do with cancer information like this," "It sounded like all the other cancer news articles I have read," "I thought it was the cancer news recommendation of the day and that it would probably change tomorrow," and "It was interesting, but I will probably forget it soon" measured on a 4-pt scale (*strongly disagree – strongly agree*). The 6 items loaded on a single factor and formed a reliable scale (Cronbach's $\alpha = .80$; $M = 2.21$, $SD = .51$).

3.6. Power Analysis

G*Power was utilized to identify the ideal sample size.[58] An achieved power analysis for (numerator = 1, number of groups = 16, $N = 880$) revealed strong power for detecting large ($f = .40$, power = 1.00), medium effects ($f = .25$, power = .99), and small effects ($f = .10$, power = .84).

4. RESULTS

As a preliminary analysis, bivariate relationships were examined among all the variables (see Table 1). Among the independent variables, source was positively related to prevention fatalism and backlash whereas higher uncertainty and news articles about treatment generated greater state-based cancer information overload. Males exhibited higher treatment fatalism and backlash scores, but they also had lower education in this sample. Partial correlations, controlling for education, revealed that males still had lower treatment fatalism ($r = -.11$, $p = .001$) and backlash scores ($r = -.17$, $p < .001$). Older individuals had lower treatment fatalism.

H1a –H2d posited that the amount and source of scientific uncertainty would be related to prevention fatalism, treatment fatalism, backlash, and overload. RQ1a – RQ2b queried whether education and article type would moderate the aforementioned main effects. To examine these hypotheses and research questions, four-way ANOVAs were conducted to examine how uncertainty, source, article type, and education (12^{th} grade US education or less vs. more than a 12^{th} grade US education) were related to the outcome variables.

For prevention fatalism, there was no significant main effect for uncertainty, $F(1, 835) = 1.41$, $p = .24$, article type, $F(1, 835) = 1.53$, $p = .22$, or education, $F(1, 835) = 1.59$, $p = .21$. There was, however, a significant main effect for source consistent with H2a, $F(1, 835) = 7.71$, $p = .006$, Cohen's $d = .19$. News articles that depicted disclosure generated significantly lower prevention fatalism ($M = 2.37$, $SD = .89$, $N = 431$) than those that depicted dueling scientists ($M = 2.54$, $SD = .90$, $N = 420$). None of the interactions were significant.

For treatment fatalism, there was no significant main effect for uncertainty, $F(1, 835) = .13$, $p = .72$, source, $F(1, 835) = .2.39$, $p = .12$, and article type, $F(1, 835) = .10$, $p = .75$. There was a significant main effect for education, $F(1, 835) = 6.06$, $p = .01$, Cohen's $d = .17$. Individuals with less than a 12^{th} grade education exhibited greater treatment fatalism ($M = 2.12$, $SD = .79$, $N = 398$) than those with more than a 12^{th} grade education ($M = 2.00$, $SD = .61$, $N = 453$). None of the interactions were significant.

For nutritional backlash, there was no significant main effect for uncertainty, $F(1, 838) = .27$, $p = .61$, or article type, $F(1, 838) = .24$, $p = .62$. There were significant main effects for source consistent with H2c, $F(1, 838) = 4.27$, $p = .04$, Cohen's $d = .16$, and education, $F(1, 838) = 21.80$, $p < .001$, Cohen's $d = .32$. News articles that depicted disclosure generated significantly lower backlash ($M = 2.16$, $SD = .48$, $N = 431$) than those that depicted dueling scientists ($M = 2.24$, $SD = .52$, $N = 423$). Individuals with less than a 12^{th} grade education exhibited greater backlash ($M = 2.28$, $SD = .49$, $N = 400$) than those with more than a 12^{th} grade education ($M = 2.12$, $SD = .50$, $N = 454$).

Given the exploratory nature of this analysis, and the focus on the moderating impact of participant education, it is worth noting the uncertainty × education interaction approached significance, $F(1, 838) = 2.86$, $p = .09$. The education effect was magnified by the uncertainty manipulation such that those with a 12^{th} grade education or less exhibited greater backlash in the higher uncertainty condition compared to the lower uncertainty condition (see Table 2). No other interaction was significant.

For state-based cancer information overload, there was no main effect for source, $F(1, 452) = .03$, $p = .88$, or education, $F(1, 452) = 2.06$, $p = .15$. Again, for exploratory purposes, it is worth noting that both uncertainty, $F(1, 452) = 3.47$, $p = .06$, and article type approached statistical significance, $F(1, 452) = 3.01$, $p = .08$. Articles with higher uncertainty triggered greater state-based overload ($M = 2.27$, $SD = .53$, $N = 229$) than those with lower uncertainty ($M = 2.16$, $SD = .49$, $N = 239$). Treatment articles triggered greater state-based overload ($M = 2.26$, $SD = .51$, $N = 237$) than prevention articles ($M = 2.16$, $SD = .51$, $N = 231$). None of the interactions were significant.

5. DISCUSSION

How do people respond to scientific uncertainty? The current study suggests that the answer is quite complex. From a communication standpoint, uncertainty is often varied to make the message more lucid to audiences with less education. Yet, in this study, there is very little evidence that systematic variation yields a significant benefit for individuals with a high school degree or less. And while past research has found that increased uncertainty can be perceived favorably by college student populations, that same pattern of results was not replicated here. Based on the data in hand, it seems plausible to assume that variations in scientific uncertainty may produce small, inconsistent effects on a number of potentially important cognitions such as fatalism, backlash, and overload. If true, then perhaps how we communicate uncertainty will need to be based on other criteria given limited direction from an effects standpoint. But it is also clear that more research is needed before any substantive conclusions can be drawn. There is no clear pattern to report at the moment, just a series of studies that seem to raise more questions than they answer.

In a lab experiment with college students, Jensen and colleagues found that uncertain articles invoked less cancer fatalism in general and marginally less backlash.(7) The present study did not find a significant main effect for uncertainty. Instead, the source of the uncertainty proved to be meaningful in that participants in the disclosure condition reported significantly less prevention fatalism and backlash. It is useful to consider how the two studies differed as this may identify an explanation for the results.

Compared to Jensen and colleagues,(7) the current study had more diversity in terms of education. For nutritional backlash, there is evidence that individuals with less education responded negatively to increased uncertainty. Yet, aside from backlash, education was not a significant moderator of any relationship. Thus, the evidence in hand is not consistent with the notion that the difference between the two studies is largely a byproduct of education. An alternative explanation focuses on the data collection environments. Jensen and colleagues(7) conducted their study online so participants could read the article on their computer, laptop, or phone, and complete the survey at a time and place of their choosing. The current study recruited in malls. The participants completed paper surveys while sitting at a table placed at a busy intersection. Both data collection approaches mirror certain realities of the news consumption process, and both have artificial elements that could be problematic. For example, the noise inherent to mall data collection could distract participants while reading the news article, or participants may attend differently to news article presented in digital versus paper formats. Perhaps one data collection environment led participants to focus on the amount of uncertainty whereas the other amplified the heuristic impact of source. Investigating how different data collection methods influence participant response could elucidate this situation.

UMT posits that uncertainty can trigger both positive and negative response[2] and other research has suggested that it will trigger less state-based cancer information overload in news coverage of cancer research.[7] However, the current study did not support this idea. If anything, there is evidence in this study that greater uncertainty triggered more state-based cancer information overload. Thus, it is possible that the basic supposition of the information overload model is incorrect.[7] It is also possible that the relationship is a byproduct of how the uncertainty is framed. Brashers[2] argued that “positive emotional responses result when uncertainty is framed as beneficial”. How to frame scientific uncertainty as beneficial is unclear, but future research should examine if different presentation formats moderate public perception of uncertainty.

Jensen[6] found that the disclosure condition enhanced participant perception of scientists and journalists, but only in the high uncertainty condition. The current study found a main effect for disclosure for prevention fatalism and backlash. UMT posits that self-disclosure could generate positive affect, and enhanced credibility.[2] It is interesting that disclosure positively impacted the two outcomes connected to cancer prevention. This indicates a connection between the two outcomes, and suggests that they may be more sensitive to source influence. Moreover, it is consistent with the idea that people have certain expectations about cancer prevention information, and that the disclosure format may represent an expectancy violation.[59] Violating an expectancy, in the positive sense, has been shown to trigger positive response.[60] Researchers should also consider the possibility that backlash is a type of reactance.[61] If true, then that might suggest other theoretical frameworks for grounding this research line, such as psychological reactance theory.[62]

There is a temptation to ascribe large influence to media, even though small or modest effects are more consistent with the research literature. Moreover, researchers should be mindful that media effects can be very small in response to a single article and perhaps only meaningful as larger effects manifest over time.[63] Longitudinal designs that examine news presentation, exposure, and effects over time may be ideal for establishing the magnitude of variations in scientific uncertainty. In fact, the inconsistency across studies so far in this research program may reflect the need to examine greater exposure over a longer period of time.

5.1. Limitations

Stimuli in this study were all about news coverage of cancer research, a limitation for researchers interested in extrapolating the results to non-cancer contexts. It is possible that news consumers respond differently to uncertainty in cancer news coverage, a situation that future research should address. For example, cancer news coverage is quite common[34] compared to news coverage of other topics. Does the frequency of cancer news coverage alter how sensitive news consumers are to uncertainty and source? Second, the stimuli utilized in this study were news articles, a limitation insofar as news information can be presented in other formats (e.g., television, radio). Future work should explore the effects of uncertainty in alternative news formats to examine whether medium differences exist. Importantly, research could examine the impact of variations of uncertainty and source in social media contexts. Understanding news consumer’s expectations about news content in social media, and how those expectations might influence processing is a pivotal question for the future. Third, the study was based on a convenience sample of adults recruited from several malls in a single state. Convenience samples may not represent the populations from which they are culled (and it is often difficult to discern which population that is) though they are useful in process-oriented research.(64) Yet, adults in the Midwestern U.S. could be more or less sensitive to variations of uncertainty, compared to adults located in other parts of the world. Finally, scientific uncertainty contained in cancer research reports represents a specific form of uncertainty. Researchers should be mindful that other forms of uncertainty (e.g., relational) may be processed in different ways. Identifying and varying these forms of uncertainty would further cultivate our understanding of uncertainty and communication.

5.2. Conclusion

The scientific enterprise has yielded significant breakthroughs in knowledge, but on a day-to-day basis it is defined by uncertainty. As others have pointed out, "the most common outcome of the scientific process is not facts, but uncertainty".(65) Consistent with this idea, the current study raises questions about which message features influence public perception of scientific research. In fact, the uncertainties of the current program mirror the scientific uncertainties at the heart of the research endeavor. Over time, patterns will emerge in this program and the relative impact of particular design choices will become clear, especially if researchers are conscious of the uncertainties in the literature. Popper(38) warned that researchers, and humans in general, are blinded by our "craving to be right". This craving leads us to ignore or subjugate uncertainties in the research process. Whether, and how, to communicate scientific uncertainty to the public remains an open question with significant uncertainties left to address.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Correlation Matrix

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Uncertainty										
2. Source	−.03									
3. Article Type	−.01	.01								
4. Education	−.04	.02	.15***							
5. Sex	.04	.02	−.04	.08*						
6. Age	.00	−.11	−.00	.05	.06†					
7. Prev. Fatalism	.02	.10**	.04	−.04	−.01†	−.02				
8. Treat. Fatalism	.00	.05	−.01	−.08*	−.12***	−.07*	.49***			
9. Nut. Backlash	.02	.08*	.02	−.16***	−.18***	−.06†	.29***	.29***		
10. Info. Overload	.11*	.01	−.11*	−.08†	.05	.02	.18***	.20***	.04	

Note. Bivariate correlations for all variables in study.

† $p < .10$

* $p < .05$

** $p < .01$

*** $p < .001$

Table 2

Means for Nutritional Backlash by Uncertainty and Education

	12^{th} grade or less	**More than 12^{th} Grade**
Lower uncertainty	2.25 (.45)[a]	2.14 (.51)[c]
Higher uncertainty	2.32 (.53)[b]	2.10 (.49)[c]

Note. Means and standard deviations (in parentheses).

Based on Bonferroni post-hoc tests, means that do not share a superscript are significantly different, $p < .05$.