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Scientific evidence and mass media: Investigating the journalistic intention to represent scientific uncertainty

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Abstract

Science journalists are responsible for the mass media's representation of life sciences (e.g. biotechnology, genetics, and nanotechnology) and for the depiction of research findings in these areas as more scientifically (un)certain. Although researchers have determined that the representational styles of scientific evidence vary among science journalists, the reasons for these differences have not yet been fully investigated. Against this background, for the first time, the present study applies a reasoned action approach and investigates the predictors of the journalistic intention to represent scientific uncertainty, using computer-assisted telephone interviews with a representative sample of German science journalists ($n = 202$). The results indicate that beliefs about the coverage of other media, perceptions regarding scientific uncertainty of the main field of coverage, perceived expectations of the audience, past behavior, and gender were the predictors that most strongly affected the journalists' intention to represent life sciences as more scientifically uncertain.

Keywords

perceptions of life science's representation, reasoned action approach, representative survey with science journalists, scientific evidence, scientific uncertainty

Science journalists report on a broad variety of different scientific issues, but they predominantly report on the latest, most topical scientific research results. One of the basic characteristics of scientific results is *scientific evidence*, which falls somewhere on a continuum from scientific uncertainty to scientific certainty (Stocking and Holstein, 1993, 2009). Automatically, this implies

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that some results are more certain than others. *Scientific certainty* is enhanced when hypotheses are confirmed, when findings are successfully replicated, or when researchers provide reliable and valid data; *scientific uncertainty* is caused by an absence of knowledge, stemming from scientific results that are tentative, not yet validated, contradictory, inconsistent, or not reproducible (Grade Working Group, 2004; Popper, 1960; Ruhrmann et al., 2013; Schwandt, 2015; Zehr, 2000). Scientific uncertainty can have many reasons and affects applied scientific research questions, such as risk assessments (Heidmann and Milde, 2013; Wiedemann et al., 2008), or evidence-based decision-making in the field of medicine (Grade Working Group, 2004).

Scientific uncertainty is a central feature of scientific research, with scientists trained to fill research gaps, develop new research questions, and discuss the limitations of their own work (Schneider, 2010; Stocking and Holstein, 2009). Although uncertainty is an integral part of science and the scientific community, there are some concerns as to whether journalists also recognize and emphasize this issue in their media reports. In a historical perspective and with respect to Fleck ([1935] 1979) and his sociology of knowledge, in a thought collective (*Denkkollektiv*), uncertainty is part of small esoteric circles of experts, but not of larger exoteric circles of lay individuals who are interested in popular science and who constitute the public opinion. Fleck defines popular science as science for non-experts, in which knowledge, as it moves from esoteric to exoteric circles, becomes simplified, lucid, apodictic, and absolutely certain (Fleck, [1935] 1979). Mass media coverage of science is part of popular science production. Hence, applying Fleck's theory could explain why science in the mass media is often perceived as simplified, concrete, certain (e.g. Dudo et al., 2011), and sometimes even mystified. And this view has for a long time influenced the debates on the sociological, public, and journalistic communication of science (Weingart and Schulz, 2014). However, contrary to this theoretical approach, content analyses have also found that in some cases, aspects of scientific uncertainty are a strong characteristic of the media's reporting on science (e.g. Heidmann and Milde, 2013; Ruhrmann et al., 2013). As journalists do not exclusively downplay scientific uncertainty, the present article is interested in investigating the predictors of the journalistic intention to represent this uncertainty in their media reports. This has to be differentiated from approaches investigating the active construction of uncertainty claims in the process of writing about science and scientific results. In some cases, journalists have been found to include aspects of scientific (un)certainty in their reports to better reach their target audience (Stocking and Holstein, 1993, 2009). For instance, some journalists may actively hype uncertainty to give their stories a higher news value (Ashe, 2013; Corbett and Durfee, 2004), or, alternatively, and in line with Fleck ([1935] 1979), may skip uncertainty-related information and create coverage in a certainty-producing process (Ebeling, 2008; Schneider, 2010).

Investigating journalistic understanding and reporting on scientific evidence is important since the mass media are the main—and often, the only—source of scientific information for laypeople, influencing their understanding and opinions of scientific research, scientific uncertainty, and science-related behaviors (e.g. Cacciatore et al., 2012). In addition, according to the concept of *public engagement with science* (e.g. Kurath and Gisler, 2009), modern media reporting should include more openness about scientific uncertainty (Rogers-Hayden and Pidgeon, 2007), as the trust stemming from transparency would also promote more acceptance of science among laypeople (Ebeling, 2008).

In particular, the present article will use empirical findings on how the representations of scientific evidence vary in media reports (e.g. Heidmann and Milde, 2013; Ruhrmann et al., 2013) to explore the reasons why only some science journalists emphasize aspects of uncertainty in their coverage, while others do not. The article argues that this difference might be explained when analyzing the *intention* to perform this specific behavior. This article will, first, discuss early

findings on scientific (un)certainty and the media and introduce different representational styles. A model investigating the journalistic intention to represent uncertainty (Guenther et al., 2015), based on the reasoned action approach (RAA; Fishbein and Ajzen, 2010), will then be presented and tested in a representative sample of German science journalists.

1. Scientific (un)certainty and the media

In their professional context, journalists are influenced by a number of factors, including the characteristics of the topics of interest, the responses of their interviewees, and the materials provided by key stakeholders, such as scientists, universities, and public relations (PR) professionals. "Some of the materials that land on journalists' desks downplay the uncertainties of knowledge claims […]; others do not" (Stocking, 1999: 23). Journalists are also influenced by organizational characteristics and their own perceptions, which they use to formulate interpretations and personal communication goals: When reporting on current research findings, journalists can represent scientific evidence of research results with statements indicating scientific certainty and/or uncertainty (Corbett and Durfee, 2004).

Most content analyses report an underrepresentation of scientific uncertainty in the media: Cacciatore et al. (2012), studying emerging technologies; Olausson (2009), studying reporting on climate change; and Dudo et al. (2011), studying reporting on nanotechnology, all found an absence of scientific uncertainty in the coverage of the issues under investigation. However, other researchers have reported over-representations (e.g. Zehr, 2000, for climate change) or at least frequent mentioning of scientific uncertainty (Anderson et al., 2005; Friedman and Egolf, 2011, both for nanotechnology; Ruhrmann et al., 2013, for medical reporting). In light of these conflicting findings, researchers agree that journalists more or less actively choose between different representational styles to cope with different levels and types of (un)certainty (Guenther et al., 2015; Guenther and Ruhrmann, 2013).

Journalists' first option is to *downplay uncertainty*, presenting scientific findings as unambiguous and uncontested, that is, certain. This can be accomplished by reducing complexity or by leaving out caveats, the specific context, and references to tentativeness, or methodological limitations that could be too complex for the audience (Ebeling, 2008; Stocking and Holstein, 1993, 2009). When journalists avoid uncertainty, their work is referred to as a certainty-producing process (Ebeling, 2008) in which stories promote a clear and confident point of view (Friedman et al., 1999, similar to theoretical assumptions made by Fleck ([1935] 1979). This certainty-producing process is perceived as especially likely when journalists assume that their readers lack the intellectual abilities or background knowledge to understand scientific language or concepts (Schneider, 2010).

Conversely, journalists can attract public attention by *hyping uncertainty* and playing up knowledge gaps or caveats. When highlighting scientific uncertainty, journalists seem to choose tentative and contradictory findings to selectively construct narratives that engage the public (Stocking and Holstein, 1993). Ashe (2013), along with Friedman et al. (1999), suggests that uncertainty is a key way to increase the newsworthiness of scientific events. Furthermore, the traditional news factor of controversy (Ashe, 2013), as well as single-source stories or a lack of context, can all produce scientific uncertainty (Corbett and Durfee, 2004; Jensen, 2008). Journalists are especially attracted to contradictory and conflicting evidence stemming from scientific controversies (e.g. disagreements among scientists; see Stocking and Holstein, 2009; Zehr, 2000). Controversy is especially influential when journalists perceive the construction of controversy as making their coverage more dramatic, objective, or balanced (compare to *false balance*;[1] Dixon and Clarke, 2012; Dunwoody, 1999).

Journalists' final option is to present scientific information in a way that their informants perceive as *accurately*. As informants are often scientists, such a representation depicts issues without highlighting or downplaying specific points of scientific certainty or uncertainty (Schneider, 2010). Such a representation pays attention to certain aspects of the specific research results along with statements indicating what aspects of scientific uncertainty still exist. However, the perception of what is accurate and what is not highly depends on the informant.

While initial research on scientific (un)certainty and the media has been beneficial, the reasons why the representational styles of scientific evidence differ among science journalists have rarely been investigated. The next section will address this gap in more detail and—based on the fact that the mass media do not exclusively downplay uncertainty statements—present a model designed to measure the predictors of a journalist's intention to represent scientific uncertainty.

2. Predictors of a journalist's intention to represent uncertainty

There have been some initial suggestions as to how to explain differences in journalistic reporting styles. Dunwoody (1997) and Stocking (1997) identified three factors that, theoretically, might influence how journalists deal with scientific evidence: individual characteristics of the journalist (e.g. personal training, opinions, and perceptions the journalist has of the audience), occupational characteristics (e.g. norms, organizational constraints, and media routines), and cultural factors (e.g. national differences). Stocking and Holstein (2009) found that personal interests, perceptions of the audience, individual understanding of science, and journalistic roles were important factors in how journalists allowed uncertainty claims to enter into their media reports. In addition, some research has focused on news selection, suggesting that newsworthiness is a relevant factor in determining if uncertainty information is selected by science journalists and receives news coverage (Ashe, 2013; Friedman et al., 1999). However, despite these findings, this area still lacks a model to explain why only some journalists emphasize scientific uncertainty in their reports, while others do not.

Guenther et al. (2015) developed a model trying to explain the journalistic representation of scientific (un)certainty, incorporating the findings of other researchers (e.g. Dunwoody, 1997; Stocking, 1997; Stocking and Holstein, 2009). This model is an adaption of the RAA (Fishbein and Ajzen, 2010) that has been translated into the field of science communication. The RAA's central assumptions have been confirmed in multiple meta-analyses (e.g. Albarracín et al., 2001; Armitage and Connor, 2001) and one of the RAA's main advantages is that it is unifying and encourages the incorporation of unique constructs from divergent disciplinary perspectives to explain behaviors (see Fishbein and Ajzen, 2010). Applying the RAA does not mean that only this model explains journalistic behavior in a wider cultural and organizational context, but as a conceptual framework, the RAA is suitable to analyze an intention to perform a certain behavior. The idea that people develop intentions to perform a certain behavior is the central assumption of the RAA (Ajzen, 2005), making intentions the most important determinants of whether or not someone will perform an action. *Intentions* are defined as a person's estimate of the likelihood of performing a given behavior. Intentions have three determinants: attitude toward the behavior, subjective norms, and perceived behavioral control (Fishbein and Ajzen, 2010), with behavioral, normative, and control beliefs, respectively, being the bases of these three constructs (see also Ajzen, 2006). *Behavioral beliefs* are beliefs about the likely consequences of a behavior, *normative beliefs* are beliefs about the normative expectations of others, and *control beliefs* are beliefs about the presence of factors that may facilitate or impede the performance of the behavior.

Applying the RAA as a theoretical umbrella in the present investigation means that a journalist's representation of scientific uncertainty is understood as an intentional action, that is, as a decision

made among alternative coverage styles.[2] Using this approach has some advantages, as the RAA-related constructs of attitudes, subjective norms, and perceived behavioral control (see also Ajzen, 2006) seem suitable to describe journalistic behavior, as these three constructs combine both individual and organizational or institutional characteristics. Journalists are guided by personal attitudes and are embedded in social and institutional environments—like their editorial offices—which espouse specific social norms. In line with the definition of control beliefs, journalists also perceive different degrees of capability and autonomy in performing their work.

The model proposed by Guenther et al. (2015) posits that a journalist's behavioral intention to represent scientific uncertainty of research findings is the best predictor of this specific behavior. A strong intention to represent uncertainty can be understood as the journalist's professional perception that aspects of scientific uncertainty should be included in journalistic reports. This intention is influenced by several predictors. According to the RAA, such predictors are attitudes toward representing uncertainty, subjective norms, and perceived behavioral control—and their beliefs, respectively (compare to Ajzen, 2006). Beliefs are measured via different expectancy-value models (Fishbein and Ajzen, 2010). Using data from preliminary and carefully prepared qualitative interviews with German science journalists and focusing on nanotechnology-related coverage of scientific (un)certainty, Guenther et al. (2015) listed items pertaining to behavioral beliefs, normative beliefs, and control beliefs. The relevant literature also discusses potential influencing factors that can be understood as such beliefs (e.g. Stocking and Holstein, 2009).

Behavioral beliefs are defined as attitudes resulting from the expected positive or negative outcomes of a behavior (Fishbein and Ajzen, 2010). Such outcomes regarding the representation of uncertainty, for instance, could be based on journalistic perceptions of their audience, professional roles, or personal interests (Dunwoody, 1997; Stocking, 1997; Stocking and Holstein, 2009). Potential outcomes German science journalists stated when asked about the consequences of the representation of scientific uncertainty of research in the preliminary study were also predominantly audience related (e.g. to lead the audience to hold a critical point of view or to lead the audience to think about the issue) or sometimes policy related (e.g. to prompt political actions; see Guenther et al., 2015).

Normative beliefs are defined as a perceived social pressure to perform or not to perform a given behavior (Fishbein and Ajzen, 2010). For journalists, media routines and corporate norms could be especially important (Dunwoody, 1997; Stocking, 1997). Normative beliefs can be divided into *injunctive normative beliefs* and *descriptive normative beliefs*. Injunctive normative beliefs are based on the expectations regarding a specific behavior held by important referents (Ajzen, 2005, 2006). According to Guenther et al. (2015), in the preliminary study, journalists' relevant referents with expectations regarding the science journalistic representation of uncertainty were scientists, audiences, colleagues, chief editors, and PR professionals (see also Stocking, 1997). Descriptive normative beliefs are based on the behavior relevant referents are observed to perform (Fishbein and Ajzen, 2010). Relevant referents for a science journalist also representing uncertainty were—with reference to our preliminary study—scientists, colleagues, and PR professionals (Guenther et al., 2015).

Control beliefs are what people identify as environmental circumstances that may facilitate or inhibit their actions (Fishbein and Ajzen, 2010). In a scenario where the representation of scientific uncertainty is defined as the action, control beliefs could be the specific scientific results, a journalist's knowledge-based comparison to previous findings, the quality of sources, or the coverage of other media (for detailed findings of the preliminary study, see Guenther et al., 2015).

Figure 1 gives an overview of how the RAA is applied in the present investigation. The model, as introduced here, has not yet been validated in a representative survey with science journalists, prompting the research question of the present article:

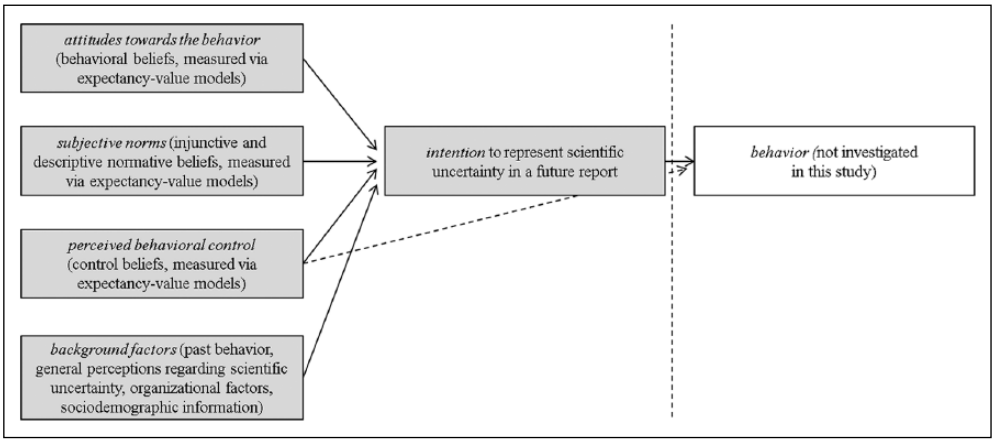

Figure 1. Model to investigate the journalistic intention to represent scientific uncertainty, based on Fishbein and Ajzen 2010 and Guenther et al. 2015.

RQ: What are the strongest predictors influencing the journalistic intention to represent scientific uncertainty?

3. Method

A database of German science journalists

In order to generate the names and contact details of a representative sample of German science journalists, a database was created. The first step in creating this database was to gather information on all German mass media (i.e., print, radio, TV, and online media) with independent editorial staff.[3] In later more detailed assessments, we ensured that the chosen media reported on science and scientific research. *Science coverage* was defined as coverage about health, medicine, natural sciences, psychology, social sciences, and the environment (Göpfert and Ruß-Mohl, 2006). The names and contact details of relevant science journalists were extracted from their news outlets or online platforms. Whenever this contact information was not available, the medium was contacted directly for the contact details of the identified journalists. All media with extreme political or highly religious points of view were excluded from the generated list.

Next, additional names and contact details of science journalists were generated with the help of databases provided by the Kroll booklets on health, nutrition, knowledge, and education (Kroll and Kroll, 2003, 2006, 2008), as well as using the Zimpel database.[4]

Finally, members of the German Federation of Journalists (*Deutscher Journalistenverband*) were added if they reported on subject areas within the defined categories. Relevant members of the German Science Journalists' Association (*Wissenschaftspressekonferenz*) were also asked for contact details and added to the sample.

Final sample and study design

These three steps yielded 1249 German science journalists, along with their names and contact details.[5] In January 2014, these journalists were e-mailed by the researchers and asked if they were interested in participating. Prospective participants were provided with information about the

research project; we also provided the contact details we had gathered and asked the journalists to confirm their correctness. The telephone numbers of those journalists who agreed to participate were submitted to Friedrich Schiller University's computer-assisted telephone interview (CATI) laboratory; the CATI method was used to reduce interview length and to minimize recording errors. Trained interviewers at the CATI laboratory called the journalists and requested interview appointments. Interviews took place from January to March 2014.

Of the initial 1249 telephone numbers generated, 857 were excluded or deemed unsuitable for study participation (this does not include journalists who declined to participate). Journalists were only considered valid for study participation if their density of current science journalistic work exceeded 33%. Journalists also had to report on issues associated with the field of life sciences (e.g. biology, molecular science, molecular medicine, biomedicine, biotechnology, nanoscale science, medicine, or technology), as the field of life sciences is characterized by high scientific uncertainty (Ruhrmann, 2012), making it a particularly suitable field in which to address the RQ.

A large number of excluded cases were due to no-answers or reaching only answering machines. Interviewers attempted up to 10 callbacks at different times of day; if these calls were all unsuccessful, then that case was excluded from the study sample. Of the 392 contacts made with journalists who fulfilled study criteria, 185 refused participation or declined to be interviewed. This yielded 207 completed interviews (53% of suitable contacts). Five interviews were used to conduct a pretest, leading to a final sample size of $n = 202$.[6]

Of these 202 interviewees, 49% worked as science journalists full-time, 22% spent between 51% and 99% of their work time on science journalism, and about 29% identified their science journalistic work as taking up 33% to 50% of their work time. With regard to the journalists' main topics of life science coverage, participants stated that they reported on a broad range of different scientific issues.[7] The journalists were mainly active in the print media (73%).[8] Others were also active in online journalism (25%), radio (15%), and TV (8%).

In terms of their working conditions, 58% of the participants were freelance journalists, 29% had permanent positions, and 12% worked as chief editors. Male (52%) and female (48%) journalists were approximately equally represented, and the average age was 52 years ($M = 51.62$; $SD = 10.89$). Regarding educational level, all participants had at least graduated from high school. In addition, 62% had graduated from university—mainly in the field of natural sciences (59%), followed by the humanities (17%), medicine (14%), and the social sciences (10%). An additional 33% of the total sample held doctoral degrees.

Measurement

This section presents the items and constructs used to measure the relevant predictors of the journalistic intention to represent uncertainty (RQ, see also Figure 1).

The variables related to the RAA were collected individually. With respect to Fishbein and Ajzen (2010), behaviors are observable events comprising the *action* that is performed, the *target* to which the action is directed, the *context* in which it is performed, and the *time* at which it is performed. Any of these aspects can be defined with any degree of specificity. The defined behavior in this investigation is the representation of scientific uncertainty of research in a future report; hence, action, context, and time were specified. As this survey does not measure actual behavior, but explores the predictors of an intention, the intention to represent scientific uncertainty in a future report was set as the dependent variable. The other relevant items and constructs—behavioral, normative, and control beliefs, as well as background factors—were all set as independent variables.

Since there is no universal understanding of scientific uncertainty, and to set a shared definition for all interviewees, a definition was given to the journalists before the interviews started. In line with the literature and the theoretical part of this article, we introduced and defined scientific uncertainty in the following way (translated into English):

> Scientific research findings are always connected to uncertainty, for instance, because findings are tentative and contradictory, because there are knowledge gaps, or because findings cannot be reproduced in follow-up studies. Although there is always uncertainty, some findings are perceived as more uncertain than others.

With this definition in mind, the interviewed journalists had to answer the survey questions.

To measure participants' intention (see also Ajzen, 2006) to represent scientific uncertainty of research, we wanted the journalists to imagine that they had to produce a report related to their main field of life science coverage within the next few days. With this goal in mind, they were asked to evaluate how "very unlikely" (1) to "very likely" (11)[9] they would be to mention scientific uncertainty of research ($M=7.24$; $SD=3.05$).

To measure behavioral beliefs using an expectancy-value model[10] (Ajzen, 2006; Fishbein and Ajzen, 2010), behavior-related positive and negative outcomes of the representation of scientific uncertainty of research were considered (see Supplementary Appendix (available at: http://pus.sagepub.com/content/by/supplemental-data) for an explanation of the questionnaire and the specific variables). In line with the RAA, the journalists first stated how "very unlikely" (1) to "very likely" (11) ($M=6.49$; $SD=2.34$) the occurrence of these outcomes would be; participants then evaluated these outcomes from "really negatively" (1) to "really positively" (11; $M=9.11$; $SD=1.87$; $\alpha=.59$).

To measure normative beliefs[11] and to be in line with the RAA (Fishbein and Ajzen, 2010), participants were first asked to what extent they "disagree" (1) to "agree" (11) that relevant referents (see Supplementary Appendix) have expectations regarding participants' representation of the uncertainty of research findings ($M=5.83$; $SD=3.06$). Participants were then asked how "less important" (1) to "very important" (11) it is for them to comply with these relevant referents' expectations ($M=6.07$; $SD=2.79$; $\alpha=.77$).

To measure control beliefs (see Supplementary Appendix), participants first stated how "very unlikely" (1) to "very likely" (11) certain beliefs were to be important for their reports ($M=9.06$; $SD=1.54$). Participants were then asked to what extent they "disagree" (1) to "agree" (11) that these beliefs can facilitate a representation of uncertainty of research findings ($M=7.26$; $SD=2.74$; $\alpha=.67$). This, again, is in line with the expectancy-value models (Fishbein and Ajzen, 2010).

In addition to assessing intention, behavioral, normative, and control beliefs, we collected information on background factors. Fishbein and Ajzen (2010) cite a large number of psychological research studies to support their theory, but identify past behavior as the only predictor that is consistently associated with increased variance explanation of their model.[12] In the present study, participants had to indicate whether they had "not at all" (1) to "totally" (11) depicted uncertainty of research findings in the past ($M=7.63$; $SD=2.54$). We were also interested in participants' general perceptions regarding scientific uncertainty of their main field of coverage. We therefore asked participants how uncertain they perceived knowledge in their area of coverage to be, from "less uncertain" (1) to "very uncertain" (11; $M=5.88$; $SD=2.02$). At the end of the interviews, participants were asked to provide information about organizational factors—the specific media organization they worked for, whether they held an executive position, and their identification as a science journalist or as a non-specific journalist. Participants were also asked to provide socio-demographic information regarding their gender, age, and educational background. Interviews took approximately 25 minutes each.

Data analysis

In order to give a detailed answer to the RQ, the focus will first be on the descriptive findings. For all of the single belief-related variables, we calculated new variables with respect to the expectancy-value models, using multiplication (see also Supplementary Appendix): For behavioral beliefs, the products of belief strengths and outcome evaluations were calculated; for injunctive normative beliefs, the products of belief strengths and the motivation to comply with different groups of relevant referents were calculated; and for control beliefs, the products of belief strengths and the power of the single control beliefs were calculated.

However, since the behavioral beliefs contained both positive and negative outcomes (i.e., consequences of representing uncertainty), the positive scale values of the single measures for both expectancy and value were recoded into scales running from negative to positive, respectively, before running the multiplications; hence, all behavioral beliefs range from −25 to 25. Conceptually, that means positive scale values of behavioral belief*s* were achieved both when the journalist believed a good outcome (see Supplementary Appendix) was likely to occur and when he or she believed a negative outcome was unlikely to occur from performing the action. On the other hand, negative scale values were achieved when the journalist believed a negative consequence was likely to occur or when he or she believed a positive outcome was unlikely to occur. As a result, higher values of this scale are expected to result in more favorable attitudes toward representing uncertainty.

For normative and control beliefs, the positive scale values of the single measures of both expectancy and value were multiplied, resulting in new variables ranging from 1 to 121. Hence, higher scale values for normative beliefs were achieved when the journalist believed that the particular referent (see Supplementary Appendix) expected him or her to represent uncertainty, as well as if he or she perceived a high motivation to comply with these expectations, with higher values of this scale expected to result in a more favorable norm toward representing uncertainty. Higher scale values for control beliefs were achieved when the journalist believed that a control belief (see Supplementary Appendix) was important for his or her professional work and if he or she also believed that this belief facilitated the representation of uncertainty, with higher values of this scale expected to result in a more favorable perceived control regarding representing uncertainty.

After presenting descriptive findings, data from Pearson's correlation tests will be examined, looking for any significant correlations between the belief-related variables, background factors, and the intention to represent uncertainty, that is, the dependent variable. Correlation testing is a fundamental step before entering variables into ordinary least squares (OLS) regression analyses. The first OLS regression model set the participants' intention to represent uncertainty in a future report as the dependent variable and the significantly correlated RAA-related beliefs[13] as the independent variables. The second model was the same as the first but included the background factors that also had significant correlations with the dependent variable.

4. Results

Content analyses in this field predominantly find that the media coverage of science lacks statements of scientific uncertainty. However, most of the journalists interviewed in the present study intended to mention the uncertainty of research findings in a future report about life sciences ($M = 7.24$; $SD = 3.04$).

With respect to the calculated behavioral beliefs, consequences that most likely led a science journalist to represent uncertainty were that the audience expected further results ($M = 9.51$; $SD = 8.71$), thought about the issue ($M = 9.24$; $SD = 10.03$), and held a more critical point of view

($M=4.57$; $SD=12.01$). Little influence was attributed to the consequences of leading the audience not to buy consumer products ($M=1.08$; $SD=8.71$) or to become more uncertain ($M=.48$; $SD=8.07$); finally, overall, the journalists believed that prompting political actions with a representation of uncertainty was rather unlikely ($M=-4.70$; $SD=11.17$).

With respect to the calculated normative beliefs, journalists reported that their audience ($M=51.79$; $SD=30.47$) and chief editors ($M=47.23$; $SD=31.88$) were the people most likely to expect them to represent uncertainty, and they wanted to comply with these expectations the most. The journalists assigned only moderate importance to the expectations of colleagues ($M=39.70$; $SD=30.24$) and scientists ($M=37.51$; $SD=31.02$), and the lowest values to the expectations of PR professionals ($M=15.60$; $SD=20.57$); the motivation to comply with these less important referents was naturally lower.

With respect to the calculated control beliefs, journalists reported assigning the highest importance to the quality of sources ($M=89.63$; $SD=29.61$), scientific results ($M=77.35$; $SD=32.64$), and their own comparisons made to previous findings ($M=67.18$; $SD=31.80$). The journalists reported assigning only moderate importance to the coverage of other media ($M=39.97$; $SD=24.63$).

There was some variance in the journalistic intention to depict scientific uncertainty: 28% said that it would be rather unlikely that they would represent scientific uncertainty of research in a future report, about 10% reported that this would neither be particularly likely or unlikely, and 62% stated that it would be rather likely that they would represent scientific uncertainty in their next report. This variance is reflected in the RQ, which concerns investigating the predictors of the journalists' intentions to represent uncertainty.

To analyze the predictors, first, correlation tests were run. As can be seen in Table 1, the variables used to measure behavioral beliefs did not correlate with the intention to represent uncertainty in a future report. In contrast to this, we achieved significant results for three of the four variables used to measure injunctive normative beliefs: audiences, colleagues, and chief editors, as well as for all the variables used to measure control beliefs: scientific results, comparisons to previous findings, quality of sources, and the coverage of other media. We also obtained significant correlations for four background factors: journalists' perceptions regarding scientific uncertainty of their main field of coverage, past behavior, age, and gender.

The results of the OLS regression analyses were able to explain 43% of variance ($F=9.325$; $df=11$; $p<.001$). As can be seen in Table 2, the coverage of other media as a control belief ($\beta=.340$; $t=4.565$; $p<.001$), individual perceptions regarding scientific uncertainty of the main field of coverage ($\beta=.305$; $t=4.249$; $p<.001$), expectations of the audience as an injunctive normative belief ($\beta=.258$; $t=2.808$; $p<.01$), past behavior ($\beta=.234$; $t=3.099$; $p<.01$), and gender ($\beta=-.222$; $t=-3.037$; $p<.01$) were all significant predictors of a journalist's intention to represent scientific uncertainty of research in a future report. Hence, if the participating science journalists identified other media as representing uncertainty, if they perceived uncertainty in their main field of coverage, if they expected their audience to favor a representation of uncertainty, or if they showed a past behavior of depicting uncertainty, they were then more likely to intend to represent uncertainty in a future report. Gender was the only predictor that had a negative influence, meaning that the intention to depict uncertainty was lower in females than in males.

5. Conclusion

Summary and discussion

The main purpose of the present article was to identify the predictors of the journalistic intention to represent uncertainty according to a model derived from the RAA (Fishbein and Ajzen, 2010;

Table 1. Correlation coefficients (Pearson's *r*) between the RAA-related belief, background factors, and the intention to represent uncertainty (the dependent variable).

Variables	Pearson's *r*
Behavioral beliefs	
Lead the audience to hold a critical point of view	.012
Lead the audience to think about the issue	.060
Lead the audience to become uncertain	.065
Lead the audience to not buy consumer products	−.048
Lead the audience to expect further results	−.024
Prompt political actions	−.007
Injunctive normative beliefs	
Scientists	.114
Audience	.374***
Colleagues	.243**
Chief editors	.377***
PR professionals	.033
Control beliefs	
Scientific results	.389***
Comparison to previous findings	.324***
Quality of sources	.260***
Coverage of other media	.279***
Background factors	
Perceptions regarding scientific uncertainty of the main field of coverage	.358***
Past behavior	.446***
Gender	−.146*
Age	−.153*

PR: public relations.
*p < .05; **p < .01; ***p < .001.

Guenther et al., 2015). The results showed that the journalistic intention to represent scientific uncertainty of research in a future report seemed to be influenced by the perception that other media also represent uncertainty, that there is scientific uncertainty in the main field of coverage, and that the audience expects uncertainty in the reporting, as well as by past behavior of representing uncertainty. Contrary to our expectations, the gender of the study participants was also a significant predictor, with male participants showing a greater likelihood to intend to represent scientific uncertainty.

The regression analyses were able to explain 43% of the variance, which is satisfactory. Apart from the effect of gender, the authors were surprised that behavioral beliefs, defined as consequences of a representation of scientific uncertainty, had no significant correlations with a participant's intention to represent uncertainty. This finding, however, does not necessarily mean that science journalists do not keep the consequences of their behavior in mind when representing scientific uncertainty of research findings. For example, one possible reason for the lack of correlation could be that the beliefs used in this article, which were adapted from preliminary qualitative interviews with science journalists covering the (un)certainty of nanotechnology (Guenther et al., 2015), might have been too subfield specific and not suited for science coverage in general. Also,

Table 2. Ordinary least squares regressions: Predictors of a journalist's intention to represent uncertainty in a future report.

Variables	Model 1		Model 2	
	β	*t*	β	*t*
Injunctive normative beliefs				
Audience	.263*	2.474	.258**	2.808
Colleagues	−.074	−0.648	−.038	−0.361
Chief editors	.139	1.191	.064	.629
Control beliefs				
Scientific results	.171	1.330	.159	1.409
Comparison to previous findings	.065	0.609	−.075	−0.778
Quality of sources	−.101	−0.935	−.091	−0.969
Coverage of other media	.239**	2.900	.340***	4.565
Background factors				
Perceptions regarding scientific uncertainty of the main field of coverage			.305***	4.249
Past behavior			.234**	3.099
Gender			−.222**	−3.037
Age			−.053	−0.662
R^2	27.4		47.8	
Adjusted R^2	23.1		42.7	

*$p < .05$; **$p < .01$; ***$p < .001$.

the weak reliability of the variables defined as behavioral beliefs may have played an important role (see Methods section). The lack of significant correlations between behavioral beliefs and intention found in the present study should encourage researchers to more broadly consider the consequences that journalists keep in mind when choosing how to represent a research finding. Additional research connecting these consequences more closely to a journalist's professional role conception and news values is needed here. In addition, researchers could expand the present study by asking participants if the stated consequences are really important and if participants consider them when performing the specific action.

The present article was able to support the assertion that reporters' beliefs about audiences' expectations of coverage are important predictors in journalistic intentions to represent uncertainty. This finding was previously supported by Dunwoody (1997) and Stocking (1997), with initial empirical evidence provided by Stocking and Holstein (2009). The reasoning as to why exactly science journalists value the perceptions they have of their audiences is that if these journalists think that their readers, viewers, or listeners cannot deal with scientifically uncertain information, they may opt for a more scientifically certain representation of research results (see also Ebeling, 2008; Friedman et al., 1999; Schneider, 2010). On the other hand, journalists who are interested in creating more upstream engagement with the public might see an inability to handle such uncertainty as an opportunity to better educate and engage the public; journalists applying this logic might therefore represent research findings as more scientifically uncertain. Furthermore, uncertainty information, as outlined in the theoretical part of this article, can be seen as a criterion for the newsworthiness of scientific events. Whether there are also cases in which scientific uncertainty is over-represented, or even hyped and dramatized, can only be answered in comparison with content analyses.

The significant findings in the present study for both individual perceptions of the main field of coverage and past behavior clearly highlight the importance of the individual in the process of explaining why science is reported the way it is. Stocking and Holstein (2009) previously stated that individual understandings of science, journalistic roles, and personal interests are important factors when it comes to the decision of whether to represent science as more or less scientifically uncertain. The findings of the present article also highlight the importance of reporters' beliefs about the coverage of other media, which seemed to guide science journalists in their representation of issues. Future research could look more closely at the different media journalists take into account when writing their own stories. Finally, the authors of the present article can offer no explanation for the gender difference indicated by their investigation, as no research to date has—to the authors' knowledge—reported on any relationship between gender and degree of (un)certainty in reporting scientific information. Questions like these remind researchers that the research in this area is still far from complete.

With respect to the fact that our model was tested for the first time in this study, we highly recommend that other researchers more broadly apply journalistic theories to improve the model and develop it further. For a deeper theoretical reflection on journalistic work, the RAA could easily be combined with the influencing levels that Shoemaker and Vos (2009) describe in their Gatekeeping Theory. For instance, news values, a journalist's professional goals, and personal interests can be combined with behavioral beliefs, while organizational influences and personal relationships with both other journalists and scientists can be combined with normative beliefs. Last but not least, constraints the journalists face and the use of sources could be combined with control beliefs. Although the degree of explained variance in the present investigation might be satisfactory, the authors of the present article believe that their model can be improved upon in future research.

Limitations

The investigation presented in this article has a number of limitations. The first group of limitations pertains to the study sample. First, the surveyed sample of science journalists may not be fully representative of German science journalists although different sampling strategies have been taken into account. Too little is known about this population. Second, since other surveys often do not claim to be representative or since their results are not always up to date, no comparisons can be made between the findings of the present study and existing research in this area. Third, our use of Kroll booklets (Kroll and Kroll, 2003, 2006, 2008) to acquire contact information was not ideal, as most of the extracted contacts ultimately could not be reached. Fourth, the surveyed science journalists had to fulfill two conditions to be included in this survey: spending at least 33% of their time as a science journalist and covering life sciences; together, meeting these two criteria greatly restricted the usable sample. Finally, since only German science journalists were surveyed and since the study was restricted to the area of life sciences, the results cannot be generalized to other national or topical contexts.

Other limitations relate to methodological aspects. First, all interviewing was done via telephone despite the fact that it might have been difficult for the journalists to evaluate their feelings and actions on an 11-point scale over the telephone. In addition, we only measured journalistic self-perceptions, and no data are available that can confirm how much the real representation of scientific uncertainty of research findings is influenced by an intention to perform this behavior—there could be cases of unintentional behaviors in which journalists do not make this choice. Within the thematic frame of the present article, journalistic work is understood as an intentional and active process of representation; however, journalists are also strongly influenced by other factors, such as the PR materials they receive, the content their scientific interviewees share with them, and

the time they can spend on a given story. We would strongly recommend that future research in this area conduct a systematic input–output analysis or conduct an observation of science journalists. Such an investigation would allow concrete statements to be made about how much journalistic reporting reflects personal perceptions and beliefs, as opposed to other factors, such as general norms and values, PR materials, or other as-yet unconsidered factors.

And in light of these limitations, this article, as well, leaves readers with some degree of scientific uncertainty.

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Notes

1. The journalistic balance norm expects journalists to give equal weight to competing points of view, qualitatively and quantitatively. "Although the journalist's take-home message […] is that truth resides somewhere in the story, the reader may get a very different message: All points of view in the story are legitimate—sometimes equally legitimate—ones" (Dunwoody, 1999: 72). In science journalism, when reporters equally cover different perspectives in cases where most scientists agree and gained evidence opposed to a minor group of people that is not agreeing, and if these journalists fail to include context about the strength of evidence, then this coverage is perceived as falsely balanced (see also Dixon and Clarke, 2012).
2. An additional coverage style would be to downplay uncertainty. This approach, as presented here, does not imply that journalists necessarily need to know about all their alternatives or that they see their behavior as rational. In fact, their behavior can even be irrational or wrong (Fishbein and Ajzen, 2010). However, journalists have at least two options: to represent aspects of scientific uncertainty of research findings or not to (Guenther et al., 2015). There is, of course, flexibility in interpretations, and when representing uncertainty, journalists can portray this in a nuanced fashion, such as by more or less extensively highlighting tentativeness or knowledge gaps. However, since this article is interested in an *intentional* action, it is not able to explain unintentional behaviors of the journalists (e.g. cases in which journalists are not actively making this choice).
3. When gathering information on print media, we noted whether the newspaper belonged to a newspaper group or produced articles on its own. Online media that belonged to a newspaper were selected only when they provided content that differed significantly from the content of the original medium. Blogs and scientific online platforms were selected only when they were created by journalists.
4. The Kroll booklets are published once a year, each time with a different thematic scope. They can best be described as databases of German journalistic and public relations (PR) professionals on specific issues. These books also list all relevant online and offline mass media, organized by scope. Zimpel is a database of German journalists and PR professionals and is predominantly used by journalists.
5. Keeping in mind that our definition of science journalists was somewhat restrictive, this number is comparable with other representative investigations conducted in Germany (e.g. Göpfert and Stamm, 2010).
6. During pretesting, interviewees identified two RAA-related questions pertaining to control beliefs as difficult to answer; we therefore changed these two questions' wording.
7. While journalists were asked open-ended questions, their answers were grouped according to a preexisting categorization system. Most of the interviewees reported on biology (19%) or basic research

(19%), followed by biotechnology (18%), therapeutic treatments (11%), biomedical topics (9%), medicine (7%), environmental sciences (6%), nanoscale science and technology (5%), and nutrition (5%).

8. Those journalists who worked in print media mostly wrote for professional journals (49%), followed by science magazines (40%), newspapers (35%), weekly and Sunday newspapers (21%), and news magazines (11%). Since journalists were asked to provide information regarding all the different media they worked for, this sums to over 100%.
9. Throughout this survey, we used 11-point Likert-type scales to measure our variables. We made this choice because we thought that it would be easier for telephone interviewees to conceptualize their levels of agreement in terms of percent. Interviewees were therefore asked to rate their agreement between 0 and 10.
10. Expectancy-value models are based on the general belief that there are expectations as well as values that affect a behavior. Compared to other measures such as semantic differentials, expectancy-value measures have the advantage of being belief-based, that is, they can provide information about causal determinants (see Fishbein and Ajzen, 2010); this makes them especially suitable for the present investigation. The applicability of expectancy-value models has also been supported by several meta-analyses (e.g. Armitage and Connor, 2001).
11. Due to time limitations, we were only able to use the expectancy-value model to measure injunctive normative beliefs but not descriptive normative beliefs (see Fishbein and Ajzen, 2010 for more information about descriptive normative beliefs).
12. Past behavior has been found to be a very good predictor of both future behavior and intentions (Fishbein and Ajzen, 2010). However, despite the fact that in some studies measurements of past behavior were able to contribute unique variance to the prediction of future behavior, past behavior is not fully mediated by attitudes, subjective norms, or perceived behavioral control (e.g. Albarracín et al., 2001; Armitage and Connor, 2001); past behavior could therefore be an extension of the RAA's sufficiency assumption (see Fishbein and Ajzen, 2010). Although past behavior may not be a factor in explaining the reasons for a specific behavior, past behavior can be a useful predictor in explaining an intention to perform a specific behavior and was therefore included it in the present investigation.
13. Different statistical approaches could be used to answer the RQ. One alternative would be to use the additive index of all six behavioral beliefs (as an indirect measure of attitudes), the additive index of all five injunctive normative beliefs (as an indirect measure of the subjective norm), and the additive index of all four control beliefs (as an indirect measure of perceived behavioral control). In our survey, we also collected direct measures of attitudes, subjective norms, and perceived behavioral control (as suggested by Ajzen, 2006 and by Fishbein and Ajzen, 2010). Using a statistical model to test these independent variables may yield significant results (e.g. "A positive attitude toward representing uncertainty is a significant predictor of the intention to represent uncertainty in the future"); however, the authors of this study believe that testing at the level of individual beliefs allows for a better description of the predictors of a journalist's intention.

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