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RESEARCH ARTICLE

Expert interviews with science communicators: How perceptions of audience values influence science communication values and practices [version 1; peer review: 2 approved with reservations]

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Abstract

Popular science communicators are a key link between scientists and publics, navigating the values of the scientific community and the perceived interests and values of readers. To do so, these professionals apply shared ideas about the role of science communication in society and about the factors that determine meaningful and newsworthy science stories. And yet we know little about the motivations and assumptions of audience values that underlie shared science communication values and criteria of story selection. Interviews with 14 popular science communicators writing in a variety of formats reveal that both their personal motivations and their perceptions of audience interests and values influence whether and how scientific research is translated into story.

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Any reports and responses or comments on the article can be found at the end of the article.

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“Science values detail, precision, the impersonal, the technical, the lasting, facts, numbers and being right. Journalism values brevity, approximation, the personal, the colloquial, the immediate, stories, words and being right now.” – Quentin Cooper of BBC Radio 4’s Material World¹.

While social science research has investigated the values of scientists in “hard” science fields toward production and communication of science, the values of journalists toward selection and production of news stories² and human values on a fundamental level^{3,4}, what appears to be lacking is a study of the interconnectedness of these value systems. Popular science communicators, or those including science journalists who translate scientific research into story for lay audiences, provide a case study in the intersection of these value systems. This is a professional group that balances adherence to the values of scientists, such as replication and hedging of scientific findings, while catering to the interests and values of lay audiences. Popular science communicators apply various norms and routines, especially those of science journalism, to science for the benefit of their readers. However, we know little about how popular science communicators perceive the interests and values of their audiences or how these perceptions affect how they cover science. How do they integrate what they perceive as audience interests and values with their own norms, routines and values as producers of popular science content? By answering these questions, we can develop a better understanding of what types and narratives of scientific research reach lay audiences through intermediary news stories, books, online science features, blog posts and other popular media formats. This is an investigation of what determines whether and how scientific research is translated into story. Specifically, we examine story selection and storytelling decisions of science communicators in the context of their subjective beliefs about readers.

Relevance to readers is one news value that appears to be important in science communication. In a study of British journalists specializing in science, Anders Hansen found that this cohort “deploy conventional news-value criteria, but emphasize in particular the importance of a ‘relevance to the reader’ criterion in the selection of science news”⁵. A study of American science journalists published in 1979 revealed a trend in science journalism toward consumer-oriented coverage of science “...so that readers can answer the question ‘what does it mean to me?’”⁶. A focus on communicators’ values as well as audience interests in the production of news has received particular emphasis in science communication research⁵. However, this research has tended to ignore the influence of culture and “how specific aspects of science become newsworthy primarily because they relate to, or ‘resonate’ with, widely held cultural beliefs”⁵.

The main purpose of this study was to understand the experiences and perspectives of science communicators, both those in the field of journalism and those in complementary fields of science communication. When science communicators engage with their non-specialist audiences, they bring these perspectives to the interchange. We collected their personal accounts and explanations of practices, norms, routines and attributes of science storytelling during qualitative interviews. This study investigates specifically whether popular science communicators reflect fundamental and universal human values defined according to Schwartz’s^{3,4} value paradigm when

selecting and telling stories about science. Additionally, this study investigates how perceptions of these values impact the narratives in which science communicators’ embed the science they cover.

Science communicators’ use of traditional journalistic and storytelling norms and values in their construction of stories about science might be shaped by their perceptions of audience value orientations. News values, or the importance journalists attribute to various news factors which describe “why a topic is newsworthy and therefore published by the media”⁷, are already known to influence story selection⁸ and drive news coverage⁹. But we investigate the potential basis of these news values in perceptions of audience interests and values. For example, news values of unexpectedness, controversy and novelty might be associated with communicators’ subjective belief that their readers endorse motivational value types related to *openness to change*⁴ including hedonism, stimulation and self-direction. And story selection is not the only area of influence for science communicators’ perceptions of audience values. Perceptions of readers’ interests and fundamental value orientations may also color how communicators tell stories about science, which narratives they build around science and how they present scientific findings. The goals of this study were to identify the basic interests and value orientations attributed to lay audiences by science communicators, and to investigate how these perceptions might guide selection, production and content of science stories in a variety of media formats.

Literature review

Definition of a science communicator

The term “science communicator” as defined in this study includes non-fiction authors, news and magazine editors, journalists, university public relations (PR) writers and bloggers communicating primarily in areas of science including but not limited to basic physical sciences, biology, engineering, medicine and environmental science. Science communicators could be professional and/or freelance journalists writing about science full-time, editors of science magazines, university writers covering broad science research topics for lay audiences as well as news writers, non-fiction science authors and science bloggers in paid or non-paid positions. In some form or fashion, the science communicator translates science directly to lay audiences. It is important to note that in today’s media landscape, especially for science, storytellers often occupy diverse roles. For example, science PR practitioners may maintain science blogs that cater directly to lay readers, science bloggers often freelance for traditional news outlets, and science journalists often transition into roles as university science writers, bloggers, editors and book authors. In this landscape, science PR practitioners, bloggers and journalists all play roles in communicating scientific research, issues and events directly to readers online and offline as the traditional science journalism industry declines¹⁰. In fact, it is becoming increasingly difficult to differentiate the roles and work of science PR writers, science bloggers and science journalists^{10,11}. It is for these reasons that we maintain that these communicators, although they occupy different spaces in the science news ecosystem and come from diverse backgrounds in science, journalism and mass communication training, all more or less actively consider the interests and values of lay audiences. These communicators also often share similar criteria of newsworthiness, despite their different backgrounds. For example, PR writers increasingly work

closely with journalists and are often former reporters themselves. Science writers often float freely between the blogosphere and the worlds of online and traditional science journalism. For this study, interviewees were recruited broadly based on active practice in the communication of science to primarily lay audiences, through blogs, newspapers, books and other digital science news sites.

News values

Wolfgang Donsbach describes¹² four main factors that influence journalistic news decisions, or the decisions on what becomes story and how: (1) news values and specific news factors, (2) institutional objectives, (3) the influence of news sources including press releases and (4) the subjective beliefs of journalists. The two that are particularly relevant in this study include news values – or the importance attributed to various news factors – and the subjective beliefs of journalists about the values of their audiences. Although institutional objectives may help determine whether and how science communicators *act* upon their subjective beliefs and perceptions of audience interests and values, these beliefs and perceptions likely heavily influence the communication values and news factors that determine selection and production of stories about science.

Fundamental human values

In a 2013 issue of PNAS dedicated to the science of science communication, Thomas Dietz advocated bringing value research to the field: “Decisions always involve both facts and values, whereas most science communication focuses only on facts”¹³. Value theory research is based upon the idea that individuals orient their lives in society according to “a hierarchical arrangement of values, a rank-ordering of values along a continuum of importance”¹⁴. Building on Rokeach’s work on value typologies, Schwartz defined values as “the criteria people use to select and justify actions and to evaluate people (including the self) and events”³. According to Schwartz’s definition of universal human values adopted herein, a value is a “(1) belief (2) pertaining to desirable end states or modes of conduct that (3) transcends specific situations, (4) guides selection or evaluation of behavior, people, and events, and (5) is ordered by importance relative to other values to form a system of value priorities”⁴. Values are “desirable transsituational goals, varying in importance, that serve as guiding principles in the life of a person or other social entity”⁴. These goals have their basis in the biological needs of individuals, social interaction motives and requirements for group survival and function^{4,15}. Schwartz developed a widely-used typology for the motivations behind values, which we will apply for the first time to science communicators.

Schwartz found that universal human values fall into ten distinct motivational types. On a higher level, these motivational types nearly universally fall into two value orientation dimensions: self-interest (power, achievement and hedonism) versus altruism (universalism and benevolence), and openness to change (stimulation and self-direction) versus conservation/traditionalism (security, conformity and tradition)¹³. Starting with self-interest types, power values are derived from social interaction motives for recognition and dominance, include social power, authority and wealth. Closely related to power values, achievement values relate to personal success according to social standards, including intelligence, capability, ambition and influence over one’s peers or society in general.

Hedonism and stimulation values relate to physical needs and the desire for enjoyment in life, including happiness, comfort and pleasure (hedonism) and excitement, novelty, variation and challenge in life (stimulation). Also related to basic needs of the individual and social interaction and survival motives are security values, including diverse values such as health, social order, national and family security. These values refer to “safety, harmony, and stability of society, of relationships, and of self”⁴. In the openness to change category, self-direction values “refer to reliance on and gratification from one’s independent capacities for decision-making, creativity, and action,”¹⁵ and include curiosity, freedom, independence and the freedom to choose one’s own goals in life. On the other hand, tradition values refer to “respect, commitment, and acceptance of the customs and ideas that traditional culture or religion provide”⁴. Closely related to tradition values, conformity values refer to constraint according to social norms, and include self-discipline, obedience and honoring parents and elders.

The altruistic, or pro-social and group function, value types include universalism and benevolence. Universalism values, including social and environmental justice, unity with nature, inner harmony and broad-mindedness, refer to “understanding, appreciation, tolerance, and protection for the welfare of all people and for nature”⁴. Benevolence values, including love, meaning in life, honesty and helpfulness, refer to “preservation and enhancement of the welfare of people with whom one is in frequent personal contact”⁴. In some cultures, a related spiritual value type emerges, encompassing values including inner harmony and meaning in life.

This value typology will help in identifying the values science communicators perceive and cater to in their readers. This study investigates what motivational types and value orientations science communicators assume in their readers. These assumptions can have significant implications for narratives constructed around science in the media, and in turn public understanding of and attitudes toward science and its role in society^{13,16}. It is important to note that the theoretical basis of this study includes fundamental human values as important aspects of science communication from the point of view of both content producers and consumers. Audiences will read and interpret stories about science based on preexisting value orientations whether or not science communicators acknowledge, understand or tap into these values.

Schwartz’s universal human values typology has been applied in research on political attitudes and behavior⁴, environmental conservation¹⁷ and even journalists’ perceptions of their role in news work². However this value typology has yet to be widely applied by mass communication and journalism researchers². We propose that universal human values play a fundamental role in another value-related concept: news factors. Adoption of particular news factors, or the goals and decision factors used by journalists and editors to determine and/or ensure interest in and newsworthiness of a particular topic or story, may relate to perceptions of the interests, values and value orientations of intended audiences of that story.

News factors and newsworthiness

Some communicators may supplement so-called human values with news values when they think about what their readers want. In

journalism, all events are assumed to possess particular characteristics that make them more or less newsworthy, and it is these characteristics, gauged by journalists, that we refer to as *news factors*¹⁸. They make up the selection criteria used by journalists when presented with a number of story ideas overwhelmingly larger than the number they can actually pursue. According to Eilders, “[t]he more newsworthy an event is considered to be by journalists, the more likely it will be selected for publication, and the more likely it will be prominently presented”¹⁸.

Some of the news factors that have been proposed to increase the likelihood of story selection include sensationalism¹⁹, frequency, proximity, importance to society, relevance to the audience, unexpectedness, oddity, drama, personalization/personification, negativism, controversy and facticity^{12,18,20,21}. More recently proposed news factors include illustration of emotions, sexuality and visualization or the availability of graphical material¹⁸. But while some of these news factors may apply broadly across various areas of journalism, science journalists may endorse particular news factors over others. For example, surveys of British science journalists indicate that they look for potential science news that is “of ‘relevance to daily life’, ‘with a human angle’ [...] or which is ‘weird and wacky’”⁵.

In his *Psychology of news decisions: Factors behind journalists’ professional behavior*, Donsbach went beyond the identification of specific new factors to a theory for why specific factors might be more powerful than others¹². The author references Schulz in a partial answer to this question: “The only causal explanation for the existence of news values is journalists’ notions of audience interest”¹². Other scholars echo this concept, that news factors are not only journalistic criteria, but also “general human selection criteria, deductible from the psychology of perception”^{18,22}. In other words, anticipation of audience interests as well as audiences’ actual selection patterns underlie journalistic news values and specific news factors¹⁸.

Donsbach enumerates two primary psychological explanations for broadly observed news decisions: journalists’ need for social validation of their perceptions, and journalists’ need to preserve pre-existing dispositions. The first explanation is a foundation for journalists’ heavy reliance on “shared” news values and standardized news factors, especially in cases where objective criteria are missing. The second explanation is a foundation for the impact of journalists’ perceptions of the interests and values of their audiences. While audience influence on news decisions can arise through institutional objectives, “journalists have their own conceptions of the audience and its taste”¹². In this way, news factors and perceptions of audience interests and values may combine to influence journalists’ decisions of what to cover, and how.

The fact that science journalists have to be extremely selective in choosing amongst an almost infinite supply of story topics based on scientific research publications, press releases and other sources, potentially enhances the role of traditional news factors and perceptions about audiences on news decisions. For example, pre-existing perceptions of what audience members care about, or what their value orientations are likely to be, may guide story selection as well as storytelling.

Science communicators’ use of narratives

In addition to news factors, nonfiction science writing often incorporates elements of storytelling including plot, strong characters, action, setting and language devices²³. Many scholars have suggested that narratives are important means “to convey information in an accurate, attractive, imaginative and memorable way”²⁴. Narratives, or stories, are easier to comprehend and more memorable than scientific facts²⁴. Some of the narrative structures that have been proposed to enhance popular interest in science include stories of history, including historical accounts of research and scientist biographies^{25,26}, stories highlighting a particular problem or drama, and stories about the struggles and successes of the scientists themselves. Stories should be exciting, elicit emotions, and should develop a connection between the reader and the subject²⁴.

Science communication values

Because scientists have increasingly entered the public sphere in the communication of their work and science on a broader level²⁷, and science journalists and bloggers are increasingly formally trained in the sciences^{10,28,29}, we must consider the communication values of the scientific community as well as the journalistic and popular science writing communities in order to understand the storytelling decisions of science communicators. The most common theme in scientists’ motivations to communicate with the public is to educate, to improve understanding of science and/or to increase awareness³⁰. However, other themes in scientists’ motivations to communicate with lay audiences include to inspire interest in science and to empower public decision-making³⁰. Some of the ways that scientists seem to envision these goals being achieved include making science relevant to audience members, highlighting overarching concepts and helping audience members see how science and scientific data affect them personally³⁰. These strategies seem to line up with some traditional journalistic news values, including importance to society, proximity and relevance to readers. However, scientists have also traditionally been skeptical about communicating science to broad public audiences, fearing that accuracy might fall prey to efforts at making science interesting, “whizz bang and glamorous”³⁰. Scientists also tend to express the need for caution with controversial and preliminary research studies, particularly preliminary medical or drug research studies, when communicating findings to lay audiences³¹. It will be interesting to see how science communicators navigate these concerns while conforming to news values and efforts to engage lay audiences.

Methods

A single primary interviewer (PB), who is a Ph.D. student in the field of mass communication, conducted in-person, in-depth elite interviews with a total of 14 science communicators in North Carolina. The cities of Raleigh and Durham are often seen as hubs for science communication, hosting many prominent science bloggers, university science public relations officers (PIOs) and members of the society of Science Communicators of North Carolina, or SCONC. The final sample of communicators interviewed were recruited via personal e-mail invitation, starting with communicators the interviewer knew personally through social media (Twitter), followed by a snowball convenience sample of communicators suggested by initial interviewees. In e-mail invitations, interviewees were briefed on the goal of study “to learn from experts in the field how they craft

their messages on science for the public” and invited to participate based on their expertise in the field of science communication. In responding to initial e-mail invitation responses, participants were also sent digital consent form files, which were signed, scanned and returned via e-mail, or signed and given to the interviewer in person.

Potential participants suggested by “snowball” sampling were contacted strategically in order to get a mix of journalists, non-fiction science authors, bloggers and editors. One interviewee volunteered based on a Twitter announcement. Almost all science communicators who responded to a personal e-mail invitation ended up in the final sample. Out of 21 potential science communicators originally invited to interview via personal e-mail, 18 responded. One respondent no longer qualified as a science communicator due to a transition into foreign news reporting, and three declined to be interviewed due to scheduling problems. Representativeness of all science communicators was not a goal of the sampling procedure; this research is inductive and seeks to build theory rather than generalizable claims.

Interviews took place in participants’ work offices, work-place conference rooms, or relatively quiet coffee shop locations convenient for participants. The semi-structured interviews, which typically lasted between 45–60 minutes, were digitally recorded and later transcribed in full by the single primary interviewer. Participants were assured of confidentiality in the use of the interview transcripts, and are thus identified here only by number (Interviewee 1–14 in chronological order). The interview transcripts and the notes taken by the interviewer during each interview form the basis of this analysis.

In-depth interviews were conducted according to methodology laid out by Lindlof and Taylor³², using a “guided introspection” interview protocol³³. This type of interview taps into information and context that only the actor, in this case the science communicator, can provide, including perceptions, beliefs, values, and *why* he or she follows certain communication rules and routines. In-depth elite interviewing “stresses the informant’s definition of the situation, encourages the informant to structure the account of the situation, and allows the informant to reveal his or her notions of what is relevant^{33,34}. Interview questions were kept broad and open-ended, with questions progressively but subtly prompting communicators to express their perceptions of audience interests and values (see [Appendix for interview procedure](#)).

Interview analysis was approached predominantly using inductive and grounded theory methods: open coding for dominant emergent themes was followed by selective and deductive coding once key categories and themes – of audience engagement through story selection, content and presentation – had been identified. However, specifically for perceptions of audience values, interview analysis also involved deductive coding based on Schwartz’s universal human value typology^{3,4}. Interview transcripts were coded and analyzed within ATLAS.ti (version 7.0.92), a software workbench for qualitative analysis of textual data. The science communication strategies and audience perceptions of the 14 science communicators were first examined as a group. Then the communicators

were divided according to occupation (PR; freelance journalism & blogging; content management and editing) and educational background (formal science training vs. formal journalism training). In addition to these external trait divisions, analysis considered emergent divisions based on the communicator’s preferred science topic (“beat”), perceived role of science communication and other internal and work-based traits.

Science communicators

Science communicators interviewed ranged in occupation from university public relations (4 interviewees; 1–10 years’ experience) or science PR consulting (1 interviewee; 19 years’ experience), to freelance science journalism in the form of newspaper articles and/or magazine articles and/or books (6 interviewees; 5–40 years’ experience), to science blogging (1 interviewee; 3 years’ experience), to content management and editing in the blogosphere (1 interviewee; 10 years’ experience) or in print (1 interviewee; 18 years’ experience). The gender breakdown of interviewees was 5/9 male/female, and interviewees ranged in age from 25 to 78 years old. One interviewee held an undergraduate degree in History of Science. One interviewee held an advanced law degree. Five interviewees held advanced degrees in science fields. All other interviewees held graduate and/or undergraduate degrees in journalism and other humanities fields.

Results

In-depth interview data on the values and practices of science communicators

1 Data File

<http://dx.doi.org/10.6084/m9.figshare.1051657>

Dominant theme categories

Following several initial rounds of open-coding and subsequent selective and deductive value-based coding of interview transcripts, codes of interest were categorized into four primary theme categories, according to important aspects of science communication brought up by interviewees: (1) news factors, or newsworthiness criteria, and institutional constraints; (2) messaging tactics and science narratives used to engage audiences; (3) perceived audience values (described in [Table 1](#) and represented visually in [Figure 1](#)); (4) science communication values (described in [Table 2](#)). In the context of this analysis and the question of whether science communicators consider their audience’s values in selecting and telling stories about science, where applicable themes and codes are interpreted in light of how they relate to Schwartz’ value typology. Major and minor themes and codes described below are also quantified by the fraction of interviewees mentioning them (in parentheses).

News factors, institutional constraints and messaging tactics

News factors, or criteria of newsworthiness, that appeared to dominate science communicators’ selection and production of stories included (1) relevance or usefulness to the reader, characterized by applicability of scientific finding(s) to the reader’s daily life (mentioned by 12/14 interviewees), and (2) importance to society, characterized

Table 1. Perceived Public Values, in order of mention frequency, identified through deductive and open-coding.

Perceived Public Value	Description	Fraction
Security Category	Includes health (39 mentions), family security and well-being (12 mentions). Often mentioned in association with Hedonistic values (comfortable life, happiness) and the news values "Importance to Society" and "Applications, Health Implications of Research." "You like things that are personal to you... ok, great, maybe one day I can regrow this crappy knee that I have and I won't have to get a knee replacement. That would be cool, I would read that story."	12/14
Hedonism and Stimulation Category	Sex/entertainment (15 mentions), excitement (17 mentions) and happiness or a comfortable life (7 mentions). Appealing to stimulation values (excitement) though interesting topics like dinosaurs; communicating a "sense of amazement." "I think we all, when we read news, I mean we're reading for knowledge, but, I think we also want to be entertained."	10/14
Self-direction Category	Includes curiosity, creativity, exploration and choosing one's own goals.	7/14
Benevolence Category	Includes helpfulness, helping others, responsibility and friendship. "The best science writers will go out and find a patient who has been suffering with, you know, X disease, and then went and took Y drug, and, miraculously, in their minds, um, recovered or felt much better or... and then go into the process of, like, well how molecularly does this drug actually work... what's the science behind its success. So it's kind of tapping into that innate... human... need to, like, want to connect with each other."	7/14
Universalism Category	Includes broadmindedness; wisdom; social justice; equality; a world at peace; a world of beauty; unity with nature; protecting the environment; inner harmony.	7/14
Universalism Category Emergent Value: Finding Meaning of Life	Includes understanding ourselves and the origins of life. An emergent value theme, in which people find it important to think of the broader, philosophical questions of life - can be an escape from the everyday, to think about bigger questions about human origins and the meaning and purpose of life.	2/14
Achievement and Power Category	Includes success; capability; ambition; influence; intelligence; self-respect.	5/14
Tradition Category	Includes accepting one's portion in life; humility; devoutness; respect for tradition; moderation.	5/14

Figure 1. Schwartz (1994) value structure prototype, adapted according to public values mentioned by science communicators, presented according to fraction of science communicators mentioning each value category. Bolded specific values emerge as dominant themes in "audience" values perceived by science communicators.

Table 2. Science Communication Values, in order of mention frequency, identified through open-coding.

Communicator Value	Description	Fraction
Putting science in context	Practices used to orient a specific research finding in the broader context of science as well as daily life; showing audiences how a specific research finding fits into a larger problem or understanding of a problem; showing audiences how a specific research finding fits in with past research findings (i.e. "science doesn't occur in a vacuum") and historical context (how science methodology has changed over time)	12/14
Fixing misconceptions, educating	Goal of educating readers on science and the scientific process; fixing misconceptions and avoiding misinformed interpretations based on language choice	10/14
Inspiring interest in science	Goal of inspiring their audiences' interest in science, either in general or in the context of education or a future science career	7/14
Need for care on hot-button topics	Being careful to explain scientifically, being straightforward and avoiding "loose" or inflammatory language on "hot-button" topics like medical breakthroughs, stem cells, evolution or climate change	7/14
Scientific accuracy	Fact checking; being scientific accurate, providing details of scientific methods and qualifiers/limitations of research findings	7/14
Intellectual honesty	Making sure examples, metaphors and language used can't be misinterpreted or inspire false hope; avoiding discussion of "cures"; being honest about who funded the research	5/14
Objectivity	Separating facts from opinions	5/14
Open/Broad-mindedness*	Being open-minded about evidence, other points of view, etc.	3/14
Sticking to the facts*	"presenting the facts, [...] this is what science says, and, you know, these are the ramifications, and you can believe it or not believe it, but this is what it is." <i>Mentioned only in science PR</i>	3/14
Engaging audience feedback*	Asking audiences questions, eliciting feedback on social media, or taking audience feedback and incorporating it into future stories; <i>mentioned only by science bloggers</i>	2/14
Avoiding Clichés*	Avoiding clichés or hackneyed terms and phrases in science communication; <i>mentioned only by print editor</i>	1/14
Being the light-house, not the tugboat*	The idea that the communicator shines light on a subject for the audience, and shows them why it is interesting, but doesn't necessarily have to "connect the dots" in an explicit way; making the audience think harder, make connections for themselves	1/14

*Indicates a minor theme

by answers to the questions "why is this [scientific finding] important?" and "why does it matter?" (9/14 interviewees). Related to these factors was the perceived need to show real-world applications, especially health, medical and/or clinical applications, of scientific research findings (8/14). One interviewee expressed this news factor as communicating to audiences that "this could have implications for..." Related to this was *personalization*, or referring to a particular person or personal story to show importance of a scientific finding for society (8/14). This might entail talking about a patient in a story about the pharmaceutical drug process.

Another dominant news factor was surprise or unexpectedness, characterized by astonishment, shock, or ideas that are counterintuitive, unexpected or conflicting with previous evidence (10/14). Two interviewees shared a special term for this – the 'zag':

"Like 'hun, that's crazy, I never really would have guessed that that would be true,' right? Um, so it's those sorts of things. The... the 'zag,' it's unexpected, it's not really... it definitely counters what you thought would be, what's going to come in the story. Yeah, so those are kind of the ones that do really well." #5, Male, University PIO

Of interest, news factors including *relevance to the reader* and *applications of research* were particularly emphasized by public

relations communicators and freelance journalists covering biological science topics, health and medicine. However, these were either not mentioned or rarely mentioned by interviewees covering space, technology, engineering, physics, energy and environment and conservation issues. On the other hand, surprise factors were mentioned more frequently by interviewees covering the later topics (with the exception of environment and conservation). The area of science covered may alter the relevance of particular news factors to story selection and production, where physical or basic science research that can't necessarily be made directly relevant to the reader most possess a high degree of novelty and unexpectedness to make a good story:

"I mean, most people want to know, how is this going to directly impact my life, you know, and if you're writing things for newspapers, or about health, or whatever, yeah, you can kind of see that a little bit more clearly. Um, but especially when it's stuff like particle physics, or, you know, origins of the universe, or things like that, you know, it's like yeah, there's not really any immediate connection, but I think that people that read science are curious about that kind of stuff just for its own sake. So, um, in some ways just the fact that it's something *new* is more of what you're trying to convey, rather than immediate personal connection to, you know, subatomic particles (laughs)." #13, Female, Editor, Print

Other important but less dominant news factors included scientific importance, or the importance of an event for scientific progress (8/12), proximity and localization (6/12), novelty or a certain threshold of news impact (4/12), the presence of graphical material to accompany a story (4/12), conflict or controversy (4/12), fairness to different views (4/14), economic relevance (4/12) and political or public policy impact (4/12). Minority expressed news factors included the presence of human interest or colorful people, and the presence of a news peg or a current event, mentioned specifically in the context of space history stories tied to spaceflight anniversaries, and environmental/conservation stories tied to current events. As might be expected, recognized traditional news values such as proximity and threshold were mentioned less frequently by science bloggers, blog managers and nonfiction book authors than by freelance journalists, university PR writers and editors.

In describing efforts to engage lay audiences in science stories, interviewees often mentioned the need to address the “why should I care?” question, to show readers why they should care about a particular scientific finding or event. According to one interviewee, the “second sentence of a press release has to address the question, ‘why does anyone care?’” (#2, *Female, PIO*). A majority of science communicators appear to address this question in part by showing how the science at hand relates to the reader’s daily life: “the idea of connecting it [the science] is to relate to something that people do every day,” (#4, *Female, Science PR Writer*). Especially with complex topics, relating a scientific finding or phenomenon to readers’ everyday experiences is often achieved by creating metaphors or analogies to things people already know (7/14) or talking about science in people’s own lexicons. For example, one interviewee gave the example of relating nanoparticle interactions to tying one’s shoestrings: “it just created this wonderful image that *everybody* knows. [...] So it really is about, you know, just painting that very simple picture of something that, that people experience almost in their daily lives” (#10, *Female, Freelance Journalist*). Another interviewee who had been trained in science writing and taken a university course on *science as literature* expressly connected the use of analogies with storytelling devices that help audience understand and remember details^{35,36}. The perceived importance of incorporating analogies to things people are already familiar with might have foundations in schema theory and the idea of conceptually-driven information-processing where, “[p]rior knowledge makes it easier to integrate new information and also raises the level of interest because the objects have already acquired meaning for a subject”¹⁸.

Storytelling, or using elements of fiction including development of narrative, metaphors, characters, plot, tension and drama, emerged as a major theme in science communicators’ descriptions of their efforts to connect with lay audiences. All interviewed communicators mentioned at least one of these elements of fiction as important devices to engage audiences (with the exception of one research PR consulting agent trained in strategic communication):

“Um, I think when you ... recast science in words that ... people would use at a dinner party, then they become engaged, and then they have the opportunity to ... start thinking about science in their own lexicon, in their own ... in their own bubble, if you will. And when they can do that, they do begin to care. And

it may not be to a passionate level, you know, but it is at least to the point where, you know, they can, they can conceive of how science impacts their life.” #10, *Female, Freelance Journalist*.

Answering the “why should I care?” question for audiences was also associated with the institutional constraint, perceived especially by university PIOs and freelance journalists, of needing to address editors’ concerns and questions of “why do I care about this? Why does this matter?” (#5, *Male, University PIO*). Whether and how this question is addressed specifically, however, seems to depend both on the science topic being covered and the perceived value orientation of the reader.

Perceptions of audience values and science communication values

Explicit or implied perceptions of audience values were coded according to Schwartz’s value typology while allowing for emergent values via open coding. Our findings of interviewees’ perceptions of audience values in the selection and production of stories about science are shown visually in **Figure 1**, arranged according to Schwartz’s fundamental human value typology. In **Figure 1**, larger and bolded fonts represent values heavily reflected in science communicators’ work.

Several dominant audience value themes emerged. Security values, including specifically individual health and family security and/or well-being, constituted an overwhelming majority of factors mentioned in response to question prompts “what are examples of stories people can relate to?” and “what do you think your audience cares about?” Several interviewees associated security values more generally with their readers’ tendency to have self-interested concerns and goals, confirming the idea that security values are related to basic needs of the individual^{3,4} and an egoistic value orientation³⁷. Interviewees that connected security values with the need to engage readers’ self-interests largely worked in public relations or freelance journalism, in areas of medical and health reporting:

“Well, health stories are obviously a winner, right? People care about themselves. [...] again, all of the health topics. Cancer, heart disease, diabetes, obesity, I mean those all have immediate... immediacy for people, those are things they care about.” #5, *Male, University PIO*

Several communicators also mentioned security values as guiding principles for their selection of potential stories:

“[W]hen choosing a story to write for the lay public, it, you really do have to pick something that, if it’s a small development, or an esoteric development, it has to be something that impacts... a relatively widely-understood topic. Like if it’s, even if it’s just ah, ah, a gene modification, or a biomarker that’s, you know, rare or whatever, it *has* to affect something big, like Alzheimer’s, or breast cancer. You know, if it’s something small, it’s *got* to be part of a big problem, or people are going to not really care, because they are going to say, ‘well, what does this have to do with me?’” #10, *Female, Freelance Journalist*

Security values of health and family security and/or well-being were also often mentioned in association with dominant news

value themes including importance to society, relevance to the reader and showing (health and clinical) applications of research findings. However, even interviewees who didn't stress traditional news values – one science blogging editor and one general science and energy nonfiction author who seemed to rely more on curiosity, entertainment and surprise to engage audiences – still mentioned security and health as basic audience values and concerns:

“I had to actually *read* and *learn* some human and medical aspects of *my* field, beyond my, you know, [biological clocks] 101 lecture notes (laughs), you know, that I took 10 years before, where, you know, we spent maybe two weeks on humans (laughs). And, uh, the *very* basics. So I had to learn in order... because that's what people were asking for.” #3, *Male, Blog Editor*

A second dominant theme in perceived audience values included hedonism and stimulation values, two categories that often overlapped when mentioned during interviews. In the hedonism category, perceived audience values included happiness/enjoyment, comfortable life (“[t]hey are interested in anything that can make their life easier...” #1, *Male, PIO*) and entertainment (“when we read news [...] I think we also want to be entertained” #10, *Female, Freelance Journalist*). In the stimulation category, perceived audience values included exploration and excitement (“I really work to convey excitement in and wonder at the topics” #11, *Male, Journalist, Author*). Hedonism values often overlapped with security and health values, especially in the case of one university PR writer who considered quality of life to be dependent on health and happiness (#1, *Male, PIO*). Communicators appeared to cater to both security and hedonistic values, such as comfort in life, when trying to engage wide audiences in science stories:

“[I]f you're trying to get that AP story that's going to go in every local newspaper in the country, and then maybe hop across to Europe, etc. etc., then you want to explain *why* (emphasis) this particular scientific finding is relevant to you [the audience]. Is it gonna stop MRSA? Is it going to maybe lead to some revolutionary new treatments for cancer, is it going to help paralyzed people walk again? Um, is it going to make your food safer? Is it going to make, is it going to revolutionize the way we think about clothing? Stuff like that. Hospital gowns. We redesigned a hospital gown, and we have gotten *huge* interest in that story. And you think, well nobody wants ... the hospital is an uncomfortable, horrible place to be. The bottom line is that if you just be assured that your rear end is covered at all times (chuckles), that is one less thing to be miserable about. So it can be really simple stuff like that.” #2, *Female, University PIO*

Belief that their readers value entertainment (in the hedonistic value category) and excitement (in the stimulation value category), on the other hand, was associated with the preferential selection of “cool” science topics. These topics included subjects such as “cockroaches, or robots, or an invisibility cloak,” (#1, *Male, PIO*) or science myths, science fiction fantasies or paleontology. These seemed to be topics that science communicators understood to not require extra effort to answer the “why should I care?” question, to personalize the subject or to show relevance to daily life:

“Then there are things that people are just interested in, like the *cool* science topics. Paleo. You don't have to ... ‘this T-Rex is relevant to you because...’ no, everybody just wants to imagine big giant toothy guys running around chomping the heads off of triceratops, that's it. It's ok (laughs). So, it depends on the subject. But if you are doing something that is a little bit more complicated, a new chemical formula... that contextualization helps – the personalization helps. Think about you as a person. Ok you've found this compound, why do I care? It's a compound that ‘well oh if we coated the curtains and the surfaces in a hospital with it and then turned on the UV lights it nukes *every* bacteria. Hey! MRSA solved, right? It doesn't get in the hospital anymore, because we've killed it. That kind of thing. So you know, people understand that, and they are like ‘oh, well that would be great!’ Take a little bit of worry off their mind about a hospital stay or whatever. It could be anything like that.” #2, *Female, University PIO*

It appears that the perceived audience values that science communicators address in their selection and production of stories depend in part on the subject or topic of science being covered. Science communicators believe that while “cool” science can feed into human values of excitement, more complicated science topics – molecular biology, genetics, engineering and technology – require tapping into self-oriented security or hedonism values in order to engage audiences. For example, one science blogger who covered space science history and space trivia rarely expressed perceptions of audience security values and did not mention a need to address relevance to reader or the “why should I care?” question. Instead, she relies on surprise and unexpectedness, reflecting human values of excitement and curiosity.

Catering to entertainment and stimulation values was also a strategy used by some science communicators as a way of engaging audiences otherwise not interested in science. One freelance journalist and nonfiction science author in particular held a minority view that catering to audience self-interests by stressing relevance to the reader and explicitly answering the “why should I care?” question involved a form of “talking down” to the audience (Interviewee #11). This interviewee instead works to incorporate a sense of amazement into his writing, assuming humans are inherently curious and interested in all things. This science writer emphasized the otherwise minority theme of *universalism values* among his readers, including broad-mindedness and a universal desire to seek an “understanding of ourselves and our universe” (#11, *Male, Author*). His interview introduced a unique science communication theme (Table 2) when he described that his job “is to be... the lighthouse, not the tugboat. Like, I illuminate so you can see what's out there, rather than going and getting you and pulling you towards where you need to be, where I think you need to go” (#11, *Male, Author*). However, he also said that he realized that although he *hopes* that his audiences recognize that everything and everyone is connected, in global energy issues for example, readers are often motivated instead by egotistical concerns and issues closer to home, such as security and health. This is an interesting finding – while most science communicators assume their audiences tend toward the self-interested end of Schwartz's human value spectrum, some work hard to activate self-transcendent values in their readers. To do this,

interviewee #11 relies on entertainment and stimulation values as well as vivid storytelling:

“I’m assuming everybody’s interested in everything, and they should be, and if they’re not, I’m so entertaining as a storyteller that I’m going to get them interested in it.” #11, *Male, Author*

“Your job is to be the eyes and the ears of everybody else. Your job is to say, ha (excited) this is my job! I’m *looking* at nuclear waste in a pool, and I’m seeing it *glow* blue. And this guy’s explaining to me what Cherenkov radiation is, and that it’s beta particles travelling faster than the speed of light *in water* – in water, right, light doesn’t travel at the speed of light, it travels more slowly – beta particles travel slightly faster than light does in water, and so they, all kind of strange things happen, which leads to this blue glow, that’s the best I can do. But, um, like, and I’m writing it down, and I’m *wearing a hard hat*, and *this is what I get paid to do! Oh my fucking god!* And you have to be saying that, not every minute is like that, but generally, you know, that’s what your job is, and to convey that sense of *amazement*, and that understanding, to your audience.” #11, *Male, Author*

Self-direction values of curiosity, creativity and choosing one’s own goals in life were mentioned or implied by half of interviewees. Perceptions of these values seemed to be partly dependent on the science topic being covered (especially physical sciences, nature and environment topics, science history and science in culture), but also related to particular science narratives (including ‘untold stories’) and science communicators’ own values. For example, one interviewee, a science blog manager, stressed self-direction values in the context of his own view that science should always be communicated in its historical and culture context. When asked why history and culture were important aspects of science communication, he responded:

“[F]irst it’s fascinating on its own. But I think it’s also useful knowledge, for a lot of people who are, ah, who have their own, ah, goals, like how to change one little aspect of culture for the better. So they can be activists for a cause, or something like that. [...] So, you know, how technological and societal changes can affect how you change your movement, for betterment of some aspect of society. And, uh, and science and how it is *done* is often a reflection of that. Because every scientific finding, in some way, not just explains the world, but also affects the way we *think* about the world. So seeing how, you know, a *very* important paper from 50 years ago has changed everybody’s thinking about ‘X’ is one of the paradigms, like, you know, how can we do something like this? Maybe we should do science! Maybe we should research how people think, or how movements win causes, or something like that. So, there is definitely practical aspects, like *know* your history so that you don’t repeat it, also know your history to see what works and what doesn’t so that you can modify it for the current situation or to succeed.” #3, *Male, Blog Editor*

Another science communication value associated with perceived self-direction audience values, visible in the above quote, is the desire to inspire an interest in science, mentioned by half of interviewees (see [Table 2](#)).

Those science communicators who emphasized that their readers tend toward self-direction values, including curiosity, also did not typically mention security or hedonism values. Interviewees who emphasized innate curiosity as a defining characteristic of their audiences – one space history blogger (#6), one general science freelance journalist and author (#11), and one a freelance journalist and science textbook author (#14) – generally did not emphasize news factors related to self-interest, including importance to society, relevance to the reader or health and clinical applications of research findings. However, perceptions of strong reader curiosity were associated with the science communication value of fixing misconceptions and educating (a major theme mentioned by 10/14 interviewees). This was true especially for one interviewee who worked as both a freelance journalist and a science textbook author. This interviewee emphasized targeting young readers’ curiosity for learning, assuming people relate to the “quest of discovery” or the “adventure” of scientific discovery (#14, *Female, Freelance Journalist, Educator*). Especially in this case, students and regular readers of science were expected to be innately curious and interested in “science for science’s sake,” a striking departure from the dominant strategy of targeting self-interest values of security and health.

A minor theme in perceived audience values emerged in the form of universalism and pro-social benevolence values. Universalism values mentioned by science communicators (7/14) included unity with nature, protecting the environment and environmental and social justice. When mentioned, these perceived audience values seemed to be strongly associated with another minor science communication value theme ([Table 2](#)): open-mindedness and broad-mindedness. This was especially the case for an open-coded audience value theme associated with universalism: Meaning of life. This emergent value involved the perception that people find it important to think of the broader, philosophical questions of life, including origins of life and the universe, and the meaning and purpose of our human lives. This value was mentioned by one interviewee in the context of a story about a physicist’s search for the Higgs Boson and universal human questions including “why are we here, where did we come from, what are the origins of, of everything we see around us” (#4, *Female, Science PR Writer*). Interviewee #11 expressed this value as a human desire to understand ourselves better:

“And, so I think that’s the hidden part of what we’re doing, is by talking about what makes us tick, you’re trying to also show us, what makes us good, what makes us *better*. Because I think that’s our job, in all parts of our lives, is to make the world a better place than it was an hour ago, a lifetime ago, a month ago. And, this is how we do that. And ah, whether it’s by doing science so that we understand and can cure disease, or by making art so that we more understand what makes us tick as humans, or by telling stories in print or on radio or in video,

so that we understand our human lives, and we can do a better job of listening to each other, and communicating to each other, and making the world a better place.” #11, *Male, Author*

Perceptions of audience universalism values did not typically coincide with mentions of major news values. In some cases, these values were actually associated with discussion about the difficulties of engaging audiences with particular science topics including environmental and conservation stories. The perceived importance of catering to universalism values seems to be largely dependent on the personal philosophy of the science communicator and his or her own orientation toward this value category, which includes values of broad-mindedness, inner harmony, social and environmental justice (Schwartz, 1994).

A final minor theme in perceived value orientations of audiences was endorsement of pro-social benevolence values. These perceived values, unlike universalism values, *were* associated with traditional news values. They were often mentioned in connection with news factors including importance to society and personalization, especially in the context of biological science, health and medical news. For example, several interviewees stressed telling the story of a patient in articles about a new cancer treatment or the drug discovery process: “You *have* to, you have to make it about humans, you have to make it about people, that’s what we care about” (#11, *Male, Author*). Benevolence values including responsibility and helpfulness were mentioned in the context of an emergent narrative of *scientists as heroes* (6/14):

“I think a lot of people come to science with the assumption that people are trying to *help*. Scientists go into science because they want to find out why something works, so that they can maybe find out a way to make it work better, or use it to help people. I haven’t met many Dr. Evils.” #2, *Female, PIO*

Tradition and conformity categories of Schwartz’ (1992; 1994) value typology were nearly absent from science communicators’ perceptions of audience values. This absence was not surprising given the emphasis on stimulation and self-direction values. Tradition and conformity values constitute one pole of Schwartz’ (1994) *conservation/traditionalism* vs. *openness to change* value orientation, while stimulation and self-direction values constitute the other. This relationship is translated visually in Schwartz’s (1994) circular value structure diagram, adapted in [Figure 1](#) for this study, where security, tradition and conformity value categories occupy a space at a 180° diagonal from stimulation and self-direction values.

Power values (i.e. wealth) were implied only in the context of showing the economic relevance of scientific findings, especially when communicating to members of legislature on the outcomes of government funding of science. Achievement values were mentioned in the context of avoiding jargon or forms of condescension toward readers (writing in ways that would make the audience feel unintelligent or uninformed). Achievement values of success and ambition were also mentioned in the context of an emergent science narrative theme of *humanizing science* (8/14), specifically helping audiences to relate to scientists’ struggles to overcome obstacles in the name of science:

“I think we relate to people more than we relate to machines. So if you put it in terms of, I mean, if you bring out a struggle that we can all relate to, like, trying to meet a deadline, I mean, every single person who’s ever gone to school has tried to meet a deadline, and, you know, known that there’s a lot at stake and consequences and all that bad stuff. You can take that same emotion of *fighting to success* and apply that to an engineer working on a rocket, and all of a sudden that story becomes something that like, yeah, I know what that feels like.” #6, *Female, Blogger*

Perceptions of values as potential obstacles in science communication

Interviewees occasionally mentioned value-related obstacles in their science communication work. For example, they perceived that readers find it difficult to connect certain fields of science such as mathematics (#2, *Female, PIO*), biochemistry and particle physics (#5, *Male, PIO*) to things they value. Science communicators also seem to believe that most readers don’t share the values of the scientific community, generally not understanding the need for replication and why it takes so long for a new pharmaceutical to go through the phases of clinical drug development (#7, *Female, Freelance Journalist*) or why scientists perform experiments on model organisms such as *Drosophila* and mice (#10, *Female, Freelance Journalist*). One common perceived obstacle involved tradition and spiritual values as agents of misunderstanding science. Five science communicators perceived respect for tradition and spiritual human values as antithetical to the understanding of scientific findings and the acceptance of scientific explanations for natural phenomena such as climate change and evolution.

“there are people that think that evolution is not real, and that everything right now is exactly the way God made it, initially, and that is going to affect the way they view anything we write about paleontology, or bacteria, or human development. So, yeah, everybody has their own beliefs. The examples that I gave tend to be sort of more often faith-based. But those are going to limit your ability to reach those audiences. They are going to limit the ability of those audiences to place any new research findings in context; or rather the context in which they are going to place those research findings is going to affect their ability to understand and appreciate them.” #1, *Male, PIO*

“these questions of, you know, *who are we? Where did we come from? What are we doing?* [...] science is one way of answering those questions... religion is *another* way of answering those questions.” #4, *Female, Science PR Writer*

“the biggest things we get responses on are things like when we write articles, you know, breaking things down like intelligent design, and then we get 300 letters, from people who like, who... people in Christian schools who make all their students write letters and things like that, and you are just like... (sigh)... you know... it reminds you the world is a very different place.” #13, *Female, Editor, Print*

Discussion

The results of this study extend previous findings and assumptions about news values in science communication by introducing

concepts of how science communicators' story selection and storytelling processes reflect perceived audience values. Twenty years after Hansen's 1994 findings, science communicators still appear to often cater to 'relevance to the reader' criteria in selecting and producing stories. However, answering the 'why should I care?' question for readers is a tactic used primarily by communicators who assume that their audiences value security and personal well-being. These science communicators stress the need to show readers how science directly impacts daily life and health. However, they also acknowledge the dangers involved in doing so, including 'hyping' scientific results and fostering undue hope in new medical therapies, for example. Also, perceptions of a self-interested value orientation seemed more prevalent among science communicators targeting wide lay audiences and/or translating biological and life science research into story. Thus, assumptions about audience interests and values, and the need to cater to these assumptions, may vary with the individual communicator as well as with communicators who write news stories for wide audiences versus those who blog for what they perceive as niche audiences³⁸. This should be investigated in future research.

Conversely, as we suspected at the beginning of this project, communicators who assume their readers endorse value types related to *openness to change*⁴ seem to rely more on news factors including surprise factors, unexpectedness and novelty, as well as innate human curiosity as a motivation for science news consumption. A relative minority of science communicators reflected benevolence and universalism value orientations among their readers in describing how they select and tell stories about science. However, it is interesting that those communicators who did also emphasized being personally motivated to inspire a broad interest in science 'for science's sake.'

It is particularly interesting that while self-direction values – including choosing one's own goals and curiosity – occupy a motivational space distant from security values according to Schwartz's *openness to change* vs. *conservation/traditionalism* value orientation scale (see [Figure 1](#)), science communicators relied on both these value categories simultaneously to engage readers. Communicators who select and produce stories about science based on the assumption that their readers endorse both of these value types equally might develop stories that conflict with the values of readers at either extreme of the *openness to change* vs. *conservation/traditionalism* orientation scale. However, at least in this study, it was often the case that for any particular story, communicators relied heavily on either perceptions of security values *or* perceptions of self-direction values, dependent on the scientific topic and their own communication motives, but not both in the same stories.

Most of the science communicators interviewed for this study emphasized the use of narrative specifically, and elements of fiction in general, as important tools of the trade. Specific science narratives also seemed to reflect particular perceptions of audience value orientations. Personalization narratives, like showing a patient in a cancer treatment story, and narratives involving 'scientists as heroes' of disease, were associated with perceived security values as well as readers' concern for other people they feel close to. Popular narratives highlighting the struggles and successes of

scientists or the history of science²⁴ were associated with perceptions that all people can relate to having self-chosen personal goals and overcoming obstacles to achieve them – a self-direction value orientation.

These results have significant implications for our understanding of science communication and what governs the translation of science research in the public sphere. Science communicators' personal motivations may combine with their perceptions of readers' fundamental values to determine what kinds of science topics are selected for storytelling and what story elements are emphasized. Some science communicators frame scientific findings as directly relevant to daily life, while others rely more on entertaining storytelling, and still others expect their audiences to meet them half-way based on an innate curiosity and motivation to explore the meaning of life. This choice may depend more on communicators' own communication goals and perceptions of other people's values than solely on their professionally shared journalistic news values.

Data availability

figshare: In-depth interview data on the values and practices of science communicators, doi: [10.6084/m9.figshare.10516573](https://doi.org/10.6084/m9.figshare.10516573)³⁹

Ethical considerations

Exemption approval for human subjects research was obtained prior to conducting qualitative interviews with science communicators from the Institutional Review Board at Louisiana State University. Questions about the ethical considerations of this research study can be addressed to Dr. Robert Mathews, Chair, 130 David Boyd Hall, Baton Rouge, LA 70803.

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Due to ethical considerations for the privacy of the science communicators interviewed for this study, the data file accompanying this manuscript does not include full interview transcripts. Select anonymized interview excerpts can be supplied upon request. Quantified mentions of all major and minor codes, per all 14 interviewees, are provided in associated spreadsheet (see [data file](#)).

Author contributions

PB and RS conceived the study. PB designed the interview protocol and questions and carried out the research. PB prepared the first draft of the manuscript. Both authors were involved in the revision of the draft manuscript and have agreed to the final content.

Competing interests

No competing interests were disclosed.

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Appendix:

Example interview introduction and questions

I am going to ask you a series of questions in order to learn more from you as an expert in science communication, about current science communication practices as well as the best practices you have encountered. I am interested in your opinions, preferences, processes, and beliefs on this subject.

- Can you tell me a little bit about your background? *How did you get into science communication?*
- How would you best describe your specific area of science communication? Do you specialize in communicating about a particular area of science?
- Can you describe the audience you write for, in your own words?
- Can you walk me through the process you go through when you write a science press release, story, article, etc? What goes through your mind as you write such a message for a lay audience, and especially what goes through your mind as you consider how to best engage with this audience?
- What do you think are some of the best ways to engage your audiences with your messages? What practices, topics, methods or message attributes do you use to best connect with your audiences? *Conversely, what practices, methods or message attributes have you found don't connect well with your audiences, and how have you changed or overcome these?*
- What do you think your lay audiences care about, and how do you address these cares? *Can you reflect on what pre-existing opinions and concerns you think your audiences might bring to your messages? Do you think you currently address these pre-existing opinions and concerns in your messages? If so, how do you do so?*
- Do you consider the social and/or individual values of your non-specialist audiences in constructing your science communications? How does that influence your messages?

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Holger Wormer

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The role of science communicators, their self-perception and their role in a growing “direct-to-consumer-culture” of scientific institutions communicating their work to a broader audience is an increasingly relevant issue. Therefore, the approach of the authors to shed light on the opinions and values of science communicators has to be appreciated. The authors should be encouraged to continue in this direction. However, I would recommend strengthening the theoretical background and some of the related research questions, restructuring the analysis of the existing data set in a certain way, and thinking about extending the data set.

Actually, the theoretical background of the paper is mainly based on Schwartz’ concept of universal structures of human values and the theory of news values. However, some theoretical approaches of science journalism and science communication (especially in the sense of science PR) must also be considered more intensively. This may be useful especially to avoid one weak point of the sample which is the rather generalized all-of-the-same definition of a “science communicator”. When the authors state that “it is becoming increasingly difficult to differentiate the roles and work of science PR writers, science bloggers and science journalists” this may be true from a non-expert audience point of view but clearly less from a normative perspective. As [Rensberger \(2009\)](#) has pointed out the era of just – as I would call it – “embedded science journalism” should be rather a point left behind in history than a suitable approach for today. Interestingly the authors themselves relativize their own initially painted picture of a more or less homogenous universal science communicator type in their own findings: They point out, for example, that “traditional news values...were mentioned less frequently by science bloggers, blog managers and nonfiction book authors than by freelance journalists, university PR writers and editors”. Or, in the final conclusion: “This choice may depend more on communicators’ own communication goals and perceptions of other people’s values than solely on their professionally shared journalistic news values.”

It seems appropriate to focus more on these differences of the “communicators” which is subject of intense debates in other countries. For example, Martin Bauer Editor of “Public Understanding of Science” underlines that a [from institutional science PR] “independent science journalism is

most needed" today (Bauer 2013). Also quite recently, all big German Academies of Sciences have published recommendations questioning the role and quality of science communicators of scientific institutions between authentic science communication and just marketing of a scientific institution (

[www.leopoldina.org/en/publications/detailview/?publication\[publication\]=580&cHash=fdc9fd538a91f7ccd5986](http://www.leopoldina.org/en/publications/detailview/?publication[publication]=580&cHash=fdc9fd538a91f7ccd5986)).

Considering such emerging debates and the important theoretical approaches concerning science communication and journalism (as a third frame additionally to the news value and human value theories) the authors may also think about rearranging and analyzing – at least – the three subgroups of their data set: Actually, 5 interviewees seem to be allocated to the public relation world of science, 6 to (freelance) science journalism. However, in the paper itself the exact role of the 2 interviewees from the blogosphere as a third possible subgroup (Are they blogging scientists or blogging journalist or blogging PR officers?) remains as unclear as the role of the interviewed print editor. If one or more of these subgroups seem to be too in-homogeneous and not consistent in itself it could be also necessary to extend the sample in a more systematically stratified way.

As the summed up findings given in the paper for the sample as a whole are often not really surprising, a better carving out of possible differences among the proposed subgroups (journalists, science communicators from scientific institutions, blogger) may deliver even more interesting findings which are especially important considering the outlined theoretical background beforehand: What kind of science communication should and can easily be done by the science communication department of scientific institutions? Where (for example in cases of controversial issues in society) is a blogging scientist or an independent journalist preferable? Which values and anticipated news values are shared by each subgroup and which accordance is rather limited? And finally: How strong are they modulated by the treated scientific topic (e.g., health and life sciences versus astronomy versus engineering etc.), their anticipated audiences and other factors? (concerning the relationship between scientists & journalists & the public see also, e.g., Peters/Dunwoody *et al.*) – Of course, some of such analysis is already given in the existing version of the article but often in a rather hidden, implicit way. A more consistent multidimensional analysis alongside the expected and normative functions of the different subgroups may be an amazing approach for the further work in the field.

As a minor point concerning the data set it could also be asked how reliable the reported self-perception of the interviewees is. Our own work has shown that there seems to be a certain discrepancy between what journalists believe that they consider as an important news value and what you can finally identify as news values in their publications. A proposal (to be included in this work or for a further development) would be to strengthen the reliability of the findings by combining the interviews with another methodological approach. One way to do so could be a qualitative content analysis including a small controlled sample of publications of each interviewee: Are the news values and human values that can be identified in their pieces of work the same that they have mentioned in the interviews?

In any case it should become clear already in the title as well as in the abstract of the publication that we see a very interesting but highly explorative piece of work which has the main focus to develop new methods of looking on the role and self-perception of different (!) kinds of science communicators. Furthermore, it should become clear that the (preliminary) findings are still

limited to a “case study from North Carolina” (or at least “a case study from the US”).

Despite all my (as I hope not too critical) comments I am really looking forward to see a revised version of the paper which has the potential to fill a real gap in the field of science communication research.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 31 July 2014

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Sarah R. Davies

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This is an interesting topic: as the authors note, the way that communicators imagine their audiences will shape their output in significant ways. And I enjoyed what clearly has the potential to be a very rich data set. But I have some reservations about the adequacy of that data set, as it currently stands, given the claims the authors make; the relevance of the analytical framework(s) they draw upon; and the extent to which their analysis has offered significant new insights - by which I mean, I would be keen to see the authors push their discussion further. My suggestions are essentially that they extend the data set they are working with to ensure that their analysis is both rigorous and generalisable, and re-consider the analytical frame they use. I will make some more concrete comments below.

With regard to the data: my feeling is that 14 interviews is a rather slim data set, and that this is heightened by the fact that they were all carried out in a single location, and recruited via snowball sampling and personal contacts. What efforts have the authors made to ensure that they are not speaking to a single, small, sub-community in the much wider category of science communicators? - a case study, if you like, of a particular group of science communicators in North Carolina? In addition, though the authors reference grounded theory as a method for analysis, I got little sense of the data reaching saturation. The reliance on one-off quotes, and on the stories and interests of particular individuals, left me unsure as to how *representative* interview extracts were. I would therefore recommend either that the data set is extended by carrying out more interviews, in a wider variety of locations (e.g. other sites in the US), or that it is redeveloped as a case study of a particular local professional community. (Which would open up some fascinating

questions - how many of these people know each other? What spaces, online or offline, do they interact in, and do they share knowledge, for instance about their audiences? Are there certain touchstone events or publics they communally make reference to?)

As a more minor point with regard to the data set and what the authors want it to do, there were some inconsistencies as to how the study was framed. On p.2 they variously describe the purpose as to "understand the experiences and perspectives of science communicators" and the goals as identifying "the basic interests and value orientations attributed to lay audiences by science communicators". Later, on p.5, they note that the "research is inductive and seeks to build theory rather than generalizable claims", while in the Discussion they talk again about having identified communicators' "personal motivations" (p.12). There are a number of questions left hanging: is the purpose to understand communicator experiences - in which case why focus on perceptions of audiences? Where is theory being built, and in what ways can this be mobilised in future work? The way that the study is framed and argued as a whole needs, I would suggest, to be clarified.

Relatedly, my sense is that some of this confusion is derived from what I find a rather busy analytical framework. I was not convinced of the value of combining inductive and deductive coding: if the 'human value typology' the authors use is 'universal', then what is added by open coding? Or, alternatively, why let their open coding, and their findings from this, be constrained by an additional, rather rigid, framework? The addition of the considerable literature on news values to the mix makes the discussion more confusing again. I would suggest that the authors either make much more clear the value of combining these different approaches - building new theory outlining how they relate, and can be jointly mobilised in practice - or fix on one. (My preference would be to focus on the findings from the open coding - but that reflects my own disciplinary biases.)

A more minor analytical point: the authors note that their interviewees come from slightly different professions, and communicate through different formats, have different levels of experience, and different educational backgrounds - but as far as I can see there is no comparative analysis based on this. Were there noticeable differences in the interview talk based on these categorisations? Or was the data set too small to identify any potential contrasts or themes? A note explaining this would be useful.

My final point has reference to the potential that this data set has, particularly if it is extended and developed. I would like to encourage the authors to take their analysis further: at the moment, I was not particularly surprised by the ways in which the communicators referenced news values or imagined their audiences. But it seems to me that the analytical work is not yet complete. What does it *mean* that communicators imagine audience values and preferences in the way that they do - who is included and excluded by these imaginations? One experiment might be to consider what 'ideal type' publics are created in the communicators' talk. What are the characteristics of the audiences constructed in the interviews and - presumably - in the communicative products of interviewees? What would these people look like? There are also some tantalizing hints in the Discussion that are not really discussed in the Findings - of, for instance, the way in which communicator's personal motivations may combine with their perceptions of audiences to shape their products. How does this happen? These are, of course, suggestions. But my wider point is that the authors need to show more clearly what is original and useful in their findings - what it is, exactly, that will be important to other scholars in the field.

I hope my comments make sense - please do not hesitate to contact me if not.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 31 Jul 2014

Paige Brown, Louisiana State University, Baton Rouge, LA, USA

Dear Sarah R. Davies, reviewer:

As one of the authors, I thank you sincerely for thoroughly reading and critiquing our study.

I think a few clarifications need to be made in a revised version of this article, to address your comments. We need to clarify that the goal of this study was not to create a generalizable dataset or analysis of science communicators, but rather to begin an exploratory analysis into a theoretical area that has received relatively little research, i.e. how story selection and production, and by extension news values, may reflect more fundamental perceptions of audience values by science writers. The fact that this research is centered around understanding how story selection and production reflects the science communicator's perceptions of audience values is the reason that open coding was combined with deductive coding. By deductively coding for universal human values according to an established human value typology (in a multiple iterative fashion that we believe reached saturation), and seeing where these codes overlap with and how they compliment openly-coded categories of news values, storytelling devices, science communicator values and science communicator personal motivations, among other categories, we begin to build theory around how the production of stories about science for lay audiences reflects perceived fundamental human values. We don't seek to fully establish a theory of news values, story selection and production and fundamental human values, but rather to establish a new typology and concepts to be tested by future researchers. We are happy to provide additional interview abstracts to reveal the representativeness of the quotes we have chosen for coded categories.

We might, in a revision, more clearly establish this as a case study of the experiences and perceptions of a particular group of science communicators in North Carolina. However, while many of these science communicators know "of" each other, through social media and some personal contacts, they were not trained in similar programs, do not have very similar communication backgrounds, and they are not communicating in the same areas of science, nor to the same audiences, nor in similar capacities. We don't believe there are any unifying factors between these science communicators that would lead them to select and produce stories about science in similar ways, other than the fact that they all operate within a U.S. centered media culture. In fact, because these communicators were chosen based on communicating in a variety of formats (books, digital news, blogging, science public relations), and on a variety of science fields or beats, they are likely to have very different conceptions of who their audiences are, what their audiences are interested in and

what their audiences value. We think, for this reason, that any unifying characteristics in their perceptions of audience values are due to more fundamental processes in science communication within a U.S. centered media culture.

In reference to your question of what is *means* that communicators imagine audience values and preferences in the way that they do, this must be explored in further discussion within this paper but also with further research by others. In particular, a clear dichotomy emerges from the data that shows that depending on the field of science covered (biology vs. astronomy, for example), communicators assume different value orientations among their audiences. However, the reflection of these value orientations has not previously been explored in any extensive way by sociologists of the news who've identified news values pertaining to science including 'relevance to the reader' and surprise or 'the wow factor.' In the future, sociologists of science news and science blogging could more fully explore *why* different news values and story production norms have applied to different science beats - perhaps because communicators covering these different fields of science assume (or must assume by the nature of their fields/beats) different basic value orientations among their readers. To our knowledge, human psychology value research has previously not been considered by sociologists in explaining how science news is framed, or why certain stories are selected over others.

Thank you,
-Paige Brown

Competing Interests: No competing interests were disclosed.

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